ПРОТОКОЛИ ОТ ТИПОВИ ИЗПИТАНИЯ за VARISIL HE-I тип вентилни отводи с полимерна външна изолация

Проведени типови изпитания	Референтни стандарти	Изпитани мостри	ИЗПИТАТЕЛНИ ПРОТОКОЛИ			Допълнителна информация
			Справка	Дата	Език	
Изпитания за издържливост на външната изолацията	IEC 60099- 4 §10.8.2	Външна изолация стойност12kV, 24&36kV	CESI AT-A1/025452	Септември 3,2001	Английски	
		Външна изолация стойност 18kV	CESI AT-A1/025961	Септември 5,2001	Английски	
Изпитания на остатъчното напрежение със стръмен мълниев и превключвателен токов импулс	IEC 60099- 4 §10.8.3	Метално-окисен варистор ном. Напрежение 5кV	Tridelta TR-E 13001RS	Януари 22, 2013	Английски	Волт-амперни характеристични криви VI8992 01 XX/E rev.03/октомври 26, 2012, англ./
Изпитания за издържливост на продължителен токов импулс	IEC 60099- 4 §10.8.4	Метално-окисен варистор ном. Напрежение 5кV	Tridelta TR-E 13001LD	Януари 22, 2013	Английски	
Изпитване в експутационен режим с висок токов импулс	IEC 60099- 4 §10.8.5	5 kV	Tridelta TR-E 1300 OD	Март 7, 2013	Английски	
Напрежено-времева /VS/характеристична крива		HE-I обсег			Английски	напрежено-времеви характеристични криви UT8992 01 XX/E rev.00-октомври 26,2012 англ./

Изпитания при късо съединение	IEC 60099- 4 §10.8.7	HE-S 24 вентилни отводи	CESI A8018577	Юни 25 , 2008	Английски	
Изпитания за частични разряди	IEC 60099- 4 §10.8.8	HE-36 вентилни отводи	CESI AT-A0/042489	Декември 22,2000	Английски	
Изпитания на момент на огъване	IEC 60099- 4 §10.8.13	HE- S 42 вентилни отводи	Tridelta TR/SCUS TR-E1219BM	Ноември 15, 2012	Английски	
Изпитване за стареене	IEC 60099- 4 §10.8.14.2.1/ 1000 часа изпитание/	HE 36 вентилни отводи	CESI AT-A2/032924	Декември 18, 2002	Английски	
	IEC 60099- 4 §10.8.14.2.2/ 5000 часа изпитание/	HE 24 вентилни отводи	CESI AT-A3/007530	Март 27, 2003	Английски	

13

TYPE TESTS PERFORMED	REFERENCE STANDARD	SAMPLES TESTED	TEST REPORT			ADDITIONAL INFORMATION
			Reference	Date	Language	
Short circuit tests	IEC 60099-4 § 10.8.7	HE-S 24 surge arresters	**CESI A8018577**	June 25, 2008	English	see **Note 2**
Partial discharge test	IEC 60099-4 § 10.8.8	HE 36 surge arresters	**CESI AT-A0/042489**	December 22, 2000	English	see **Note 2**
Bending moment test	IEC 60099-4 § 10.8.13	HE-S 42 surge arresters	**TRIDELTA / SCÜS TR-E 12019BM**	November 15, 2012	English	see **Note 2**
Weather ageing test	IEC 60099-4 § 10.8.14.2.1 (1000 h test)	HE 36 surge arrester	**CESI AT-A2/032924**	December 18, 2002	English	see **Note 2**
	IEC 60099-4 § 10.8.14.2.2 (5000 h test)	HE 24 surge arrester	**CESI AT-A3/007530**	March 27, 2003	English	see **Note 2**

Note 1 : Reference is made to the latest version of IEC 60099-4 standard, namely edition 2.2 published in May 2009

Note 2 : The HE-I arrester design is very similar to the HE and identical to the HE-S.
In particular, the HE-I arrester range is built with MO resistors of the same size than HE and HE-S but upgraded to line discharge class 2, and resulting in lower voltage stress per unit length and unit thickness.
Therefore, type tests carried out on HE or HE-S samples also cover the HE-I range as long as the MO resistor performance are not directly involved.

ВЯРНО С ОРИГИНАЛА

75

ВЯРНО С ОРИГИНАЛА

TRIDELTA Parafoudres S.A.

TYPE TEST REPORTS relating to VARISIL™ HE-I polymer housed surge arresters & associated accessories

TYPE TESTS PERFORMED	REFERENCE STANDARD	SAMPLES TESTED	TEST REPORT			ADDITIONAL INFORMATION
			Reference	Date	Language	
Insulation withstand tests on the housings	IEC 60099-4 § 10.8.2	Housings rated 12 kV, 24 kV & 36 kV	**CESI AT-A1/025452**	September 3, 2001	English	see **Note 2**
		Housing rated 18 kV	**CESI AT-A1/025961**	September 5, 2001	English	see **Note 2**
Steep, lightning and switching current impulse residual voltage tests	IEC 60099-4 § 10.8.3	5 kV MO resistors	**TRIDELTA TR-E 13001RS**	January 22, 2013	English	Voltage vs current characteristic curve **VI 8982 01 XX / E rev. 00** (October 26, 2012, English)
Long duration current impulse withstand test	IEC 60099-4 § 10.8.4	5 kV MO resistors	**TRIDELTA** TR-E 13001LD	January 22, 2013	English	
High current impulse operating duty test	IEC 60099-4 § 10.8.5	5 kV prorated sections	**TRIDELTA** TR-E 13001OD	March 7, 2013	English	
Voltage vs time characteristic curve	IEC 60099-4 § 6.10	HE-I range				Curve **UT 8982 01 XX / E rev. 00** (October 26, 2012, English)

INSULATION
AT-AO / 041765

TEN DIELECTRIQUE
HE ENEL

[redacted]

REMPLACE RAPPORT
CESI AT-AO/041765

CESI

ВЯРНО С
ОРИГИНАЛА

client	ALSTOM Parafoudres S.A. - Bagneres de Bigorre Cedex (France)
equipment under test	housing of 10kA polymeric housed surge arresters
tests performed	dry lightning impulse voltage test; wet power frequency voltage test.
normative documents	IEC 60099-4 (1991-06)

receipt date of the sample	december 15, 2000	
test date	from december 19, 2000	to february 01, 2001

the test results relate only to the sample tested
this document shall not be reproduced except in full without the written approval of CESI
and of the accreditation body, if any

n° 0030

no. of pages 12 no. of pages annexed --

issue date	September 03, 2001	
prepared	PeC/TEST - C. Del Giorgio	Carlo Del Giorgio
verified	PeC/TEST - A. Sironi	Alberto Sironi
approved	PeC/TEST - V. Scarioni	

CESI
CENTRO ELETTROTECNICO SPERIMENTALE ITALIANO
Business Unit
Prove e Componenti
Il Responsabile del Laboratorio

tests witnessed by: Mr. F. Malpiece - ALSTOM Parafudre S.A.

identification of the object: effected
The Manufacturer guarantees that the tested objects are manufactured according to the submitted drawings.
CESI checked that these drawings adequately represents in shape and dimensions the essential details and the parts of the tested objects.
These drawings identified by CESI and numbered **A0/041852 no.1 (12kV)**, **A0/041853 no.1 (24kV)**, **A0/041855 no.1 (36kV)** are annexed to this document.

The data necessary to permit repetition of the tests are contained in the document marked: AT–A0/041765

The measurement uncertainties of the test results reported in this document are the following:
- dielectric tests with impulse voltage : **peak voltage: ± 3 % ; time parameters: ± 10 %**
- dielectric tests with impulse current : **peak value: ± 3 % ; time parameters: ± 10 %**
- dielectric tests with alternating voltage : **voltage (rms): ± 3 %**
- dielectric tests with direct voltage : **voltage: ± 3 %**

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to a confidence level of about 95 %) and have to be considered as maximum values.

activity code: 29380X
keywords: 12015R 23801L 31020W 41040M 53001D 62501B

ВЯРНО С ОРИГИНАЛА

79

ВЯРНО С
ОРИГИНАЛА

M00.A1002X3

contents	page	test date
rated characteristics of the test voltage declared by the manufacturer	4	
test voltage values	5	
summary of test results	6	
dry lightning impulse voltage test	7	dec.19, 2000 - feb.01,
wet power frequency voltage test	8	dec.19, 2000 - feb.01,
circuit A002	9	
circuit A059	10	
panoramic view of the test samples	11	
panoramic view of the test arrangement	12	

reference document annexed

12kV sample - drawing no. W 8997 12 31 identified by CESI and numbered **A0/041852 no.1**
24kV sample - drawing no. W 8997 24 31 identified by CESI and numbered **A0/041853 no.1**
36kV sample - drawing no. W 8997 36 31 identified by CESI and numbered **A0/041855 no.1**

rated characteristics of the test voltage declared by the manufacturer

12kV sample

manufacturer	ALSTOM Parafudre S.A.
type	HE
drawing no.	W 8997 12 31
rated voltage (U_r)	12 kV
nominal discharge current (I_N)	10 kA
line discharge class	1
dry lightning impulse withstand voltage	95 kV_{pk}
wet power frequency withstand voltage	38 kV_{rms}

24kV sample

manufacturer	ALSTOM Parafudre S.A.
type	HE
drawing no.	W 8997 24 31
rated voltage (U_r)	24 kV
nominal discharge current (I_N)	10 kA
line discharge class	1
dry lightning impulse withstand voltage	125 kV_{pk}
wet power frequency withstand voltage	50 kV_{rms}

36kV sample

manufacturer	ALSTOM Parafudre S.A.
type	HE
drawing no.	W 8997 36 31
rated voltage (U_r)	36 kV
continuous operating voltage (U_c)	30 kV_{rms}
nominal discharge current (I_N)	10 kA
line discharge class	1
dry lightning impulse withstand voltage	170 kV_{pk}
wet power frequency withstand voltage	70 kV_{rms}

ВЯРНО С ОРИГИНАЛА

30

test voltage values

12kV sample

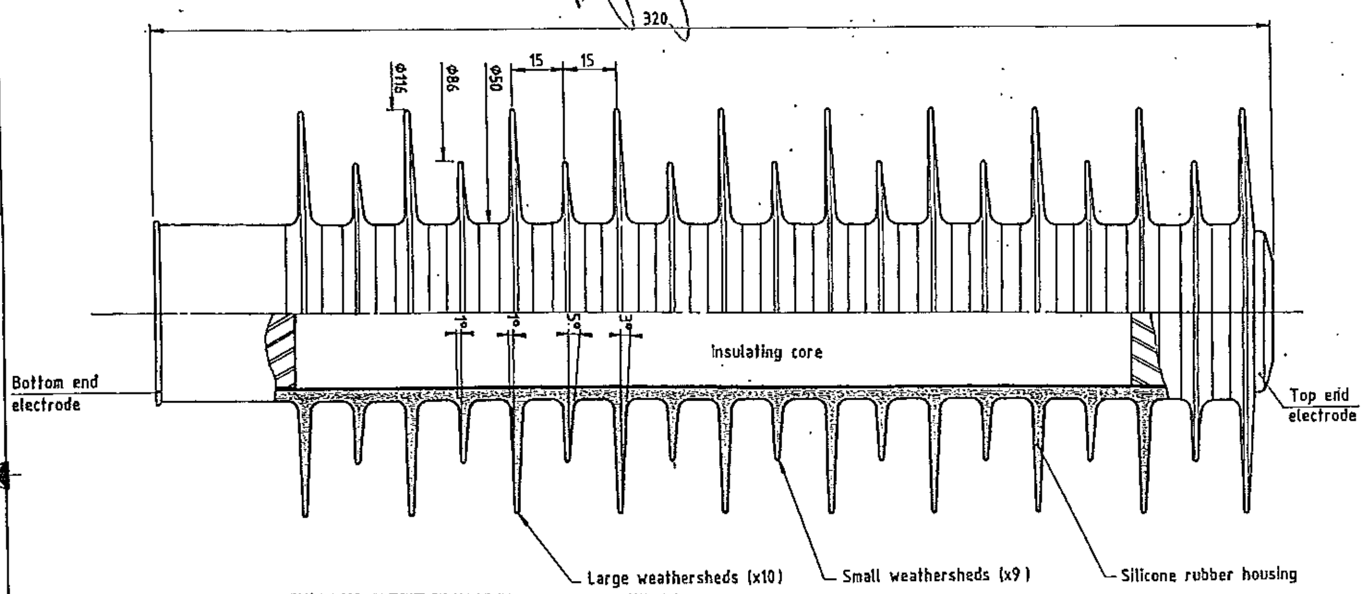
Lightning impulse voltage test (dry)	95 kV_{pk}
Power frequency voltage test (wet)	38 kV_{rms}

24kV sample

Lightning impulse voltage test (dry)	125 kV_{pk}
Power frequency voltage test (wet)	50 kV_{rms}

36kV sample

Lightning impulse voltage test (dry)	170 kV_{pk}
Power frequency voltage test (wet)	70 kV_{rms}



CEI
PROTOCOLLO DATA
A 07 04 1 8 5 , n 0 0 1 1 9 DIC. 2000
Firma

Nominal arc length : 355 mm

Nominal creepage distance : 1200 mm

Modification :	Dessinateur :	Date :	Vérification :
Tolérances générales :			
Matière :			
Traitement :			
Echelle :	Dessinateur : HS	Date : 12/12/00	Vérification :

Accessibilité du plan : Confidentiel ☐ Libre ☒

36 kV rated silicone rubber housing for VARISIL type HE surge arresters.

ALSTOM TRANSMISSION & DISTRIBUTION Parafoudres B.P. 256 65202 Bagnères-de-Bigorre

A3 | APF | W 8997 36 31 | Folio : 1/1 | Indice : 00

ВЯРНО С ОРИГИНАЛА

summary of test result

dry lightning impulse voltage test
For each rated voltage level one housing of 10kA polymeric housed surge arresters was tested.
The test was performed at the specified lightning impulse voltage obtained applying the corrections for atmospheric conditions.
Fifteen impulses were applied at positive and negative polarity to each sample under test.
No external flashovers occurred and the housings have not been damaged by these tests
Therefore the test result is to be considered positive.

wet power frequency voltage test
For each rated voltage level one housing of 10kA polymeric housed surgo arresters was tested.
The test samples withstood for one minute the wet power frequency withstand voltage claimed by the manufacturer.
Therefore the test result is to be considered positive.

84

ВЯРНО С ОРИГИНАЛА

MOD.A1420-G

dry lightning impulse voltage test

test object: housing of 10kA polymeric housed surge arresters

test circuit: A002

test housing	positive polarity						negative polarity						test date
	requested voltage	correction factor	applied voltage	applied impulses	flashover	test result	requested voltage	correction factor	applied voltage	applied impulses	flashover	test result	
	kV	K	kV	no.	no.		kV	K	kV	no.	no.		
12kV sample	95,0	0,978	92,9	15	0	withstand	95,0	0,978	92,9	15	0	withstand	December 19, 2000
24kV sample	125,0	0,978	122,3	15	0	withstand	125,0	0,978	122,3	15	0	withstand	December 19, 2000
36kV sample	170,0	0,986	167,6	15	0	withstand	170,0	0,986	170,0	15	0	withstand	February 01, 2001

note:

85

wet power frequency voltage test

test object: housing of 10kA polymeric housed surge arresters

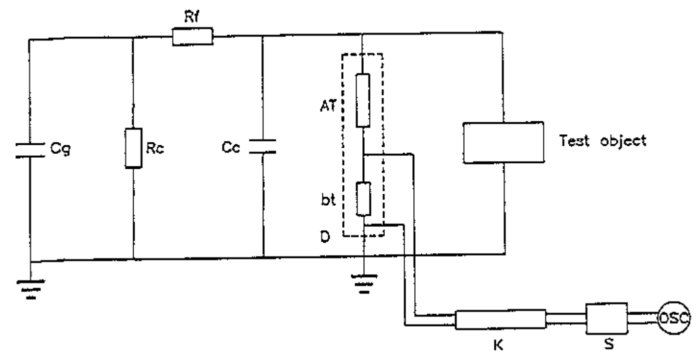
test circuit : A059

	precipitation conditions				
	precipitation rate mm / min			water temperature	water resistivity
	top	center	bottom	°C	$\Omega \times m$
vertical	--	1,5	--	15,0	100,0
horizontal	--	1,6	--		

test housing	voltage			test duration	test result	test date
	required (U)	correction factor	applied ($U \times K_t$)			
	kV_{rms}	K_t	kV_{rms}	s		
12kV sample	38,0	1,008	38,2	60	withstand	December 19, 2000
24kV sample	50,0	1,006	50,3	60	withstand	December 19, 2000
36kV sample	70,0	1,000	70,0	60	withstand	February 01, 2001

Note:

circuit A002

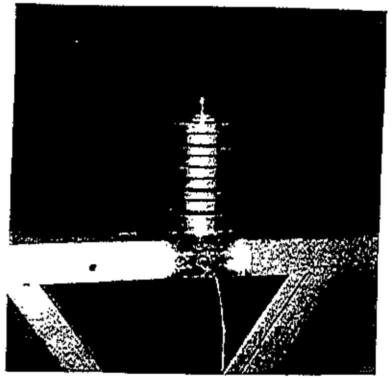


lightning impulse test circuit

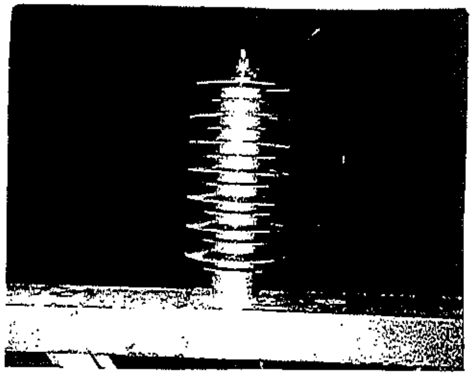
Cg : Impulse generator capacitance
Rf : Front resistor
Rc : Tail resistor
Cc : Load capacitance
D : Divider type RC series
K : coaxial cable
S : attenuation and termination unit
Osc : Oscilloscope

ВЯРНО С ОРИГИНАЛА

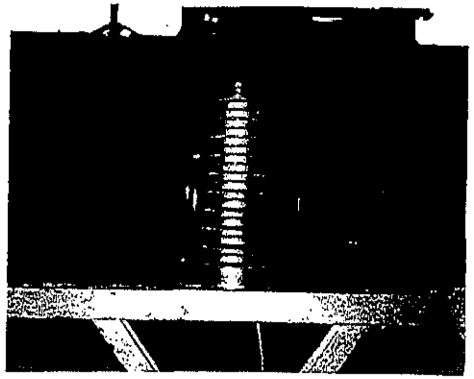
panoramic view of the test samples



12kV sample

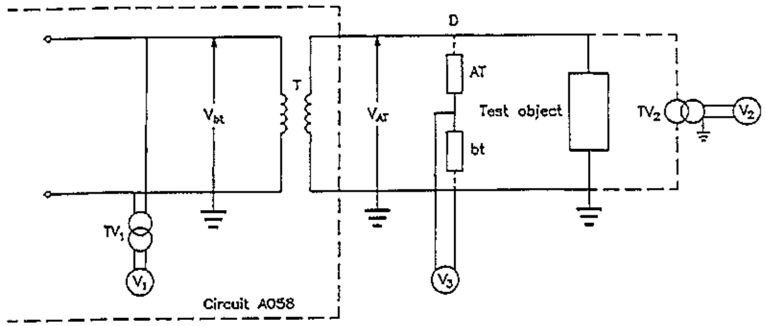


24kV sample



36kV sample

circuit A059



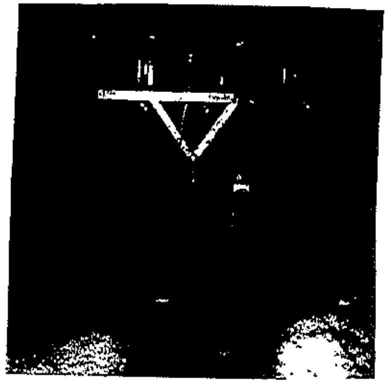
power frequency measuring circuit

TV_2: voltage transformer
V_2 : voltmeter
D : voltage divider type RC series
low voltage arm
V_3 : voltmeter
TV_1: voltage transformer
V_1 : voltmeter

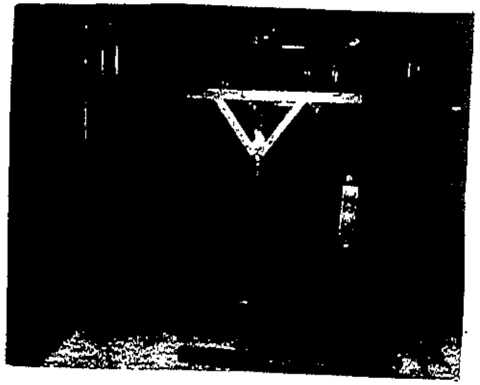
ВЯРНО С
ОРИГИНАЛА

88

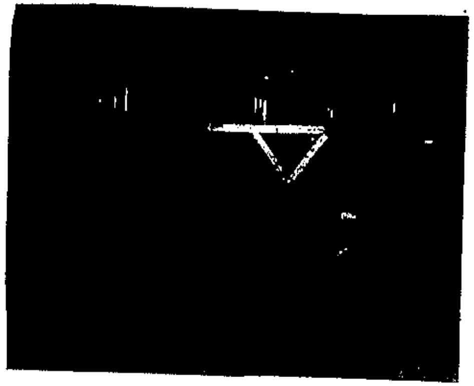
panoramic view of the test arrangement



12kV sample



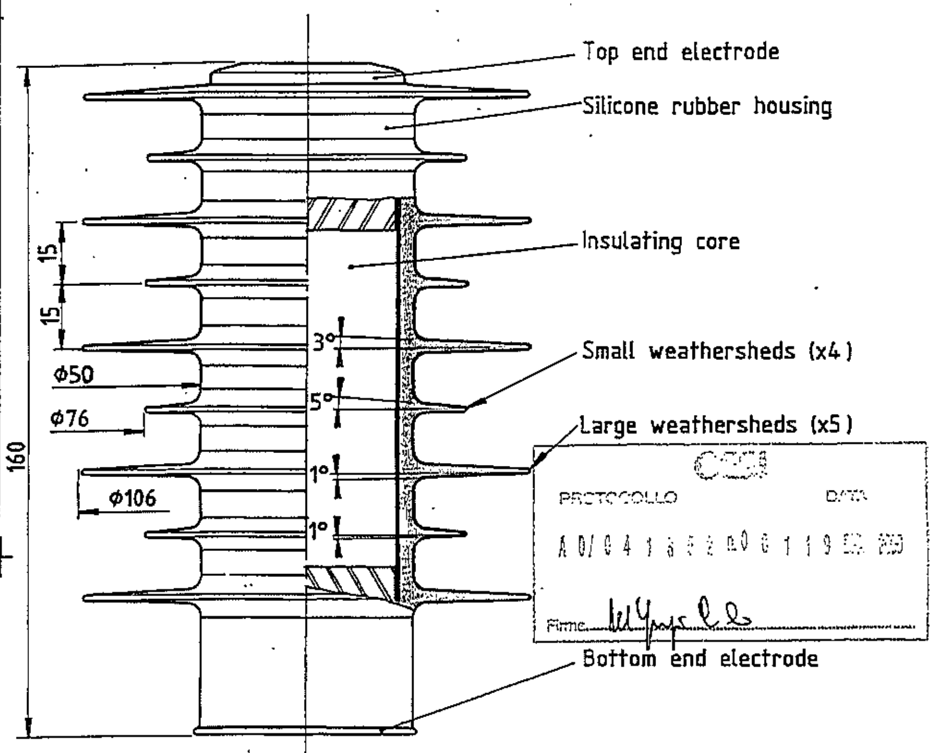
24kV sample



36kV sample

ВЯРНО С
ОРИГИНАЛА

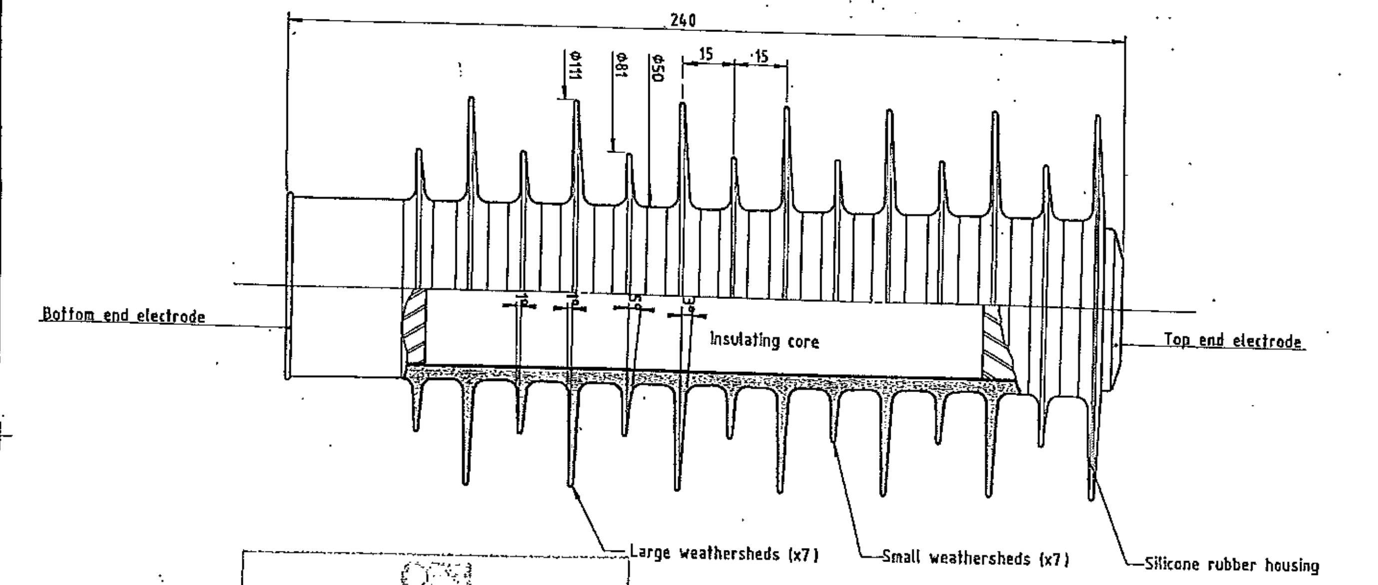
89



Nominal arc length : 195 mm
Nominal creepage distance : 480 mm

Accessibilité du plan : Confidentiel ☐ Libre ☒	Modification :	Dessinateur :	Date :	Vérification :
	Tolérances générales :			
	Matière :			
	Traitement :			
	Echelle :	Dessinateur : HS	Date : 12/12/00	Vérification :
Ce plan est propriété de ALSTOM Parafoudres SA ; il ne peut être ni reproduit ni communiqué sans autorisation préalable	12 kV rated silicone rubber housing for VARISIL type HE surge arresters.			ALSTOM TRANSMISSION & DISTRIBUTION Parafoudres B.P. 256 65202 Bagnères-de-Bigorre
	A4	APF	W 8997 12 31	Folio : 1 / 1 Indice : 00

ВЯРНО С ОРИГИНАЛА



PROTOCOLLO DATA
A 0/0 4 1 8 3 2 A 0 0 1 1 9 DIC 200
Firma

Nominal arc length : 270 mm

Nominal creepage distance : 800 mm

Modification :		Dessinateur :	Date :	Vérification :
Tolérances générales :				
Matière :				
Traitement :				
	Echelle :	Dessinateur : HS	Date : 12/12/00	Vérification :

Accessibilité du plan : Confidentiel ☐ Libre ☒

Ce plan est propriété de ALSTOM Parafoudres SA ; il ne peut être ni reproduit ni communiqué sans autorisation préalable

24 kV rated silicone rubber housing for VARISIL type HE surge arresters.

ALSTOM TRANSMISSION & DISTRIBUTION Parafoudres B.P. 256 65202 Bagnères-de-Bigorre

A3	APF	W 8997 24 31	Folio : 1 / 1 Indice : 00

ВЯРНО С ОРИГИНАЛА

CESI

TENUE DIELECTRIQUE
HE ENEL
[redacted]

ВЯРНО С
ОРИГИНАЛА

client	ALSTOM Parafoudres S.A. - Bagneres de Bigorre Cedex (France)
equipment under test	polymer housed surge arrester housing
tests performed	lightning impulse voltage test; power frequency voltage test - wet.
normative documents	ENEL technical specifications DY 557 (July 1999, draft), DY 1018 (May 1999, draft); IEC 60099-4 (1991-06)
receipt date of the sample	May 29, 2001
test date	from May 30, 2001 to May 30, 2001

the test results relate only to the sample tested
this document shall not be reproduced except in full without the written approval of CESI and of the accreditation body, if any

no. of pages	12	no. of pages annexed	--

issue date	September 5, 2001	
prepared	PeC/TEST - C. Del Giorgio	Carlo Del Giorgio
verified	PeC/TEST - A. Sironi	Alb.l. S
approved	PeC/TEST - V. Scarioni	

CESI
CENTRO ELETTROTECNICO SPERIMENTALE ITALIANO
Business Unit
Prove e Componenti
Il Responsabile del Laboratorio

ВЯРНО С ОРИГИНАЛА

94

10

tests witnessed by: Mr. F. Malpiece - ALSTOM Parafuodres S.A.

identification of the object: effected
The Manufacturer guarantees that the tested object is manufactured according to the submitted drawings.
CESI checked that these drawings adequately represent in shape and dimensions the essential details and the parts of the tested object.
These drawings identified by CESI and numbered **A1/021094 no.1 and no.4** are annexed to this document.

The data necessary to permit repetition of the tests are contained in the document marked: AT–A1/016942

The measurement uncertainties of the test results reported in this document are the following:
- dielectric tests with impulse voltage : **peak voltage:** ± 3 % ; **time parameters:** ± 10 %
- dielectric tests with impulse current : **peak value:** ± 3 % ; **time parameters:** ± 10 %
- dielectric tests with alternating voltage : **voltage (rms):** ± 3 %
- dielectric tests with direct voltage : **voltage:** ± 3 %

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to a confidence level of about 95 %) and have to be considered as maximum values.

activity code: 31126P
keywords: 12015R 23801L 31020W 41040M 53001D 62501B

ВЯРНО С ОРИГИНАЛА

contents	page	test date
rated characteristics of the test voltage declared by the manufacturer		
test voltage values	4	
summary of test result	5	
dry lightning impulse withstand voltage test	6	
wet power frequency withstand voltage test	7	May 30, 2001
circuit A002	8	May 30, 2001
circuit A059	9	
panoramic view of the test samples	10	
panoramic view of the test arrangement	11	
	12	

reference document annexed

- drawings identified by CESI and numbered **A1/021094 no.1 and no.4**

rated characteristics of the test voltage declared by the manufacturer

manufacturer	ALSTOM Parafudre S.A.
ALSTOM designation	VARISIL HE 18 sd/E
ENEL type	DY 557/4
code	B 8997 07 18
drawing no.	W 8997 07 18/I
rated voltage (U_r)	18 kV
continuous operating voltage (U_c)	15 kV
nominal discharge current (I_N)	10 kA
line discharge class	1
minimum creepage distance of arrester housing	650 mm

bracket type	S3/E
drawing no.	B 8997 09 41/I

[redacted]

ВЯРНО С
ОРИГИНАЛА

test voltage values

arrester housing

Lightning impulse voltage test (dry)

$U_{pk} = 1{,}3xU_{LIPL} = 1{,}3x65 = 84{,}5\ kV_{pk}$

U_{LIPL} : lightning impulse protection level (according to ENEL technical specifications) = 65 kV_{pk}

Power frequency voltage test (wet)

$U_{pk} = 0{,}88xU_{LIPL} = 0{,}88x65 = 57{,}2\ kV_{pk}$

$U_{rms} = U_{pk}/\sqrt{2} = 40{,}44\ kV_{rms}$

U_{LIPL} : lightning impulse protection level (according to ENEL technical specifications) = 65 kV_{pk}

bracket

Lightning impulse voltage test (dry)

$U_{test} = 73\ kV_{pk}$

Power frequency voltage test (wet)

$U_{test} = 40\ kV_{rms}$

ВЯРНО С ОРИГИНАЛА

summary of test result

arrester housing

dry lightning impulse voltage test
For each rated voltage level one housing of 10kA polymeric housed surge arresters was tested.
The test was performed at the specified lightning impulse voltage obtained applying the corrections for atmospheric conditions.
Fifteen impulses were applied at positive and negative polarity to each sample under test.
No external flashovers occurred and the housings have not been damaged by these tests
Therefore the test result is to be considered positive.

wet power frequency voltage test
For each rated voltage level one housing of 10kA polymeric housed surge arresters was tested.
The test samples withstood for one minute the wet power frequency withstand voltage claimed by the manufacturer.
Therefore the test result is to be considered positive.

bracket

dry lightning impulse voltage test
For each rated voltage level one bracket of surge arresters was tested.
The test was performed at the specified lightning impulse voltage obtained applying the corrections for atmospheric conditions.
Fifteen impulses were applied at positive and negative polarity to each sample under test.
No external flashovers occurred and the housings have not been damaged by these tests
Therefore the test result is to be considered positive.

wet power frequency voltage test
For each rated voltage level one bracket of surge arresters was tested.
The test samples withstood for one minute the wet power frequency withstand voltage claimed by the manufacturer.
Therefore the test result is to be considered positive.

ВЯРНО С ОРИГИНАЛА

98

H00.A1423G

dry lightning impulse withstand voltage test

test circuit: A002

test object: polymer housed surge arrester housing

test object	positive polarity						negative polarity						test date
	requested voltage	correction factor	applied voltage	applied impulses	flashover	test result	requested voltage	correction factor	applied voltage	applied impulses	flashover	test result	
no.	kV_{peak}	K	kV_{peak}	no.	no.		kV_{peak}	K	kV_{peak}	no.	no.		
1	84,5	0,989	84,5	15	0	withstand	84,5	0,989	84,5	15	0	withstand	May 30, 2001

note:

test object: bracket

test object	positive polarity						negative polarity						test date
	requested voltage	correction factor	applied voltage	applied impulses	flashover	test result	requested voltage	correction factor	applied voltage	applied impulses	flashover	test result	
no.	kV_{peak}	K	kV_{peak}	no.	no.		kV_{peak}	K	kV_{peak}	no.	no.		
1	73,0	0,978	71,4	15	0	withstand	73,0	0,978	71,4	15	0	withstand	May 30, 2001

note:

ВЯРНО С
ОРИГИНАЛА

100

MOD.A1223/0

wet power frequency withstand voltage test

test circuit: A059

	precipitation conditions				
	precipitation rate mm / min			water temperature	water resistivity
	top	center	bottom	°C	Ω × m
vertical	--	1,8	--	22,6	95,0
horizontal	--	1,6	--		

test circuit : polymer housed surge arrester housing

test object	voltage			test duration	test result	test date
	required (U)	correction factor	applied (U × K_t)			
no.	kV_{rms}	K_t	kV_{rms}	s		
1	57,2	0,992	56,7	60	withstand	May 30, 2001

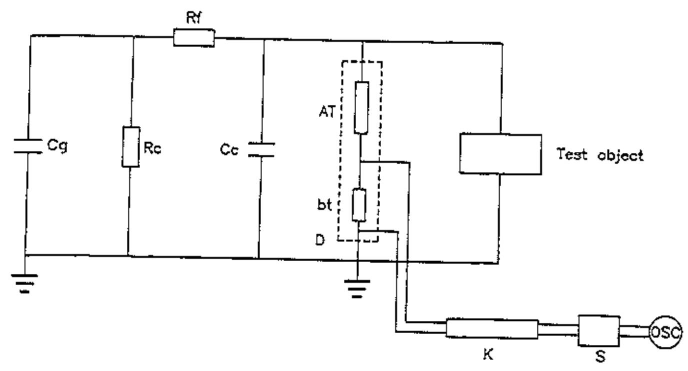
Note:

test circuit : bracket

test object	voltage			test duration	test result	test date
	required (U)	correction factor	applied (U × K_t)			
no.	kV_{rms}	K_t	kV_{rms}	s		
1	40,0	0,990	39,6	60	withstand	May 30, 2001

Note:

circuit A002



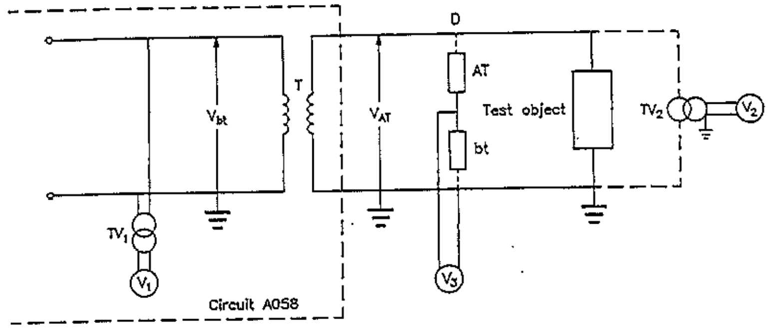
lightning impulse test circuit

Cg : Impulse generator capacitance
Rf : Front resistor
Rc : Tail resistor
Cc : Load capacitance
D : Divider type RC series
K : coaxial cable
S : attenuation and termination unit
Osc : Oscilloscope

ВЯРНО С ОРИГИНАЛА

101

circuit A059

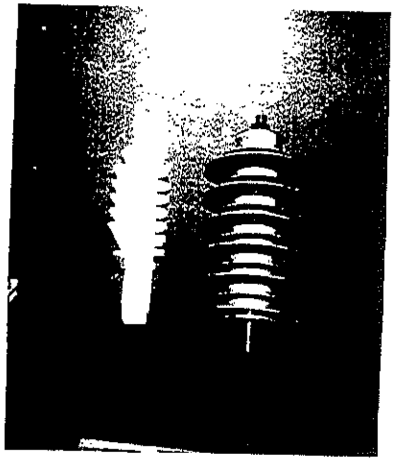


power frequency measuring circuit

TV_2: voltage transformer
V_2 : voltmeter
D : voltage divider type RC series
low voltage arm
V_3 : voltmeter
TV_1: voltage transformer
V_1 : voltmeter

ВЯРНО С
ОРИГИНАЛА

panoramic view of the test sample



ВЯРНО С ОРИГИНАЛА

103

ВЯРНО С
ОРИГИНАЛА

104

Type Test Report

No.: TR-E 13001LD

Equipment under test:	**Polymer housed surge arrester of line discharge class 2 type series, VARISIL HE-I, TRIDELTA Parafoudres S.A.**
Normative documents:	IEC 60099-4 Edition 2.2 clause 8.4
Test performed:	Long duration current impulse withstand test - Line discharge class 2
Test date:	$09/10^{th}$ of January 2013
Number of pages:	10

First issue date: 22^{nd} of January 2013

Tested / Edited by:	Dipl.-Ing.	U. Plötner	
Approved by:	Dipl.-Ing.	H. Klaube	i.V.

Hermsdorf, 22^{nd} of January 2013

TRIDELTA Überspannungsableiter GmbH
Marie-Curie-Straße 3
07629 Hermsdorf - Deutschland
Telefon: +49 (0)3 66 01/9328 300
Fax: +49 (0)3 66 01/9328 301
Internet: http://www.tridelta.de

ВЯРНО С ОРИГИНАЛА

1055

Subject:

Surge arrester type series: VARISIL HE-I,
manufactured by TRIDELTA Parafoudres S.A.
Tests on 3 arrester sections, each consisting of 1 resistor TRIDELTA OD40.

Caused by:

Type Test Report

Test arrangement / course of test:

Test acc. to IEC 60099-4 Edition 2.2 clause 8.4
"Long duration current impulse withstand test"

The test was performed on 3 arrester sections of rated voltage of (5.22...5.28) kV.

Test procedure:

Measurements before the test:
- measurement of reference voltage at reference current $\hat{i}$=1 mA,
- measurement of residual voltage at $\hat{i}$=125 A (40/100),
- measurement of residual voltage at $\hat{i}$=10 kA (8/20)

The test was carried out at ambient temperature of 20 °C in open air.
Each section was subjected to 18 discharges, divided in 6 groups of 3 impulses.

Parameters for the line discharge test (clause 8.4.2 table 5)

$Z = 2.4 \cdot U_r = 12.67\ \Omega$

$U_L = 3.2 \cdot U_r = 16.90\ kV$

$T = 2000\ \mu s$

Required long duration impulse energy:

$W = U_{(125A)} \cdot (U_L - U_{(125A)}) \cdot T \cdot 1/Z$

$W = 9.93 \cdot (16.90 - 9.93) \cdot 2/12.67$

$W = 10.85\ kJ$

$W' = 2.05\ kJ/kV_{U_r}$

ВЯРНО С ОРИГИНАЛА

106

Test samples and results:

sample no.	LD 1	LD 2	LD 3
$\hat{u}_{ref}$ ($\hat{i}$=1 mA) [kV]	7.10	7.11	7.19
U_r=0,735 x $\hat{u}_{ref\,(\hat{i}=1\,mA)}$ [kV]	5.22	5.23	5.28

Residual voltage at 125 A (40/100) $\hat{u}_{res}$ [kV]	9.89	9.82	9.93
Nominal residual voltage at 10 kA (8/20) before [kV] after [kV] change [%]	 13.44 13.46 +0.15	 13.33 13.33 ±0.00	 13.47 13.48 +0.07
real charging voltage [kV] number of discharges duration of peak [µs]		26.4 18 1980	
discharge current 1^{st} [A] 18^{th} [A] residual voltage 1^{st} [kV] 18^{th} [kV] impulse energy 1^{st} [kJ] 18^{th} [kJ]	515 509 10.66 10.81 12.75 12.80	519 513 10.53 10.71 12.70 12.77	515 508 10.67 10.85 12.76 12.82
specific energy per impulse: average 18 imp. [kJ/kV$_{Ur}$]	2.45	2.44	2.43

The applied energy for each impulse on each tested sample was higher than the calculated (required) energy.

During the test there were no breakdowns or flashovers. The visual inspection after the test showed no cracks or other damages.
The change of the nominal residual voltage amounted less than +0.15 %.

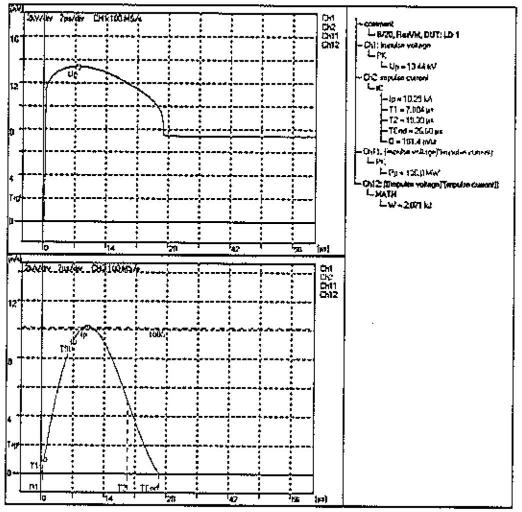
The samples passed the test.

ВЯРНО С ОРИГИНАЛА

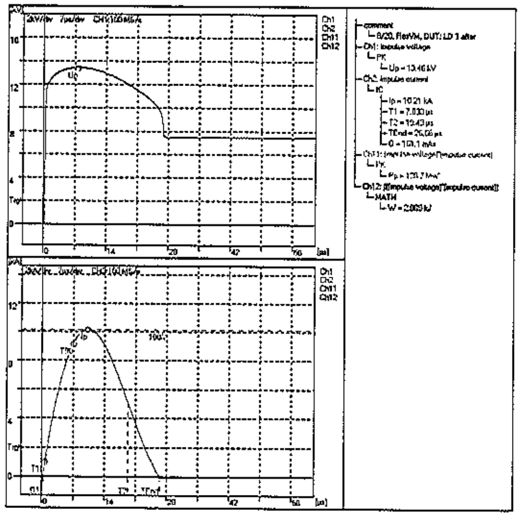
107

The following oscillograms show the results of the measurements.

Sample LD 1:



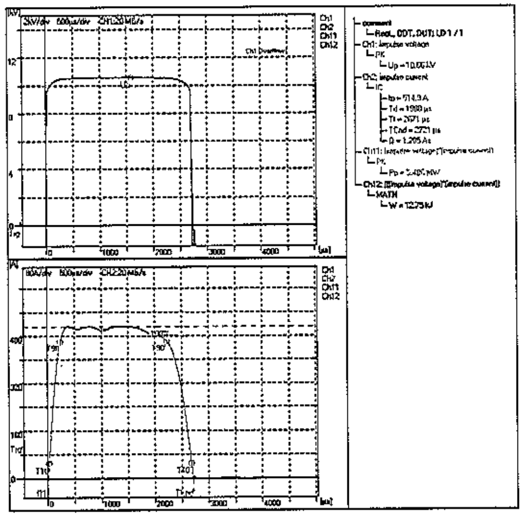
Nominal residual voltage
before the test at 10 kA (8/20)



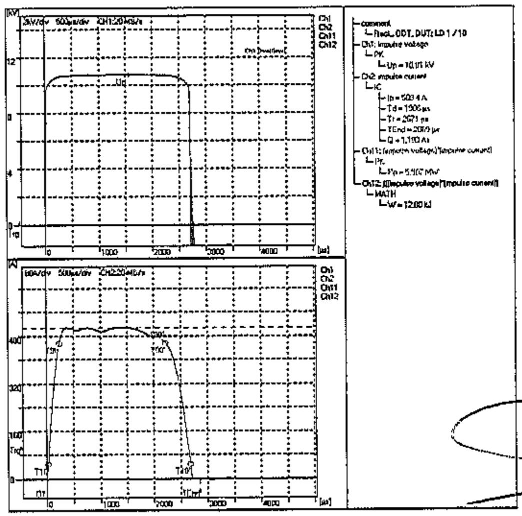
Nominal residual voltage
after the test at 10 kA (8/20)

ВЯРНО С ОРИГИНАЛА

108



1st impulse
Line discharge class 2



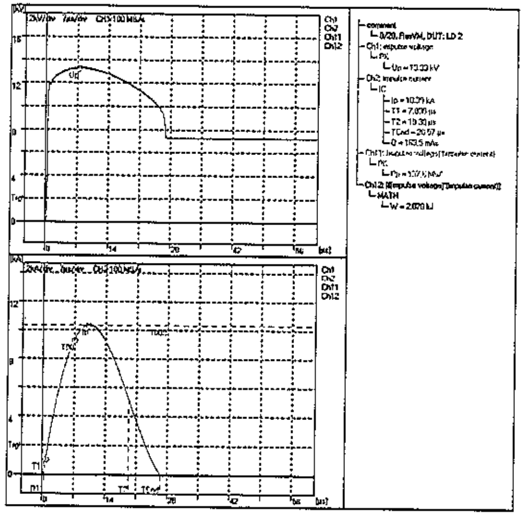
18th impulse
Line discharge class 2

ВЯРНО С ОРИГИНАЛА

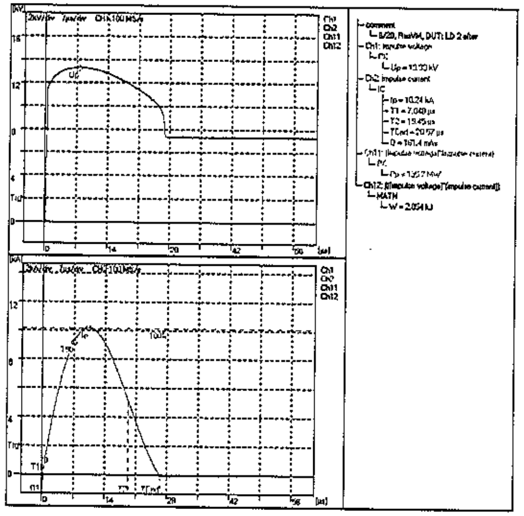
109

ВЯРНО С ОРИГИНАЛА

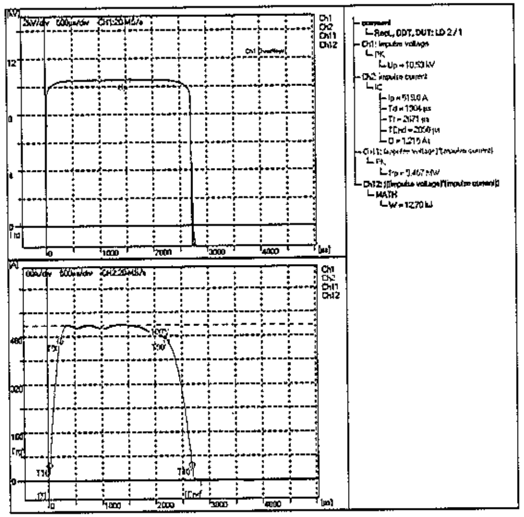
Sample LD 2:



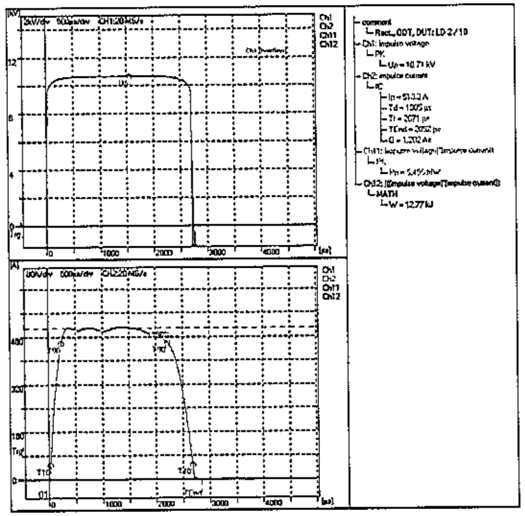
Nominal residual voltage
before the test at 10 kA (8/20)



Nominal residual voltage
after the test at 10 kA (8/20)



1st impulse
Line discharge class 2

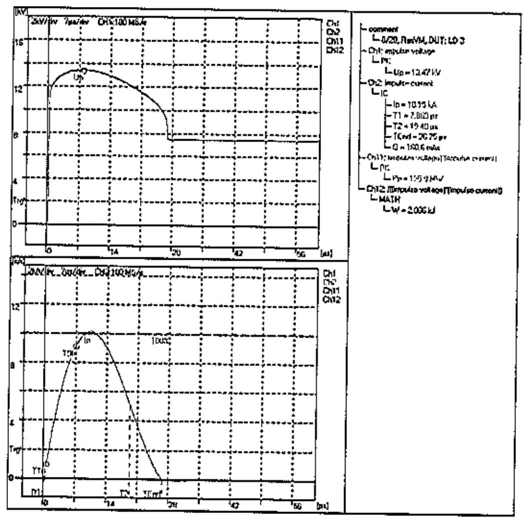


18th impulse
Line discharge class 2

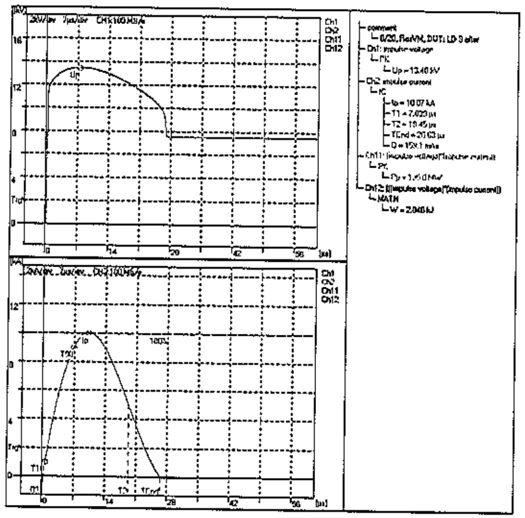
ВЯРНО С ОРИГИНАЛА

111

Sample LD 3:

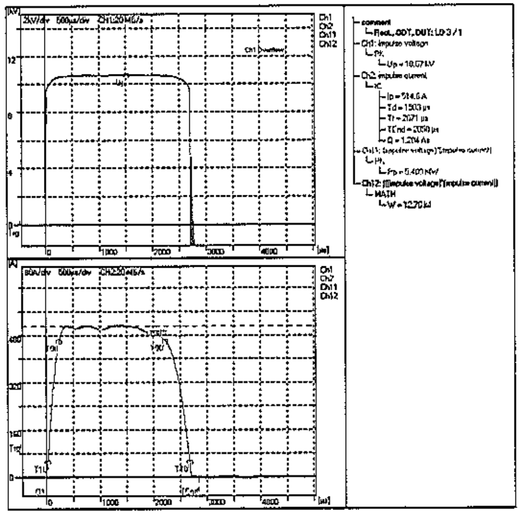


Nominal residual voltage
before the test at 10 kA (8/20)

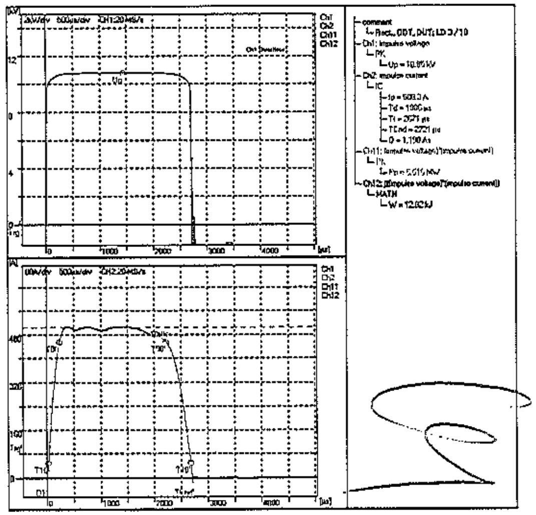


Nominal residual voltage
after the test at 10 kA (8/20)

ВЯРНО С
ОРИГИНАЛА



1st impulse
Line discharge class 2

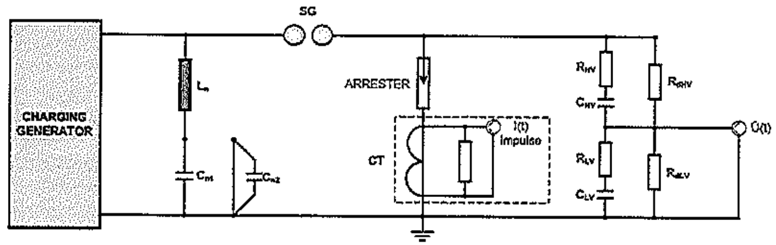


18th impulse
Line discharge class 2

ВЯРНО С
ОРИГИНАЛА

113

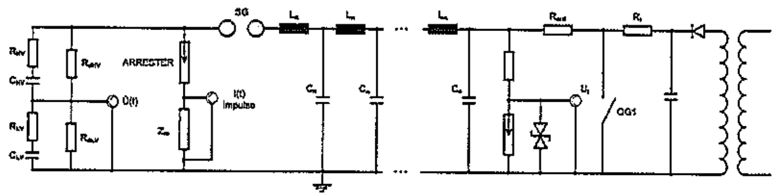
Test circuit for Residual voltage test on prorated arrester sections:



Current waveforms:	
8/20 µs	Ln
40/100 µs	Ln
1/<20	Ln

C_1, C_2	Capacitive divider
R_{dHV}	Damping resistance of the HV-side condensator (C_{HV})
R_{HV}	HV-side measuring resistance
C_{HV}	HV-side measuring capacitance
R_{dLV}	Damping resistance of the LV-side condensator (C_{LV})
R_{LV}	LV-side measuring resistance
C_{LV}	LV-side measuring capacitance
L_n	Charging inductance (n=1...9)
C_{n1}, C_{n2}	Charging capacitances (n=1...9)
CT	Current transformer

Test circuit for Long duration current impulse withstand test



R_{dHV}	Damping resistance of the HV-side condensator (C_{HV})
R_{HV}	HV-side measuring resistance
C_{HV}	HV-side measuring capacitance
R_{dLV}	Damping resistance of the LV-side condensator (C_{LV})
R_{LV}	LV-side measuring resistance
C_{LV}	LV-side measuring capacitance
Z_m	Measuring impedance
L_n	Inductance (n=1...9)
C_n	Charging capacitances (n=1...9)

ВЯРНО С ОРИГИНАЛА

114

Type Test Report
No.: TR-E 13001RS

Equipment under test: **Polymer housed surge arrester of line discharge class 2 type series, VARISIL HE-I, TRIDELTA Parafoudres S.A.**

Normative documents: IEC 60099-4 Edition 2.2 clause 8.3

Test performed: Residual voltage test

Test date: 08/09th of January 2013

Number of pages: 13

First issue date: 22nd of January 2013

Tested / Edited by:	Dipl.-Ing.	U. Plötner	....
Approved by:	Dipl.-Ing.	H. Klaube	i.V. ....

Hermsdorf, 22nd of January 2013

ВЯРНО С ОРИГИНАЛА

TRIDELTA Überspannungsableiter GmbH
Marie-Curie-Straße 3
07629 Hermsdorf - Deutschland
Telefon: +49 (0)3 66 01/9328 300
Fax: +49 (0)3 66 01/9328 301
Internet: http://www.tridelta.de

115

Subject:

Surge arrester type series: VARISIL HE-I,
manufactured by TRIDELTA Parafoudres S.A.
Tests on 3 arrester sections, each consisting of 1 resistor, TRIDELTA OD40.

ВЯРНО С ОРИГИНАЛА

Caused by:

Type Test Report

Test arrangement/course of test:

Test acc. to IEC 60099-4 Edition 2.2 clause 8.3 "Residual voltage tests"
The test was performed on 3 arrester sections of rated voltage of (5.24 ... 5.26) kV.

sample no.	RV 1	RV 2	RV 3
$\hat{u}_{ref}$ ($\hat{i}$=1 mA) [kV]	7.15	7.13	7.15
U_r=0,735 x $\hat{u}_{ref\ (\hat{i}=1\ mA)}$[kV]	5.26	5.24	5.26

Test procedure:

Clause 8.3.1 Steep current impulse residual voltage test (1/20)
$\hat{i}$ = (5 kA), **10 kA**, (20 kA)

Clause 8.3.2 Lightning impulse residual voltage test (8/20)
$\hat{i}$ = (500A), (1 kA), (2.5 kA), **5 kA**, **10 kA**, **20 kA**, (40 kA)

Clause 8.3.3 Switching impulse residual voltage test (40/100)
$\hat{i}$ = **125 A**, (250A), **500 A**, (1kA), (2kA), (3kA)

116

Test results:

Residual voltage test at steep current impulse 1/<20 (The residual voltage of the arrester sections was determined with correction for inductive effects of the voltage measuring circuit)

î [kA]	sample	5	**10**	20
û [kV]	**RV 1**	13.17	**14.17**	15.44
	RV 2	13.08	**14.07**	15.38
	RV 3	13.16	**14.14**	15.46

Residual voltage test at lightning current impulse 8/20

î [kA]	sample	0.5	1	2.5	**5**	**10**	**20**	40
û [kV]	**RV 1**	10.64	11.07	11.78	**12.48**	**13.47**	**14.83**	16.79
	RV 2	10.52	10.93	11.66	**12.36**	**13.36**	**14.73**	16.71
	RV 3	10.64	11.05	11.77	**12.49**	**13.47**	**14.83**	16.80

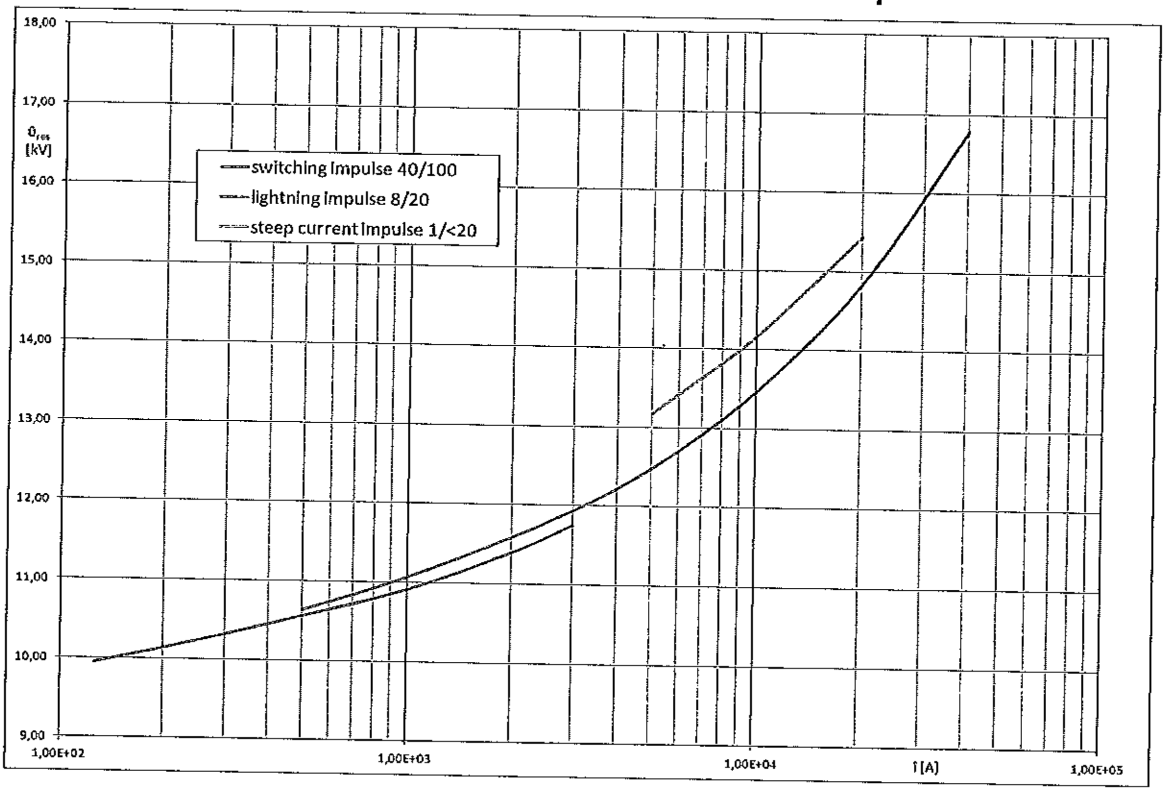
Residual voltage test at switching current impulse 40/100

î [A]	sample	**125**	250	**500**	1000	2000	3000
û [kV]	**RV 1**	**9.94**	10.23	**10.56**	10.91	11.40	11.76
	RV 2	**9.83**	10.10	**10.43**	10.78	11.27	11.63
	RV 3	**9.93**	10.21	**10.56**	10.91	11.39	11.75

ВЯРНО С ОРИГИНАЛ

117

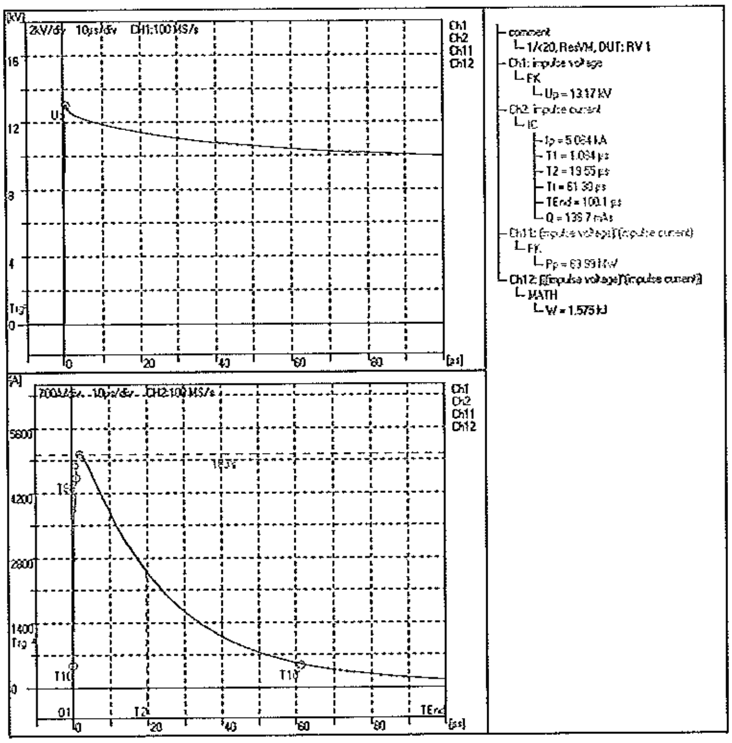
The diagram shows the results of the measurement on Sample 1:



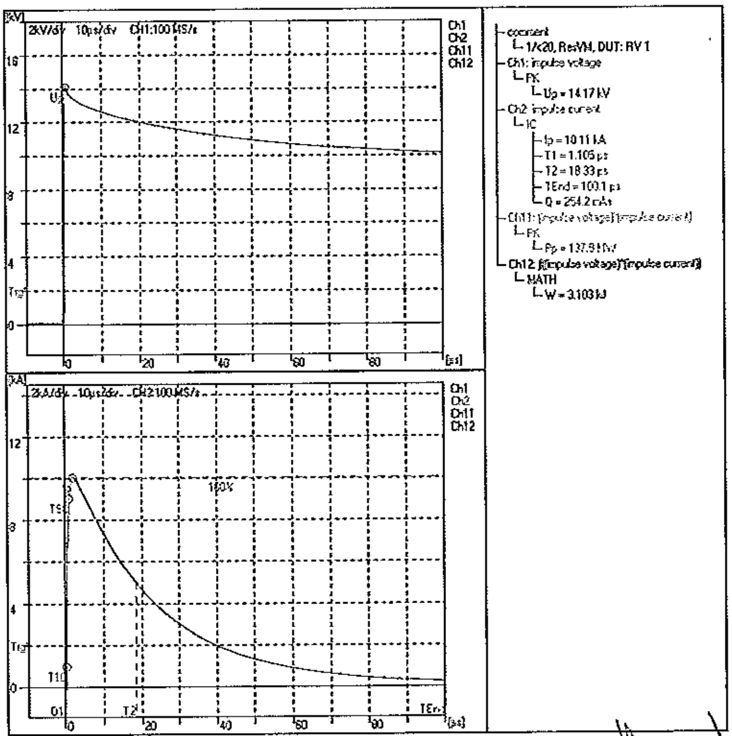
ВЯРНО С ОРИГИНАЛА

118

The following oscillograms show the measurement on Sample 1:



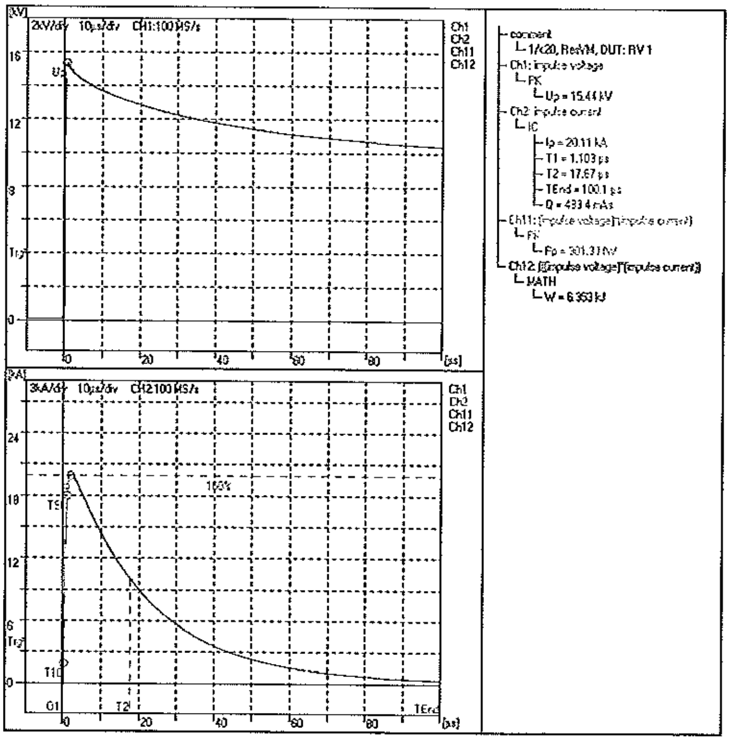
5 kA (1/<20)



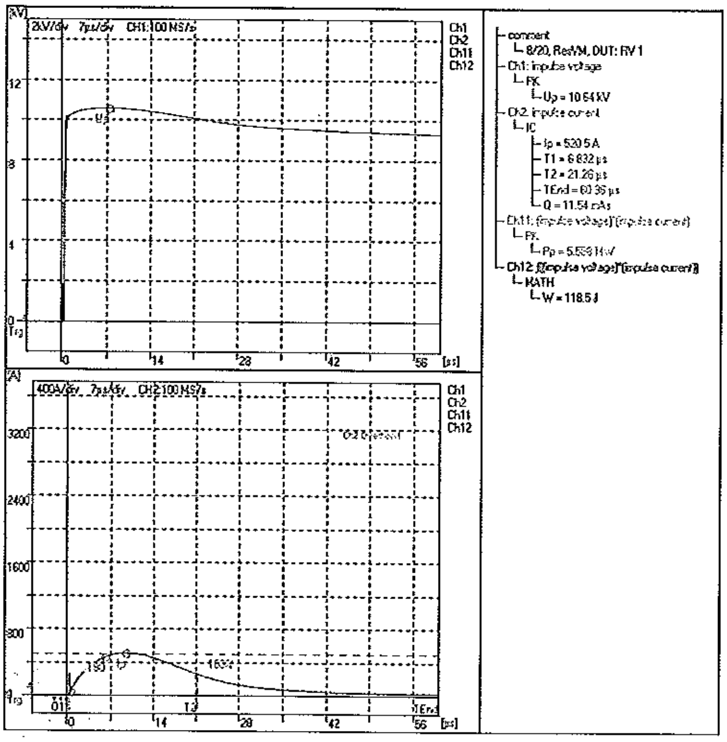
10 kA (1/<20)

ВЯРНО С ОРИГИНАЛА

119



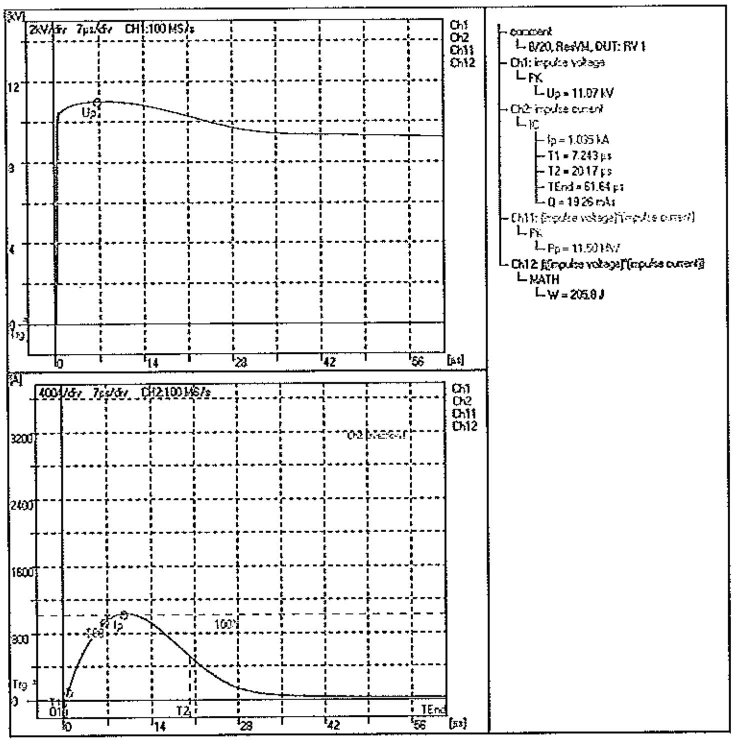
20 kA (1/<20)



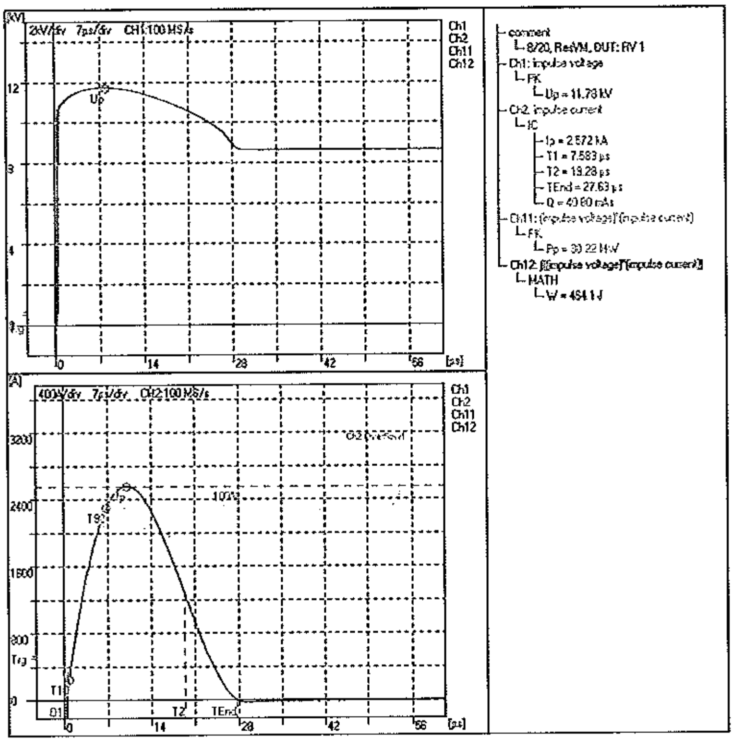
500 A (8/20)

ВЯРНО С ОРИГИНАЛА

120

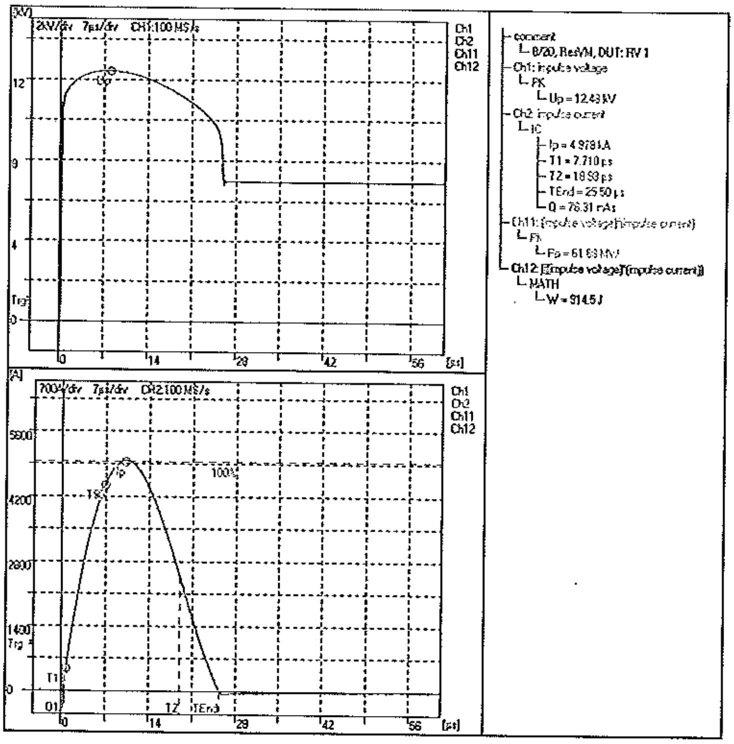


1 kA (8/20)

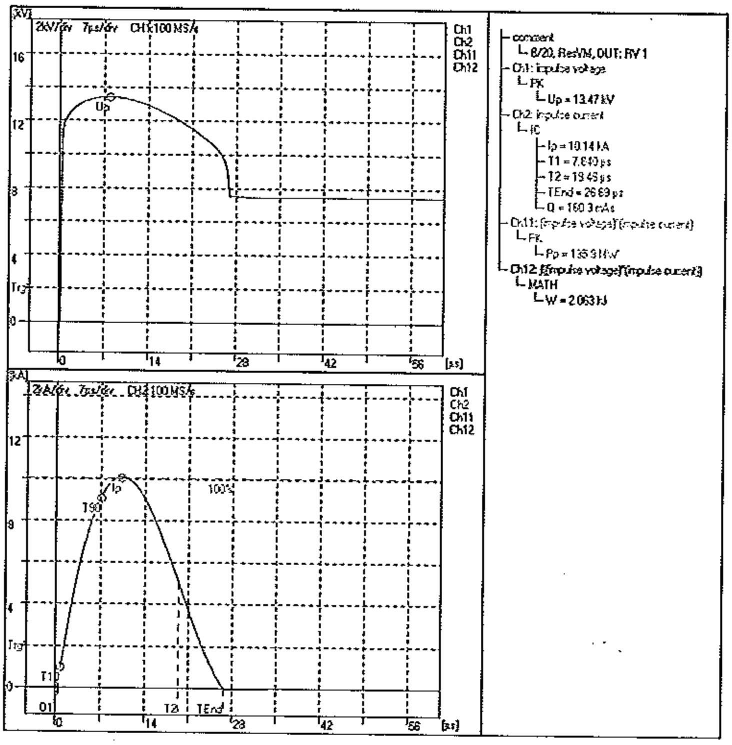


2,5 kA (8/20)

ВЯРНО С ОРИГИНАЛА



5 kA (8/20)

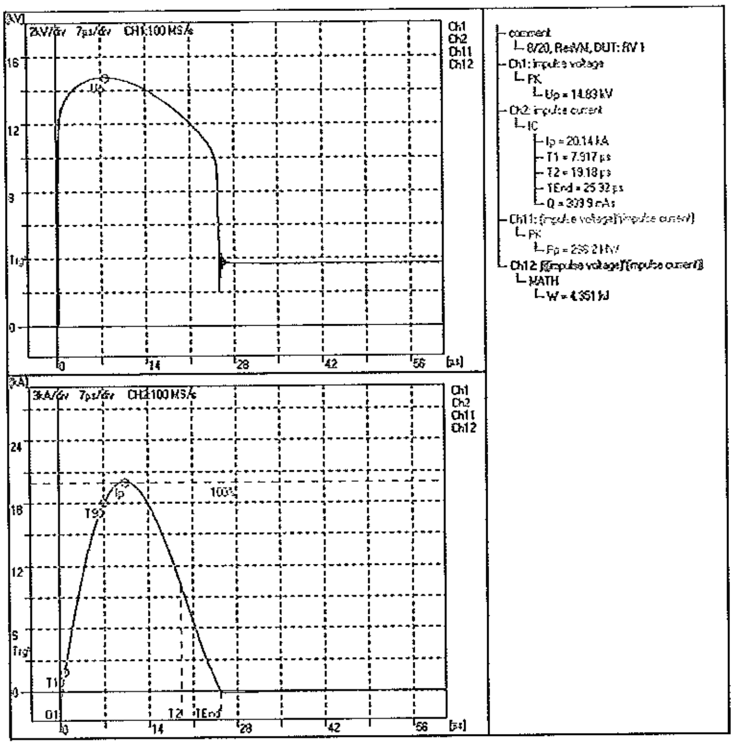


10 kA (8/20)

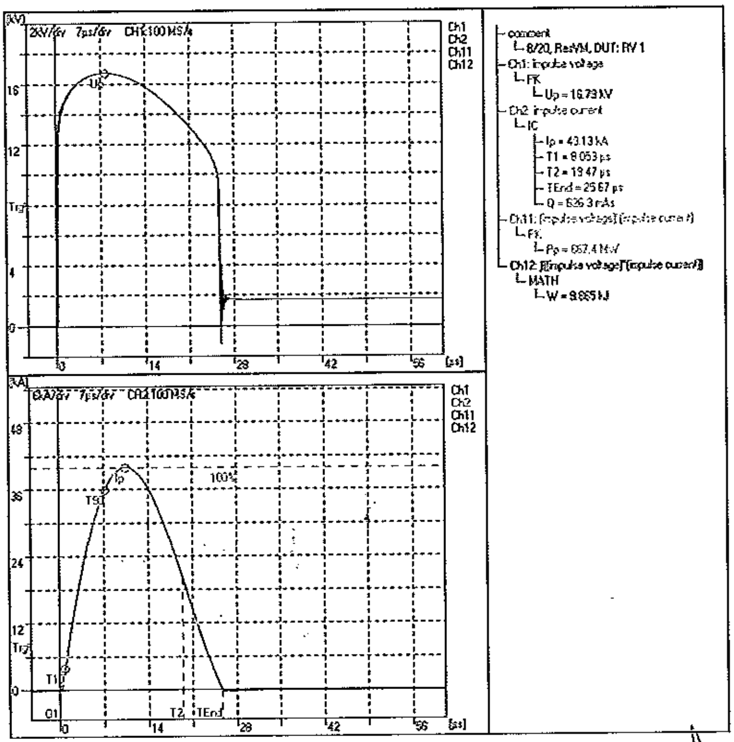
ВЯРНО С ОРИГИНАЛА

122

20 kA (8/20)

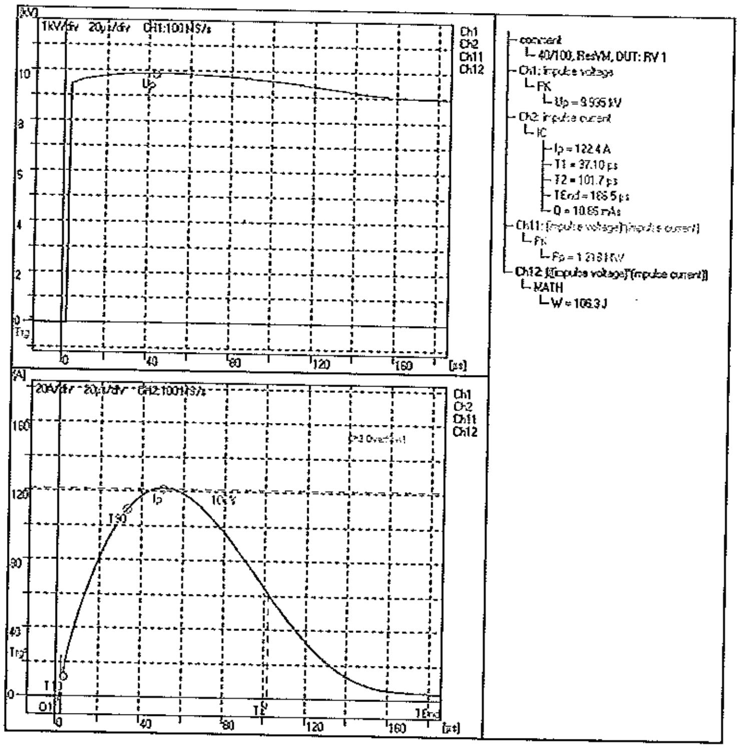


40 kA (8/20)

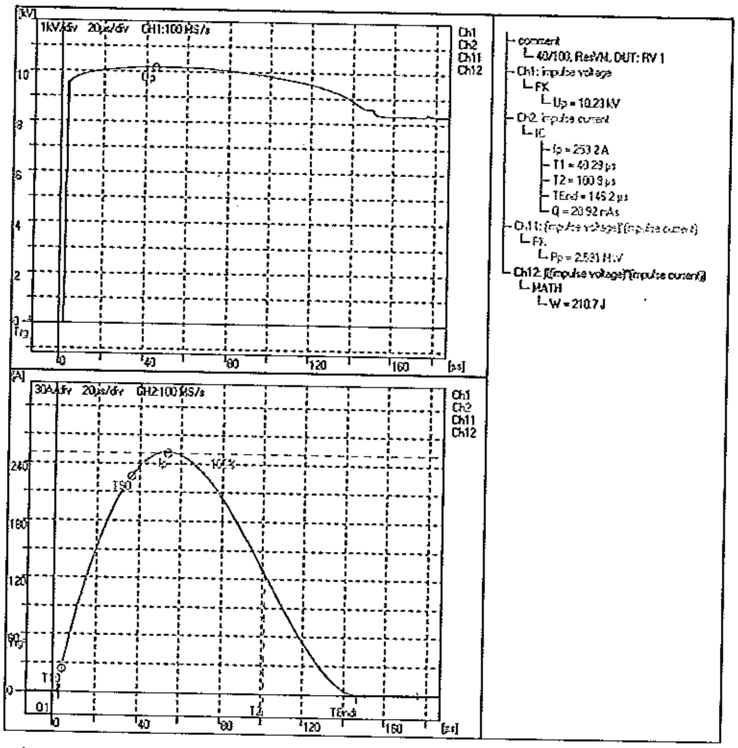


ВЯРНО С
ОРИГИНАЛА

123



125 A (40/100)

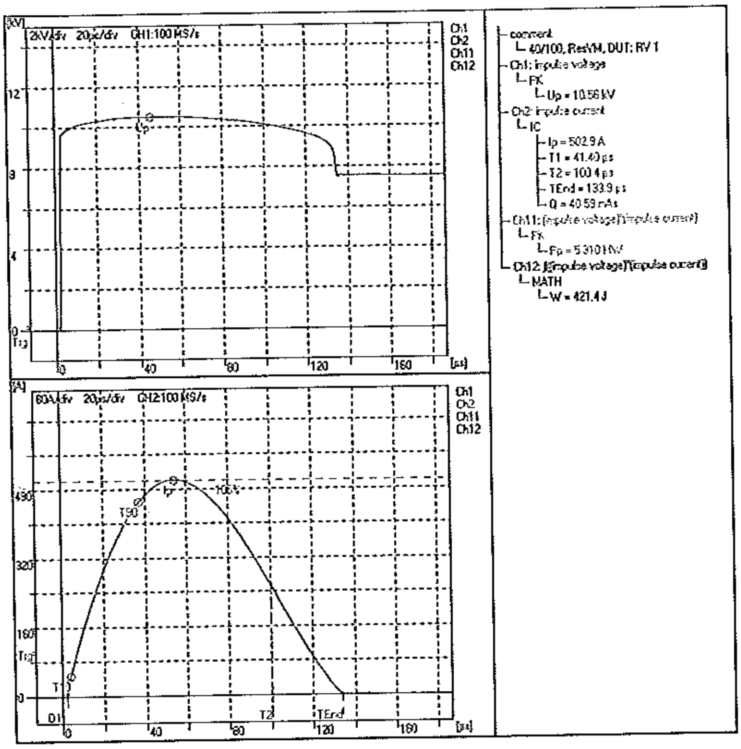


250 A (40/100)

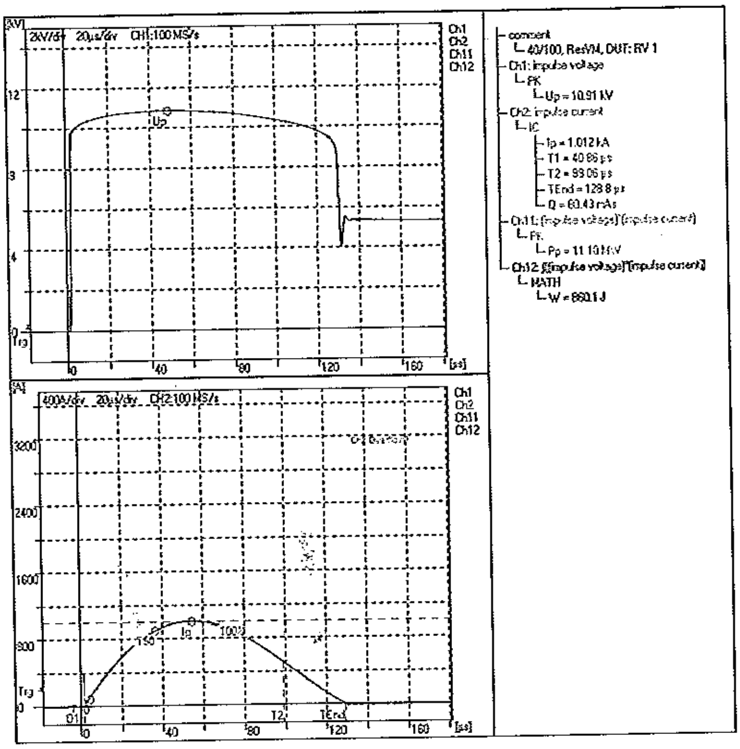
ВЯРНО С ОРИГИНАЛА

124

500 A (40/100)

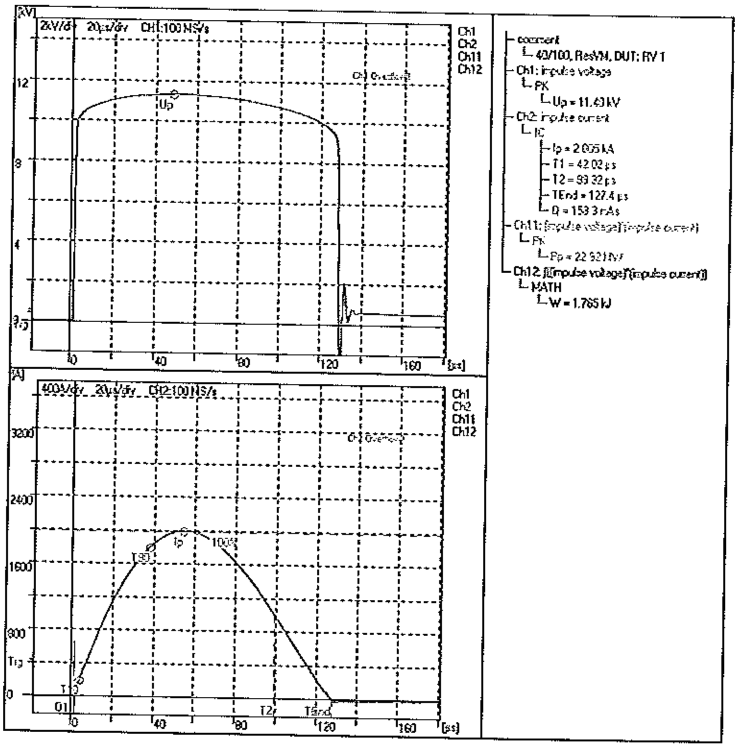


1 kA (40/100)

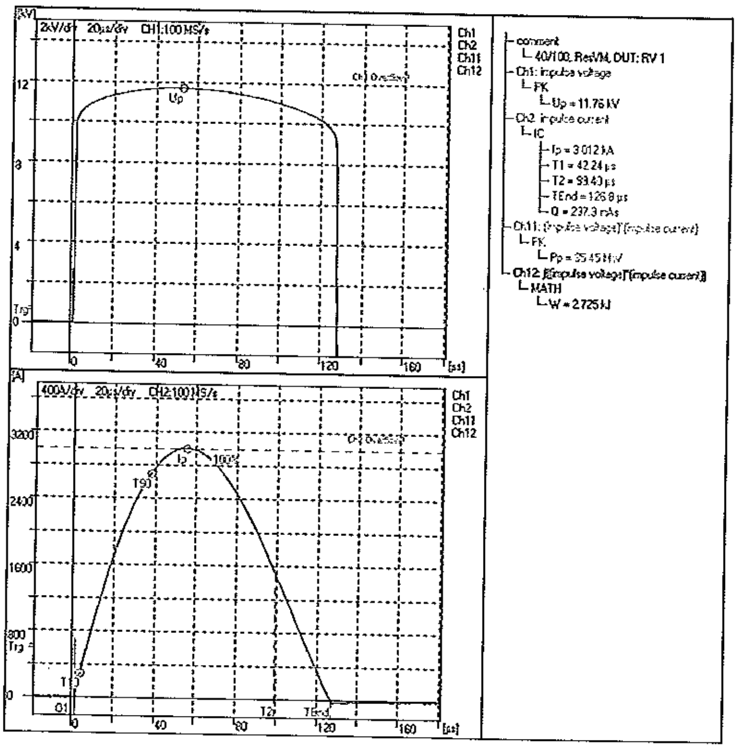


ВЯРНО С
ОРИГИНАЛА

125



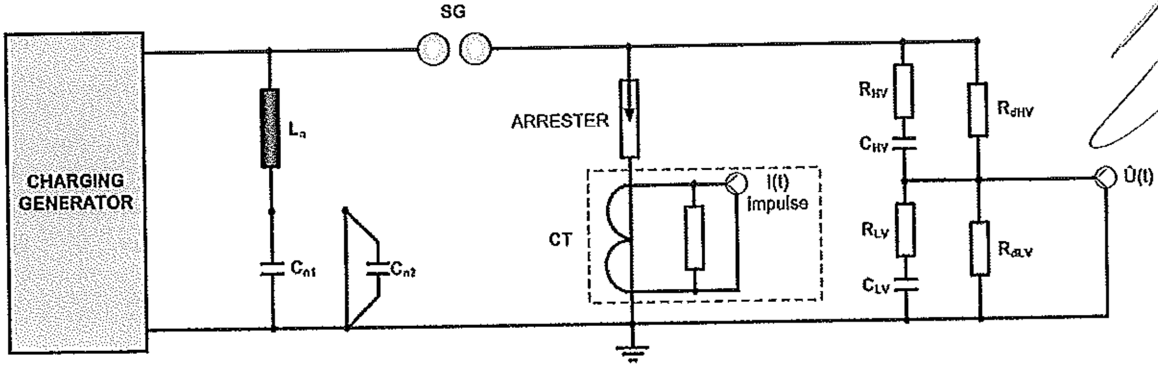
2 kA (40/100)

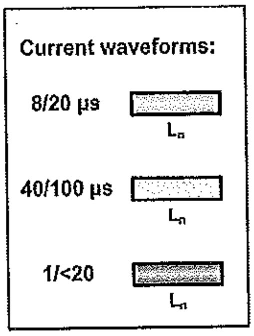


3 kA (40/100)

ВЯРНО С
ОРИГИНАЛА

Test circuit for Residual voltage test on prorated arrester sections:





C_1, C_2	Capacitive divider
R_{dHV}	Damping resistance of the HV-side condensator (C_{HV})
R_{HV}	HV-side measuring resistance
C_{HV}	HV-side measuring capacitance
R_{dLV}	Damping resistance of the LV-side condensator (C_{LV})
R_{LV}	LV-side measuring resistance
C_{LV}	LV-side measuring capacitance
L_n	Charging inductance (n=1...9)
C_{n1}, C_{n2}	Charging capacitances (n=1...9)
CT	Current transformer

ВЯРНО С
ОРИГИНАЛА

Type Test Report

No.: TR-E 13001LD

Equipment under test:	**Polymer housed surge arrester of line discharge class 2 type series, VARISIL HE-I, TRIDELTA Parafoudres S.A.**
Normative documents:	IEC 60099-4 Edition 2.2 clause 8.4
Test performed:	Long duration current impulse withstand test - Line discharge class 2
Test date:	09/10th of January 2013
Number of pages:	10

First issue date: 22nd of January 2013

Tested / Edited by:	Dipl.-Ing.	U. Plötner	....
Approved by:	Dipl.-Ing.	H. Klaube	i.V. ....

ВЯРНО С
ОРИГИНАЛА

Hermsdorf, 22nd of January 2013

TRIDELTA Überspannungsableiter GmbH
Marie-Curie-Straße 3
07629 Hermsdorf - Deutschland
Telefon: +49 (0)3 66 01/9328 300
Fax: +49 (0)3 66 01/9328 301
Internet: http://www.tridelta.de

128

Subject:

Surge arrester type series: VARISIL HE-I,
manufactured by TRIDELTA Parafoudres S.A.
Tests on 3 arrester sections, each consisting of 1 resistor TRIDELTA OD40.

Caused by:

Type Test Report

Test arrangement / course of test:

Test acc. to IEC 60099-4 Edition 2.2 clause 8.4
"Long duration current impulse withstand test"

The test was performed on 3 arrester sections of rated voltage of (5.22...5.28) kV.

Test procedure:

Measurements before the test:

- measurement of reference voltage at reference current î=1 mA,
- measurement of residual voltage at î=125 A (40/100),
- measurement of residual voltage at î=10 kA (8/20)

The test was carried out at ambient temperature of 20 °C in open air.
Each section was subjected to 18 discharges, divided in 6 groups of 3 impulses.

Parameters for the line discharge test (clause 8.4.2 table 5)

$Z = 2.4 \cdot U_r = 12.67\ \Omega$

$U_L = 3.2 \cdot U_r = 16.90\,kV$

$T = 2000\,\mu s$

Required long duration impulse energy:

$W = U_{(125\,A)} \cdot (U_L - U_{(125\,A)}) \cdot T \cdot 1/Z$

$W = 9.93 \cdot (16.90 - 9.93) \cdot 2/12.67$

$W = 10.85\,kJ$

$W' = 2.05\,kJ/kV_{U_r}$

ВЯРНО С ОРИГИНАЛА

129

Test samples and results:

sample no.	LD 1	LD 2	LD 3
$\hat{u}_{ref}$ ($\hat{i}$=1 mA) [kV]	7.10	7.11	7.19
U_r=0,735 x $\hat{u}_{ref\ (\hat{i}=1\ mA)}$ [kV]	5.22	5.23	5.28

Residual voltage at 125 A (40/100) $\hat{u}_{res}$ [kV]	9.89	9.82	9.93
Nominal residual voltage at 10 kA (8/20) before [kV] after [kV] change [%]	 13.44 13.46 +0.15	 13.33 13.33 ±0.00	 13.47 13.48 +0.07
real charging voltage[kV] number of discharges duration of peak [µs]		26.4 18 1980	
discharge current 1st [A] 18th [A] residual voltage 1st [kV] 18th [kV] impulse energy 1st [kJ] 18th [kJ]	515 509 10.66 10.81 12.75 12.80	519 513 10.53 10.71 12.70 12.77	515 508 10.67 10.85 12.76 12.82
specific energy per impulse: average 18 imp. [kJ/kV$_{Ur}$]	2.45	2.44	2.43

The applied energy for each impulse on each tested sample was higher than the calculated (required) energy.

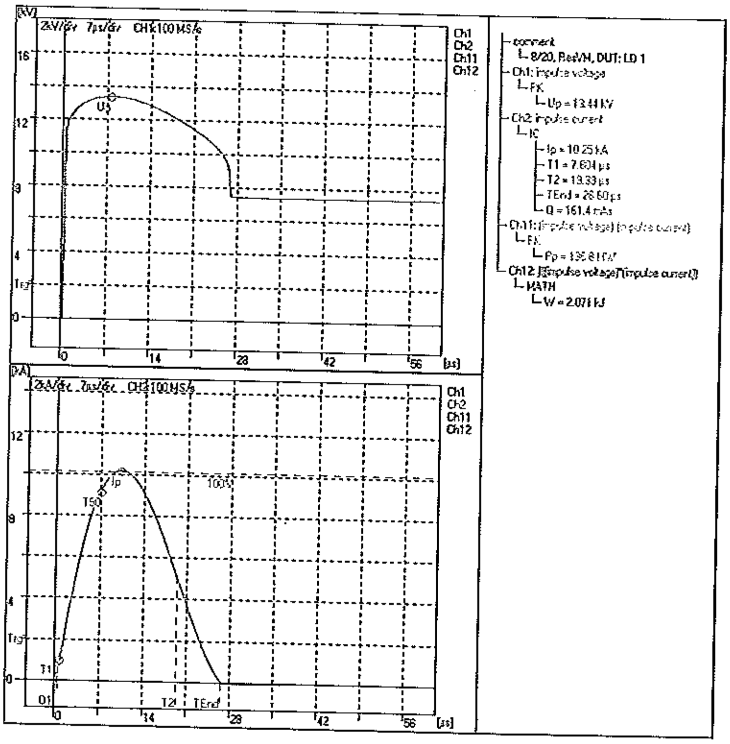
During the test there were no breakdowns or flashovers. The visual inspection after the test showed no cracks or other damages.
The change of the nominal residual voltage amounted less than +0.15 %.

The samples passed the test.

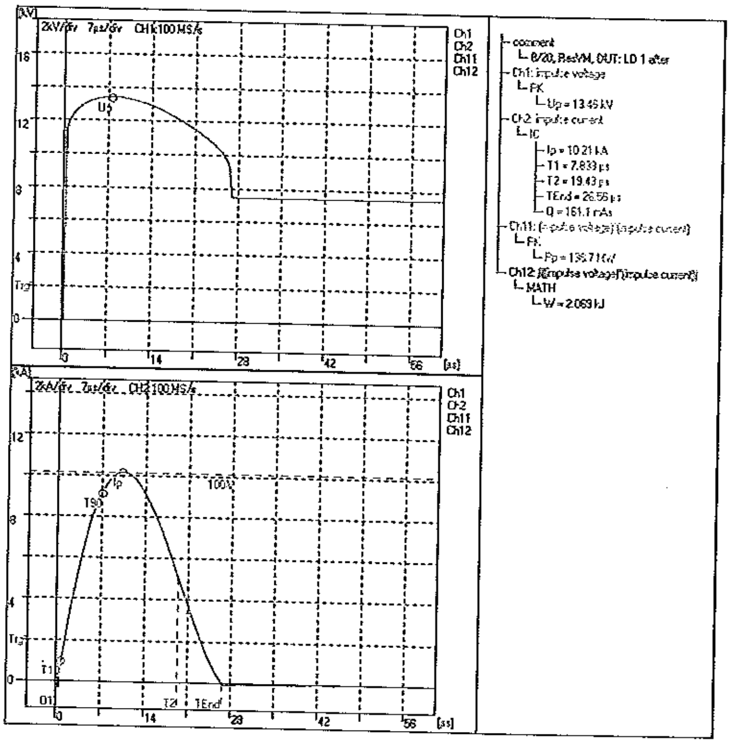
ВЯРНО
ОРИГИНА

The following oscillograms show the results of the measurements.

Sample LD 1:

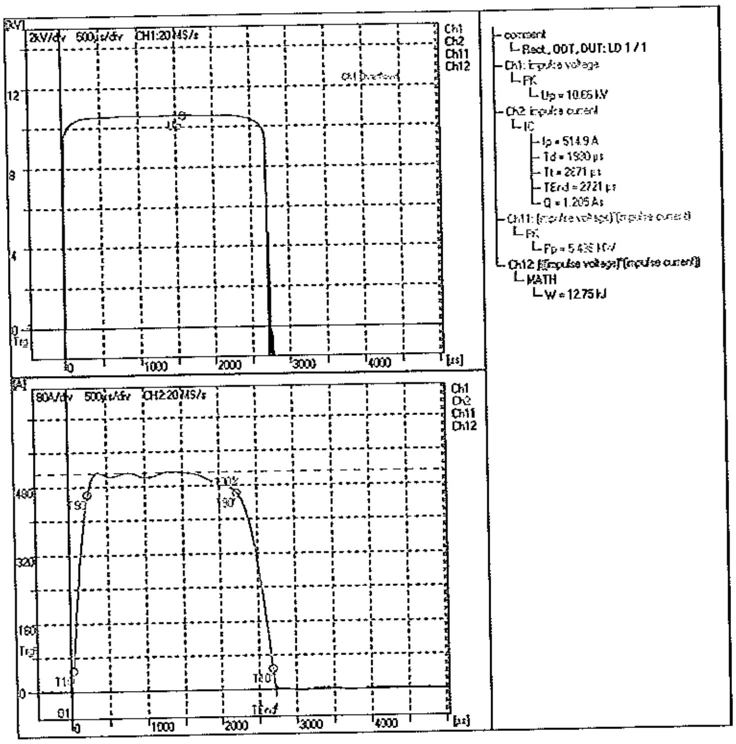


Nominal residual voltage before the test at 10 kA (8/20)

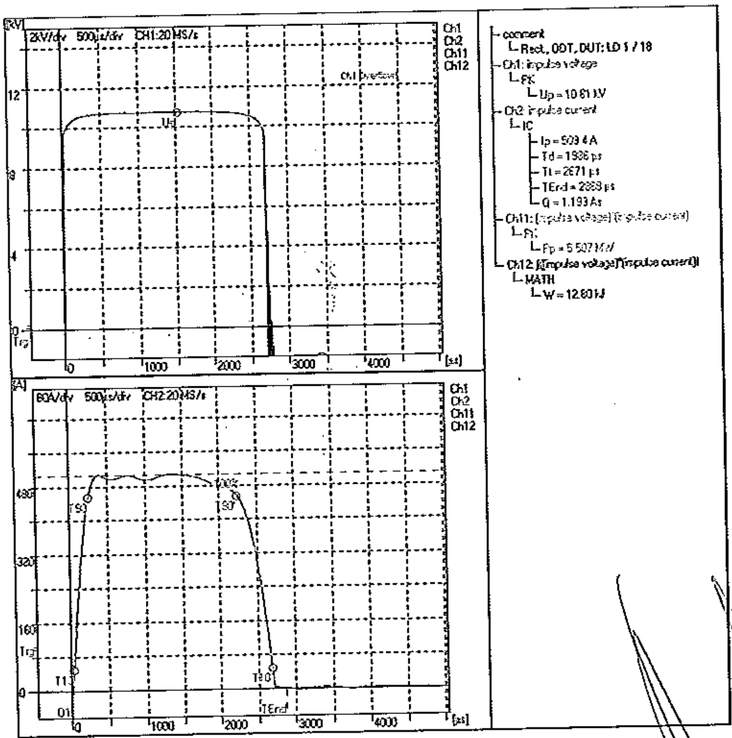


Nominal residual voltage after the test at 10 kA (8/20)

ВЯРНО С ОРИГИНАЛА



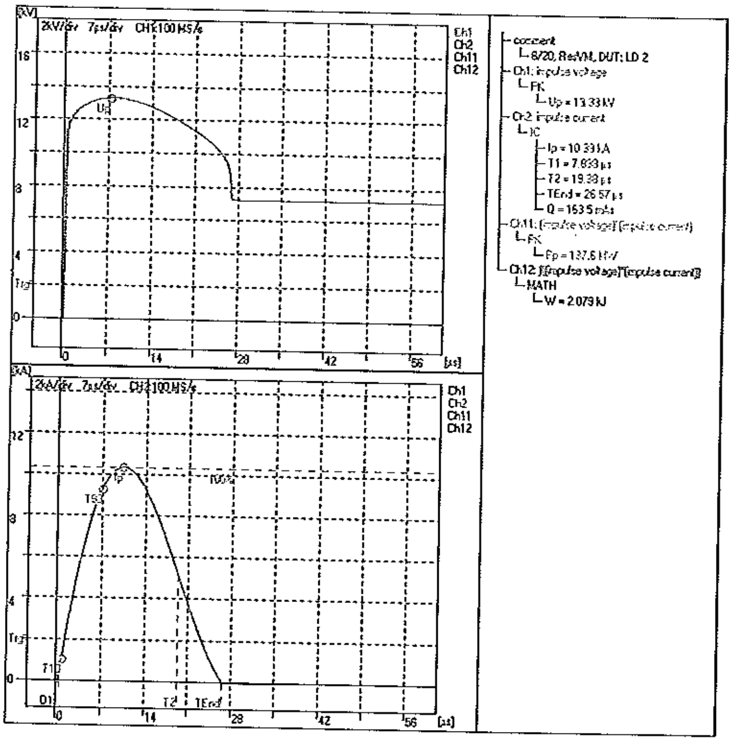
1st impulse
Line discharge class 2



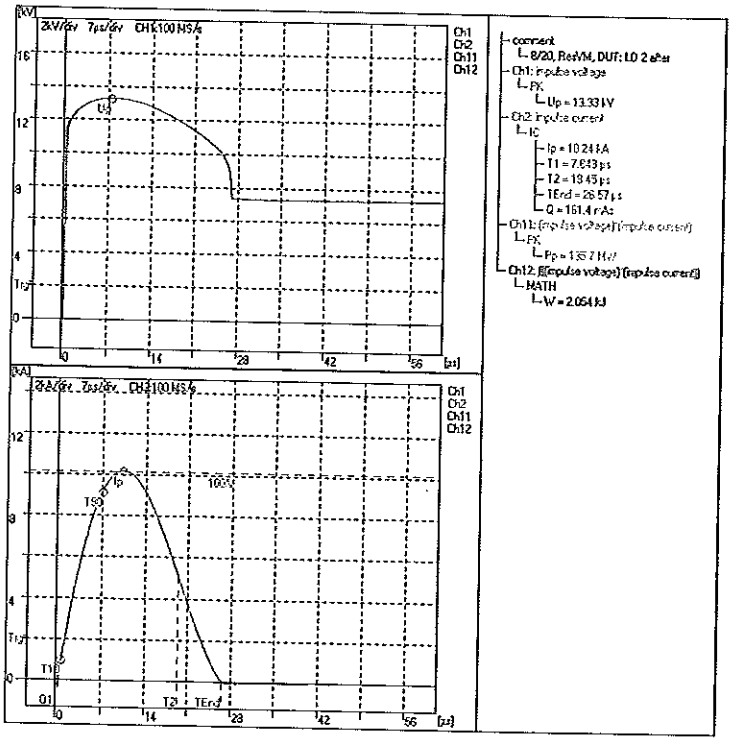
18th impulse
Line discharge class 2

ВЯРНО
ОРИГИНА

Sample LD 2:



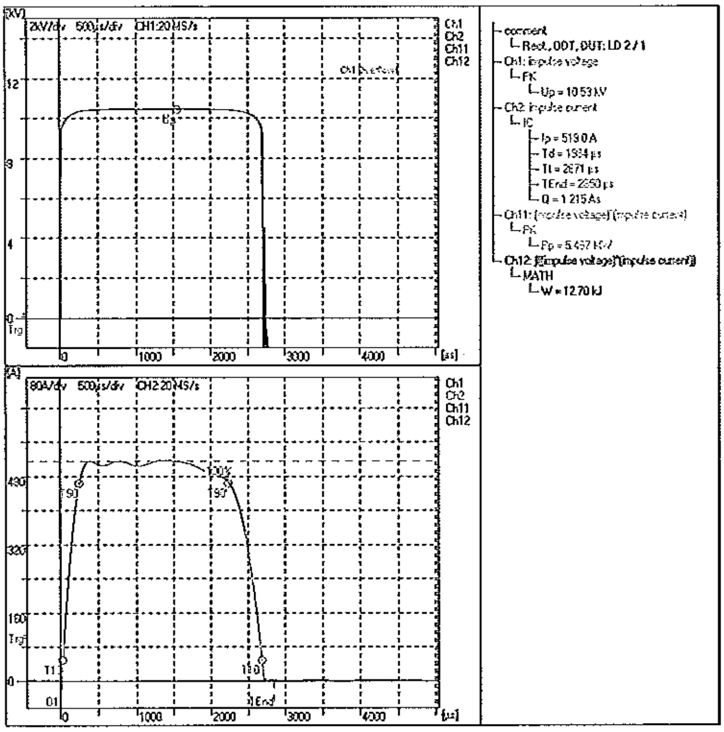
Nominal residual voltage before the test at 10 kA (8/20)



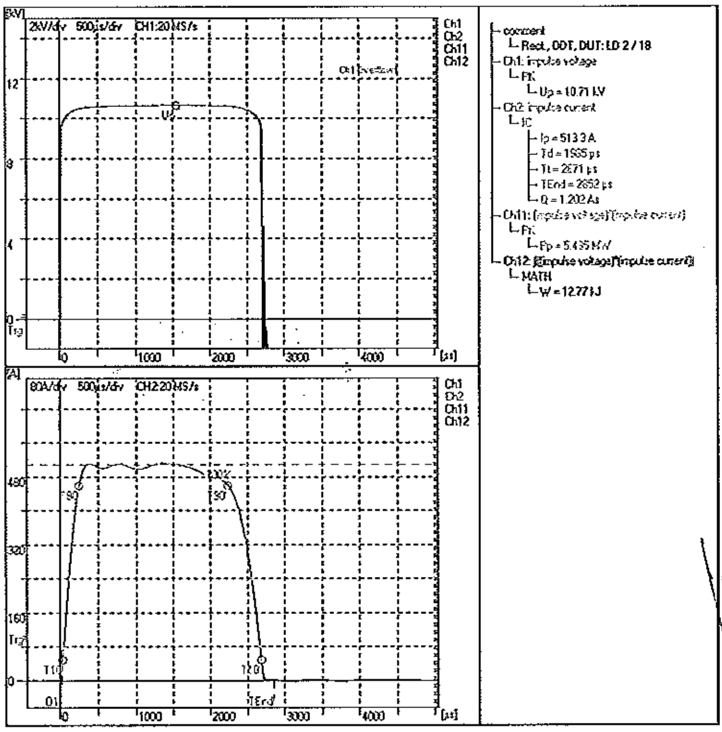
Nominal residual voltage after the test at 10 kA (8/20)

ВЯРНО С ОРИГИНАЛА

133



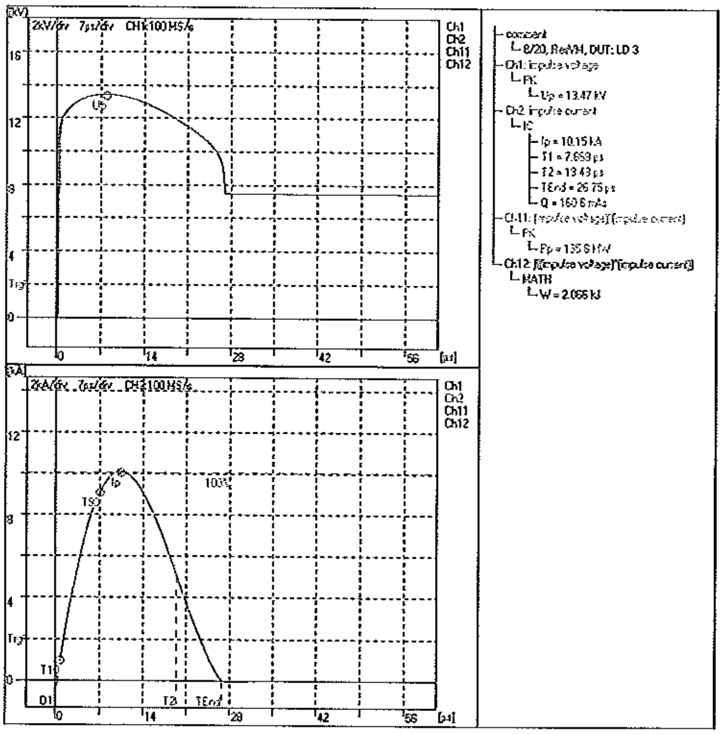
1st impulse
Line discharge class 2



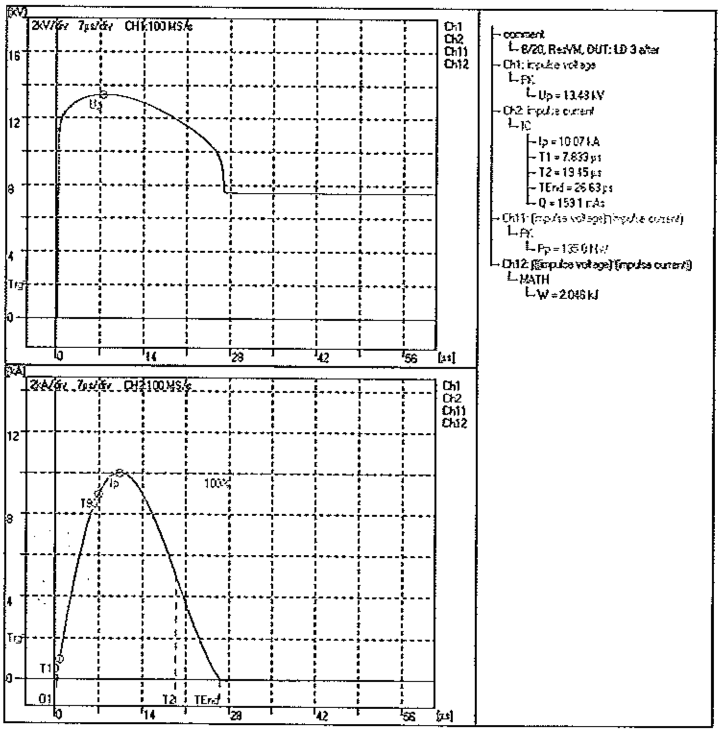
18th impulse
Line discharge class 2

ВЯРНО С
ОРИГИНАЛА

Sample LD 3:



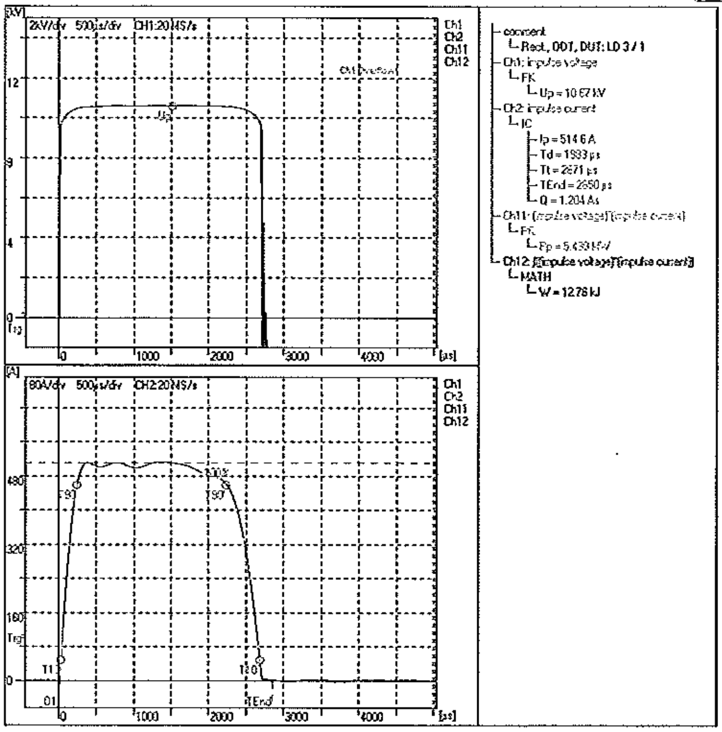
Nominal residual voltage before the test at 10 kA (8/20)



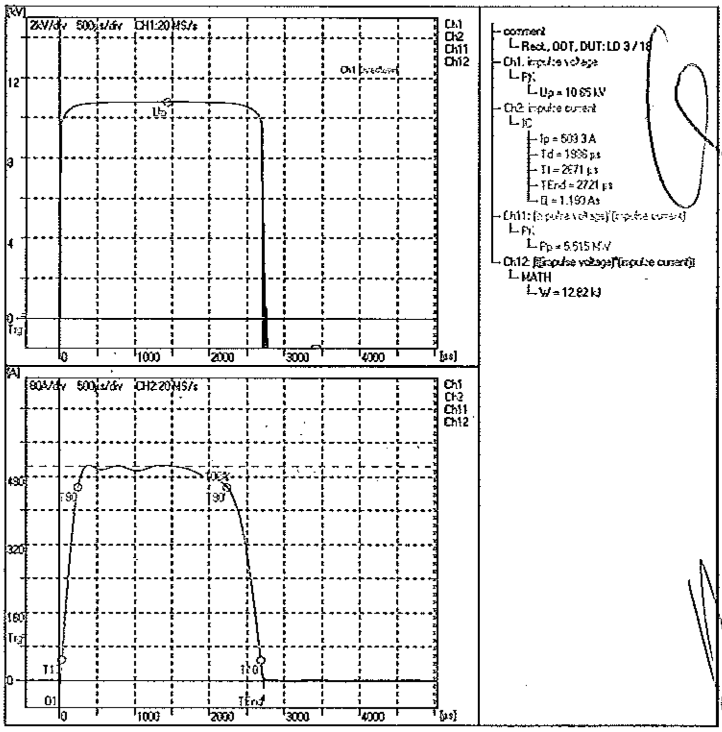
Nominal residual voltage after the test at 10 kA (8/20)

ВЯРНО С
ОРИГИНАЛА

135



1st impulse
Line discharge class 2

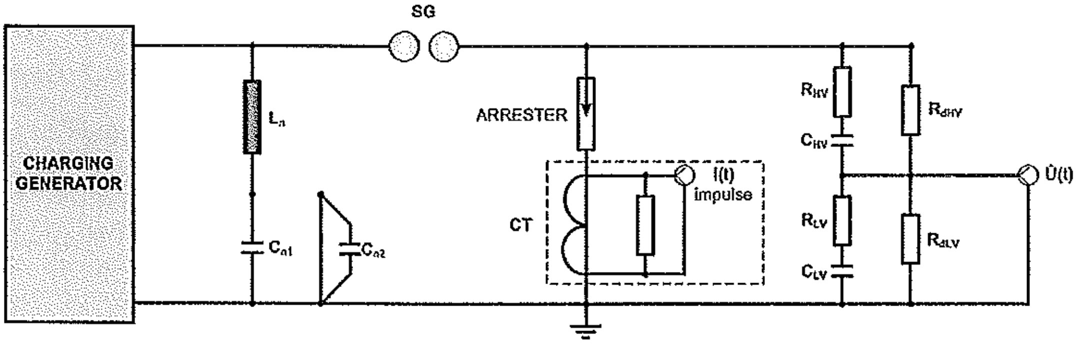


18th impulse
Line discharge class 2

ВЯРНО С ОРИГИНАЛА

136

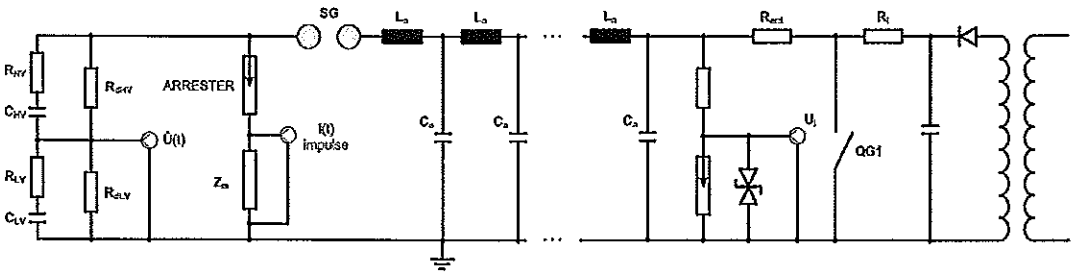
Test circuit for Residual voltage test on prorated arrester sections:



Current waveforms:	
8/20 µs	L_n
40/100 µs	L_n
1/<20	L_n

C_1, C_2	Capacitive divider
R_{dHV}	Damping resistance of the HV-side condensator (C_{HV})
R_{HV}	HV-side measuring resistance
C_{HV}	HV-side measuring capacitance
R_{dLV}	Damping resistance of the LV-side condensator (C_{LV})
R_{LV}	LV-side measuring resistance
C_{LV}	LV-side measuring capacitance
L_n	Charging inductance (n=1...9)
C_{n1}, C_{n2}	Charging capacitances (n=1...9)
CT	Current transformer

Test circuit for Long duration current impulse withstand test



R_{dHV}	Damping resistance of the HV-side condensator (C_{HV})
R_{HV}	HV-side measuring resistance
C_{HV}	HV-side measuring capacitance
R_{dLV}	Damping resistance of the LV-side condensator (C_{LV})
R_{LV}	LV-side measuring resistance
C_{LV}	LV-side measuring capacitance
Z_m	Measuring impedance
L_n	Inductance (n=1...9)
C_n	Charging capacitances (n=1...9)

ВЯРНО С
ОРИГИНАЛА

137

HIGH CURREN IMP. OPERAT.

Type Test Report

No.: TR-E 13001OD

Equipment under test:	**Polymer housed surge arrester of line discharge class 2 type series, VARISIL HE-I, TRIDELTA Parafoudres S.A.**
Normative documents:	IEC 60099-4 Edition 2.2 clause 10.8.5/8.5
Test performed:	Operating duty tests - pre-stressed with 2 line discharge class 2 impulses
Test date:	26th -27th of February 2013
Number of pages:	19

First issue date: 07th of March 2013

Tested / Edited by:	Dipl.-Ing. U. Plötner	....	(Test engineer)
Approved by:	Dipl.-Ing. H. Klaube	i.A.	(Senior R&D engineer)

Hermsdorf, 07th of March 2013

ВЯРНО С ОРИГИНАЛА

138

139

Subject:
Surge arrester type series: VARISIL HE-I,
manufactured by TRIDELTA Parafoudres S.A.

Tests on 3 arrester sections, each consisting of 1 resistor TRIDELTA OD40.

Caused by:
Type Test Report

Test arrangement / course of test:

Test acc. to IEC 60099-4 Edition 2.2 clause 10.8.5
"Switching surge operating duty test" according to clause 10.8.5.5

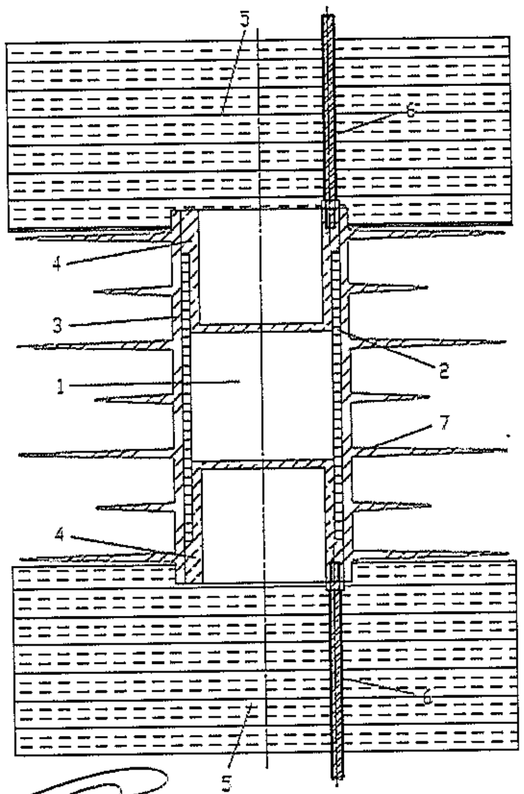
The test was performed on 3 arrester sections of rated voltage of 5.45 – 5.51 kV.
The initial measurements and the conditioning were carried out with housing at ambient temperature of 20 °C.
During the subsequent line discharge class 2 and power frequency voltage applications the varistors were placed in a test vessel (thermal model). These test samples represent the thermal and electrical behaviour of a complete assembled arrester or arrester unit containing most resistors per unit length.

ВЯРНО С ОРИГИНАЛА

Test procedure:

- initial measurements:
  measurement of reference voltage at reference current $\hat{i}$=1 mA,
  measurement of residual voltage at $\hat{i}$=125 A (40/100),
  measurement of residual voltage at $\hat{i}$=10 kA (8/20)
- conditioning:
  20 impulses 10 kA (8/20) divided in 4 groups of 5 discharges at 1.2 times of U_c, impulse polarity was the same as that of the half cycle of power frequency voltage during which the impulse occurs at 60 ° el. before peak.
- conditioning:
  2 impulses 100 kA (4/10) with the same polarity as for 10 kA conditioning,
- preheating the test samples (thermal model) to 60 °C
- 2 discharges of line discharge class 2 (impulse distance 60 s)
- application of the rated voltage U_r within ≤ 100 ms for 10 s and switching the test voltage to continuous operating voltage U_c for 30 min. and continuous registration of varistor current and power loss for prove of thermal stabilisation
- after cooling down to ambient temperature,
  one additional line discharge class 2 impulse applied to the sample
  measurement of nominal residual voltage at 10 kA (8/20),
  evaluation of the sample,

Arrester section (thermal model) of VARISIL ... HE-I type series metal oxide surge arrester



1	ZnO varistor type OD40	5	Uncompressed foamed-material (Polyurethane)
2	Prepreg wrapper	6	Electrical terminals
3	Silicone tube	7	Silicone shed
4	Aluminium end plug		

ВЯРНО С ОРИГИНАЛА

110

141

Test samples and results:

sample no.	ODT 1	ODT 2	ODT 3
$\hat{U}_{ref}$ ($\hat{i}$=1 mA) [kV]	7.50	7.42	7.46
$U_r = \hat{U}_{ref(Soc.)} \cdot \frac{U_{r(A)}}{\hat{U}_{ref\ min.(A)}}$ $U_r = \hat{U}_{ref} \cdot 0.735$ [kV]	5.51	5.45	5.48
$U_c = 0.8 \cdot U_r$ [kV]	4.41	4.36	4.39
$\hat{U}_{res\ (125\ A,\ 40/100)}$ [kV]	9.75	9.80	9.87
calculation of class 2 energy: $W = \hat{U}_{res}(U_L - \hat{U}_{res}) \cdot T/Z$ [kJ]	11.62	11.45	11.51
nominal residual voltage at 10 kA (8/20) before the test [kV] after the test [kV] change [%]	 13.39 13.52 + 0.97	 13.26 13.39 + 0.98	 13.30 13.45 + 1.13
conditioning with 20 impulses 10 kA (8/20) at $U = 1.2 \cdot U_c$	passed	passed	passed
conditioning with 2 imp. 100 kA (4/10)	passed	passed	passed
energy per impulse [kJ/kV$_{Ur}$]	≈ 2.77	≈ 2.80	≈ 2.78
line discharge test, class 2 $[kJ/kV_{U_r}]$ 1st impulse 2nd impulse	 2.42 2.42	 2.46 2.47	 2.45 2,46
switching time to rated voltage [ms]	92.2	88.7	88.9
rated voltage (10 s) U_r* [kV] $\hat{i}$ [mA] P_{max} [W]	5.51 189 197	5.45 179 182	5.48 140 157
cont. operating voltage U_c* [kV]	4.41	4.36	4.39
after 5 min. $\hat{i}$ [mA] P [W]	1.50 1.98	1.42 1.84	1.34 1.71
after 30 min. $\hat{i}$ [mA] P [W]	0.75 0.69	0.76 0.62	0.76 0.62

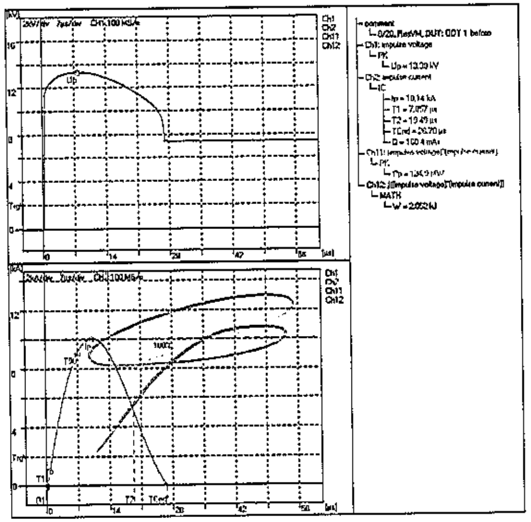
All Samples were able to cool down during the continuous operating voltage application.
The visual inspection after the test did not show any breakdowns, flashovers or mechanical damages. One additional line discharge class 2 impulse was applied after the samples have cooled down to ambient temperature to verify that no damage

ВЯРНО С ОРИГИНАЛА

occurred (checked by oscillographic records).
The change of nominal residual voltage was less then + 1.13 %.
The samples passed the test.

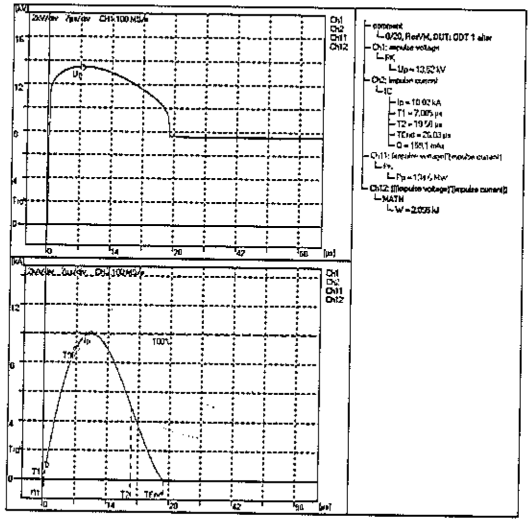
The following figures show the oscillograms of the operating duty tests.

Sample ODT 1:

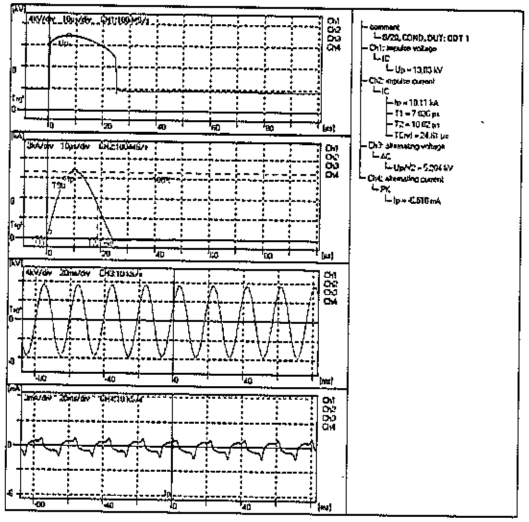


Nominal residual voltage before the test at 10 kA (8/20)

ВЯРНО С ОРИГИНАЛ
142



Nominal residual voltage
after the test at 10 kA (8/20)

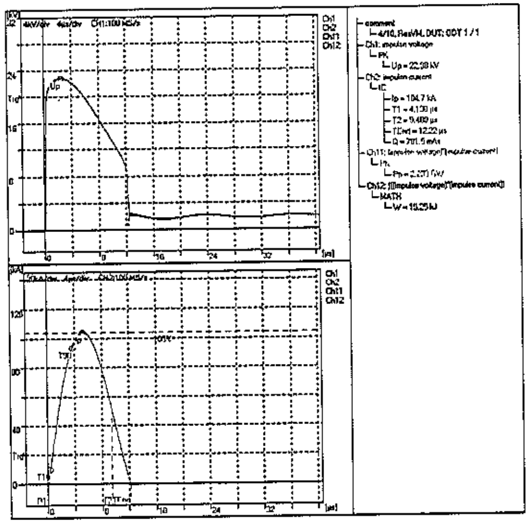


conditioning with 10 kA, 8/20
at U=1.2 U_c

20th impulse

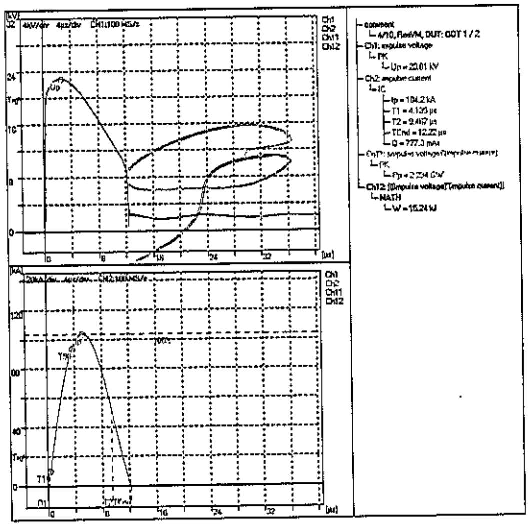
ВЯРНО С ОРИГИНАЛА

143



conditioning with 100 kA, 4/10

1st impulse

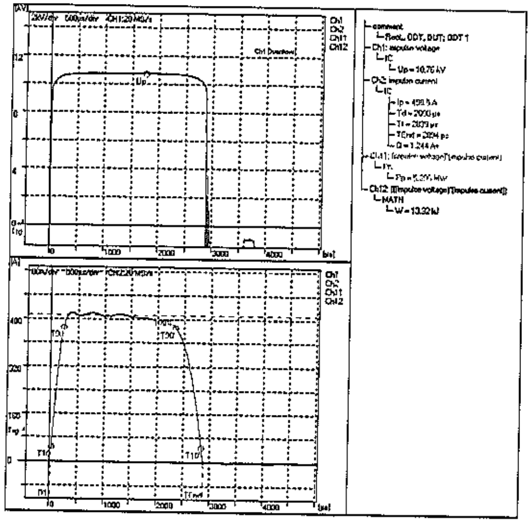


conditioning with 100 kA, 4/10

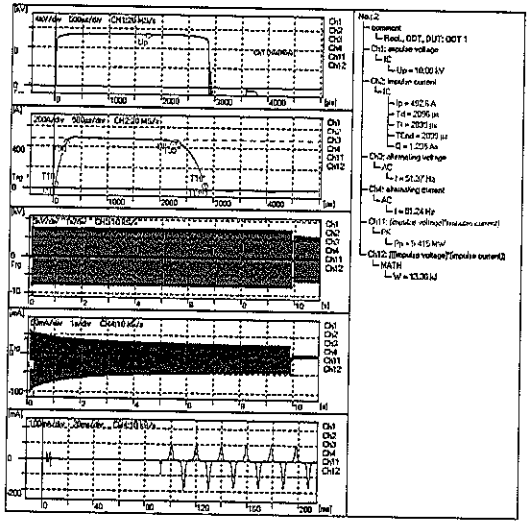
2nd impulse

ВЯРНО С ОРИГИНАЛА

111

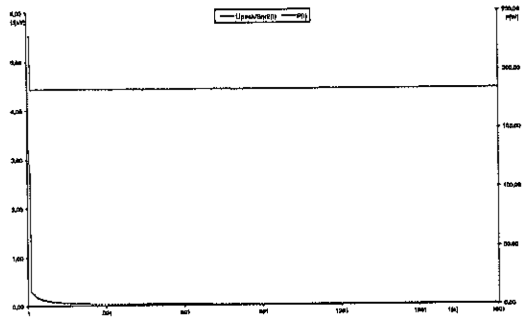


1st impulse
line discharge class 2



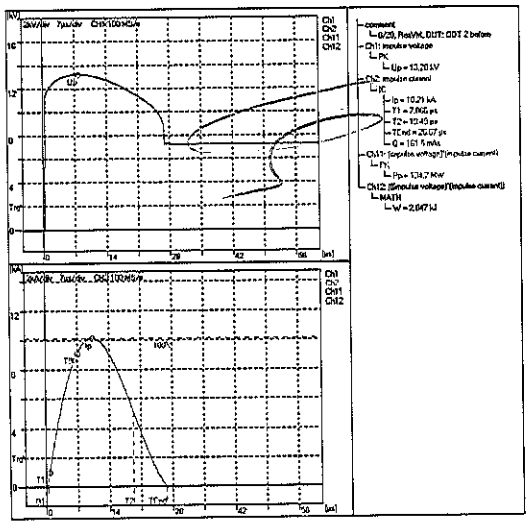
2nd impulse
line discharge class 2
and process of switching to
rated voltage.

145



Course of test voltage and watt loss

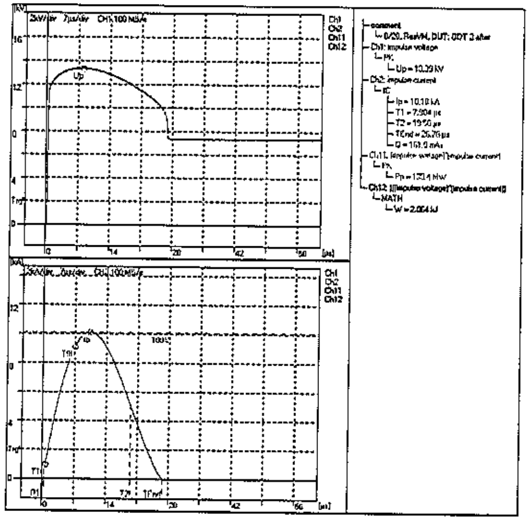
Sample ODT 2:



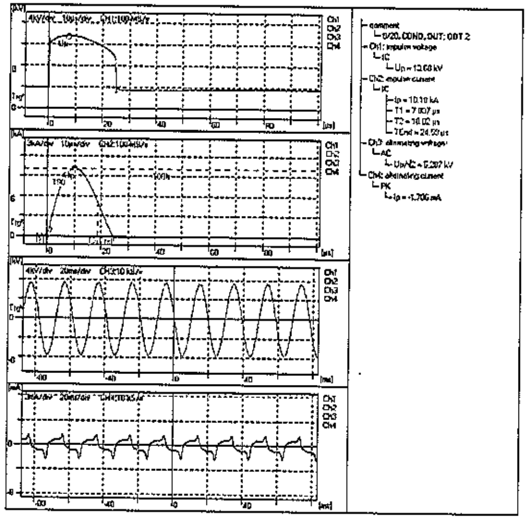
Nominal residual voltage before the test at 10 kA (8/20)

ВЯРНО С ОРИГИНАЛА

146



Nominal residual
voltage
after the test at 10 kA
(8/20)

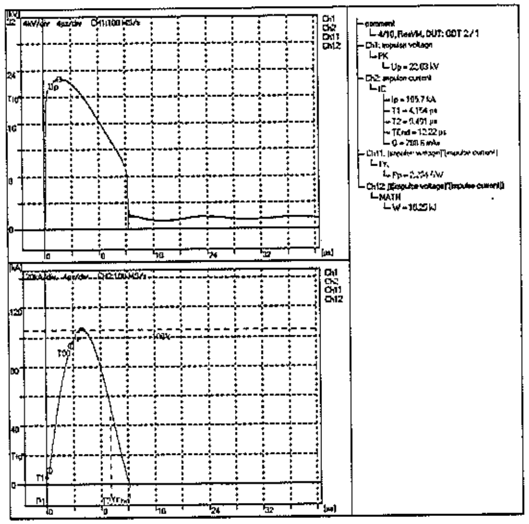


conditioning with 10 kA,
8/20 at U=1.2 U_c

20[th] impulse

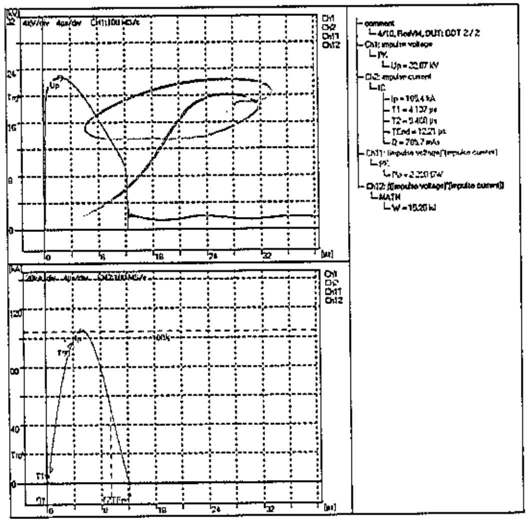
ВЯРНО С
ОРИГИНАЛА

147



conditioning with
100 kA, 4/10

1st impulse

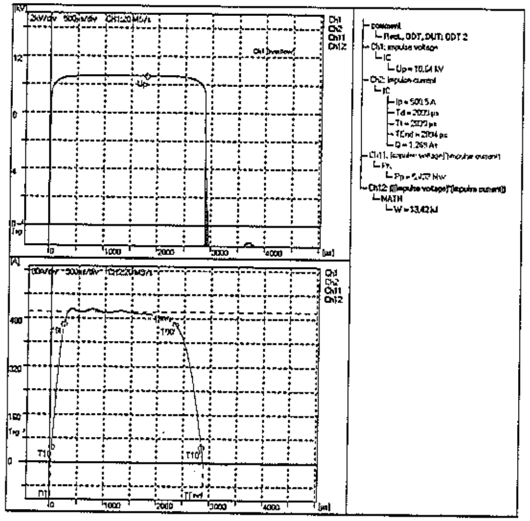


conditioning with
100 kA, 4/10

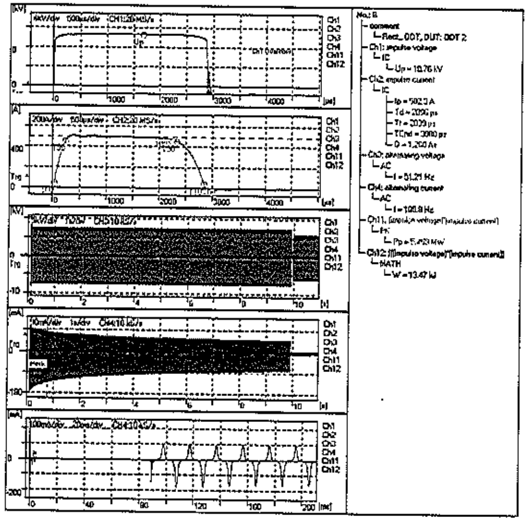
2nd impulse

ВЯРНО С
ОРИГИНАЛА

148

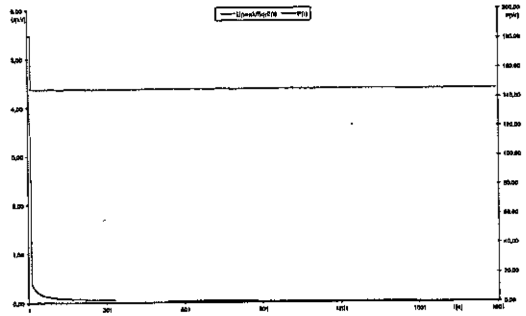


1st impulse
line discharge class 2



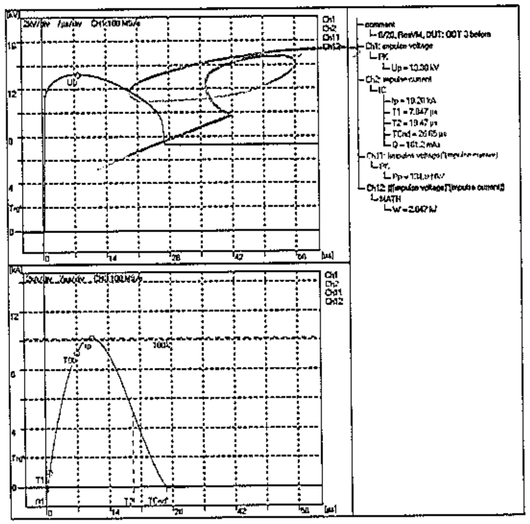
2nd impulse
line discharge class 2
and process of
switching to rated
voltage

149



Course of test voltage and watt loss

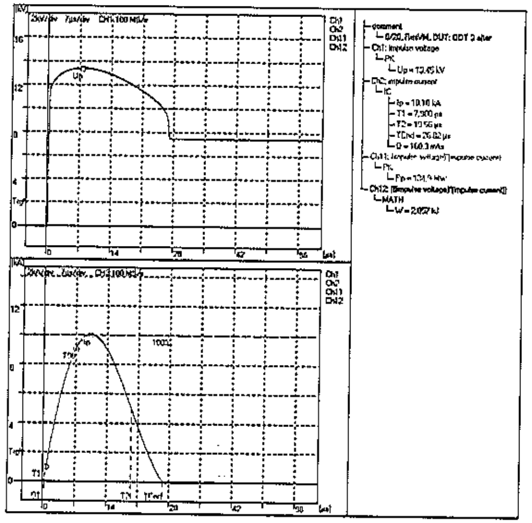
Sample ODT 3:



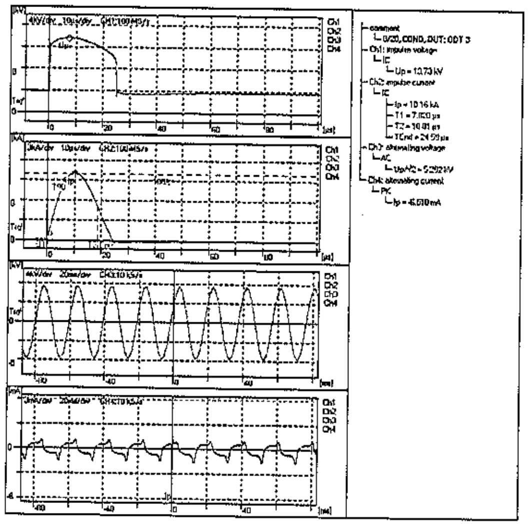
Nominal residual voltage before the test at 10 kA (8/20)

ВЯРНО С ОРИГИНАЛА

150



Nominal residual voltage
after the test at 10 kA (8/20)

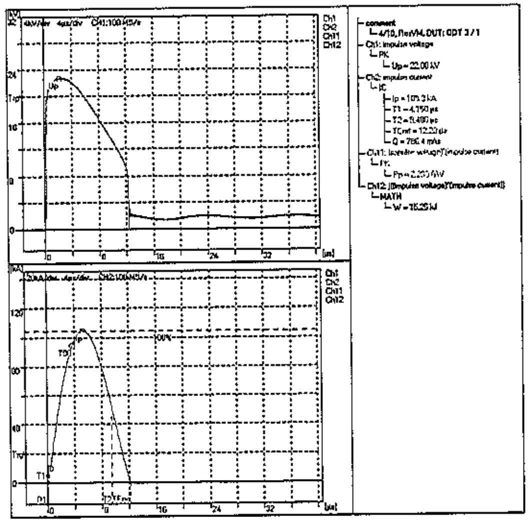


conditioning with 10 kA, 8/20
at U=1.2 U_c

20[th] impulse

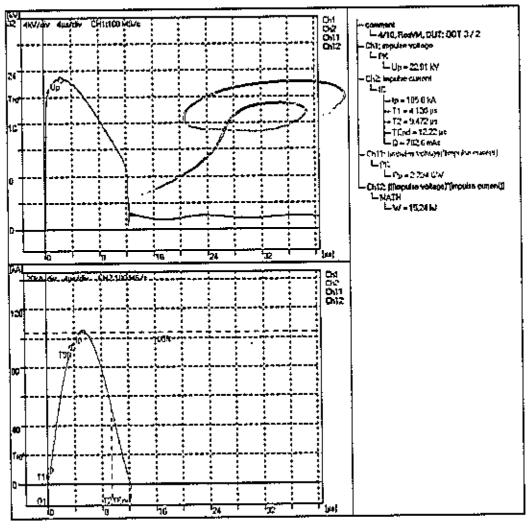
151

ВЯРНО С ОРИГИНАЛА



conditioning with 100 kA, 4/10

1st impulse

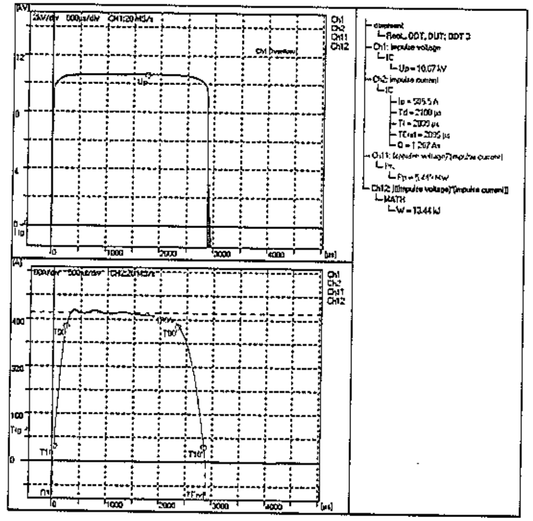


conditioning with 100 kA, 4/10

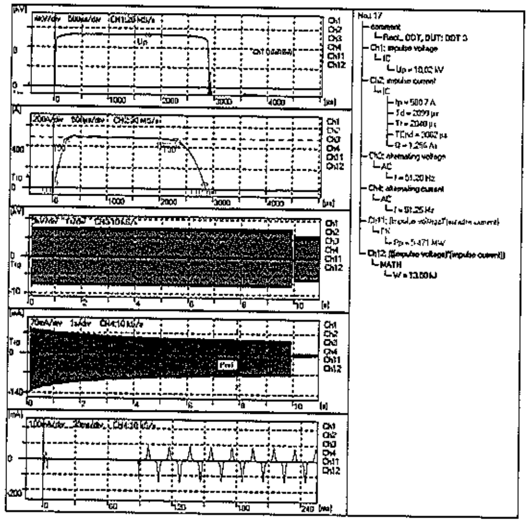
2nd impulse

ВЯРНО С ОРИГИНАЛ

152



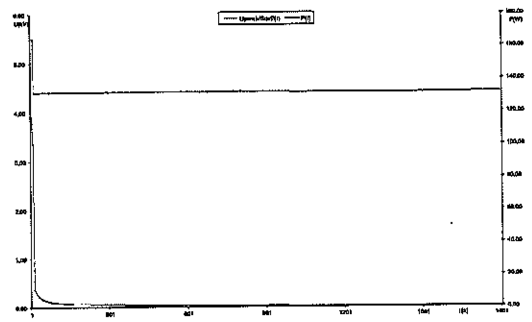
1[st] impulse
Line discharge class 2



2[nd] impulse
line discharge class 2
and process of switching to
rated voltage

ВЯРНО С ОРИГИНАЛА

153



Course of test voltage and watt loss

ВЯРНО С ОРИГИНАЛА

151

DATA & RESULTS FOR THE ACCELERATED AGEING TEST
performed on metal oxide resistors intended for VARISIL Type HE-I surge arresters

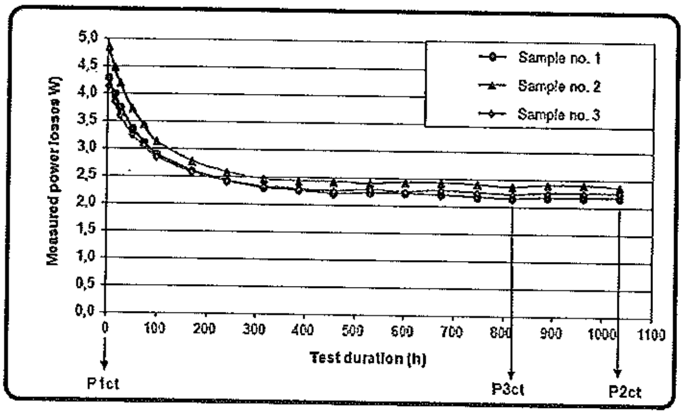
Test conditions : according to the procedure and the requirements defined at clause 8.5.2 of IEC 60099-4 - Edition 2.2 (May 2009)

Test samples : 3 sliced parts of HE-I surge arrester built with a single MO resistor rated 5 kV   Test temperature : 115 +/- 3 °C   Total test duration : 1032 h

Test voltage : Uct = Uc x (1 + D x H) x Uref / Urefmin   where : Uc = 4000 V rms is the continuous operating voltage of a MO resistor rated 5 kV
D = 15 %/m is the maximum distortion of voltage distribution considered within the HE-I range
H = 0.655 m is the maximum arrester length corresponding to the HE-I 54 model
Uref = 5090 V peak/V2 is the reference voltage at 1 mA peak a.c. of the test samples
Urefmin = 4810 V peak/V2 is the specified minimum reference voltage for a MO resistor rated 5 kV

Uct = 4660 V rms

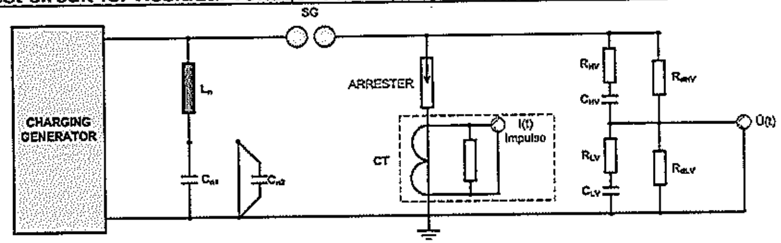
Testing time (h)	Sample no. 1	Sample no. 2	Sample no. 3	
1,5	4,28	4,84	4,14	= P1ct
12	4,00	4,49	3,86	
24	3,76	4,19	3,62	
48	3,36	3,74	3,27	
72	3,11	3,44	3,07	
96	2,91	3,14	2,87	
168	2,59	2,78	2,59	
240	2,43	2,58	2,43	
312	2,31	2,46	2,34	
384	2,27	2,43	2,30	
456	2,21	2,43	2,27	
528	2,24	2,40	2,30	
600	2,24	2,43	2,27	
672	2,21	2,43	2,30	
744	2,18	2,40	2,27	
816	2,15	2,36	2,24	= P3ct
888	2,18	2,40	2,27	
960	2,18	2,40	2,27	
1032	2,18	2,36	2,27	= P2ct



CONCLUSION : as both P2ct <= 1.1 x P3ct and P2ct <= P1ct for all three test samples, the switching surge operating duty test according to clause 10.8.5 of IEC 60099-4 can be performed on new MOV blocks at Usr and Usc without any additional correction

ВЯРНО С ОРИГИНАЛА

Test circuit for Residual voltage test on prorated arrester sections:

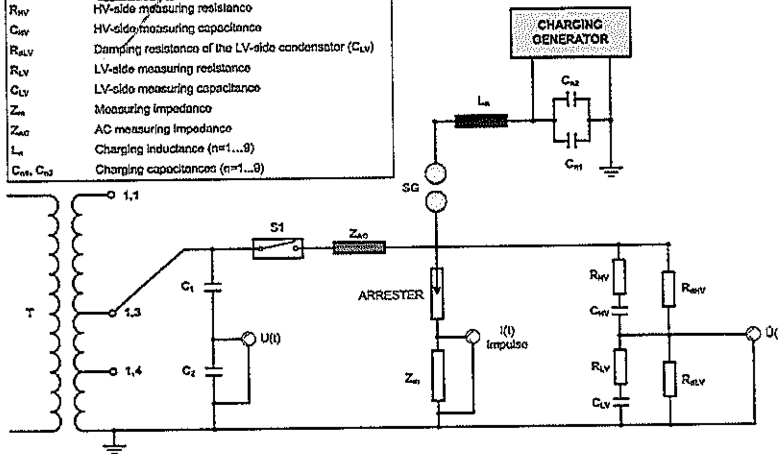


Current waveforms:	
8/20 µs	L_n
40/100 µs	L_n
1/<20	L_n

C_1, C_2	Capacitive divider
R_{dHV}	Damping resistance of the HV-side condensator (C_{HV})
R_{HV}	HV-side measuring resistance
C_{HV}	HV-side measuring capacitance
R_{dLV}	Damping resistance of the LV-side condensator (C_{LV})
R_{LV}	LV-side measuring resistance
C_{LV}	LV-side measuring capacitance
L_n	Charging inductance (n=1...9)
C_{n1}, C_{n2}	Charging capacitances (n=1...9)
CT	Current transformer

Test circuit for operating duty test:

T	Test transformer
S1	AC switch
C_1, C_2	Capacitive divider
R_{dHV}	Damping resistance of the HV-side condensator (C_{HV})
R_{HV}	HV-side measuring resistance
C_{HV}	HV-side measuring capacitance
R_{dLV}	Damping resistance of the LV-side condensator (C_{LV})
R_{LV}	LV-side measuring resistance
C_{LV}	LV-side measuring capacitance
Z_m	Measuring impedance
Z_{AC}	AC measuring impedance
L_n	Charging inductance (n=1...9)
C_{n1}, C_{n2}	Charging capacitances (n=1...9)



ВЯРНО С ОРИГИНАЛА

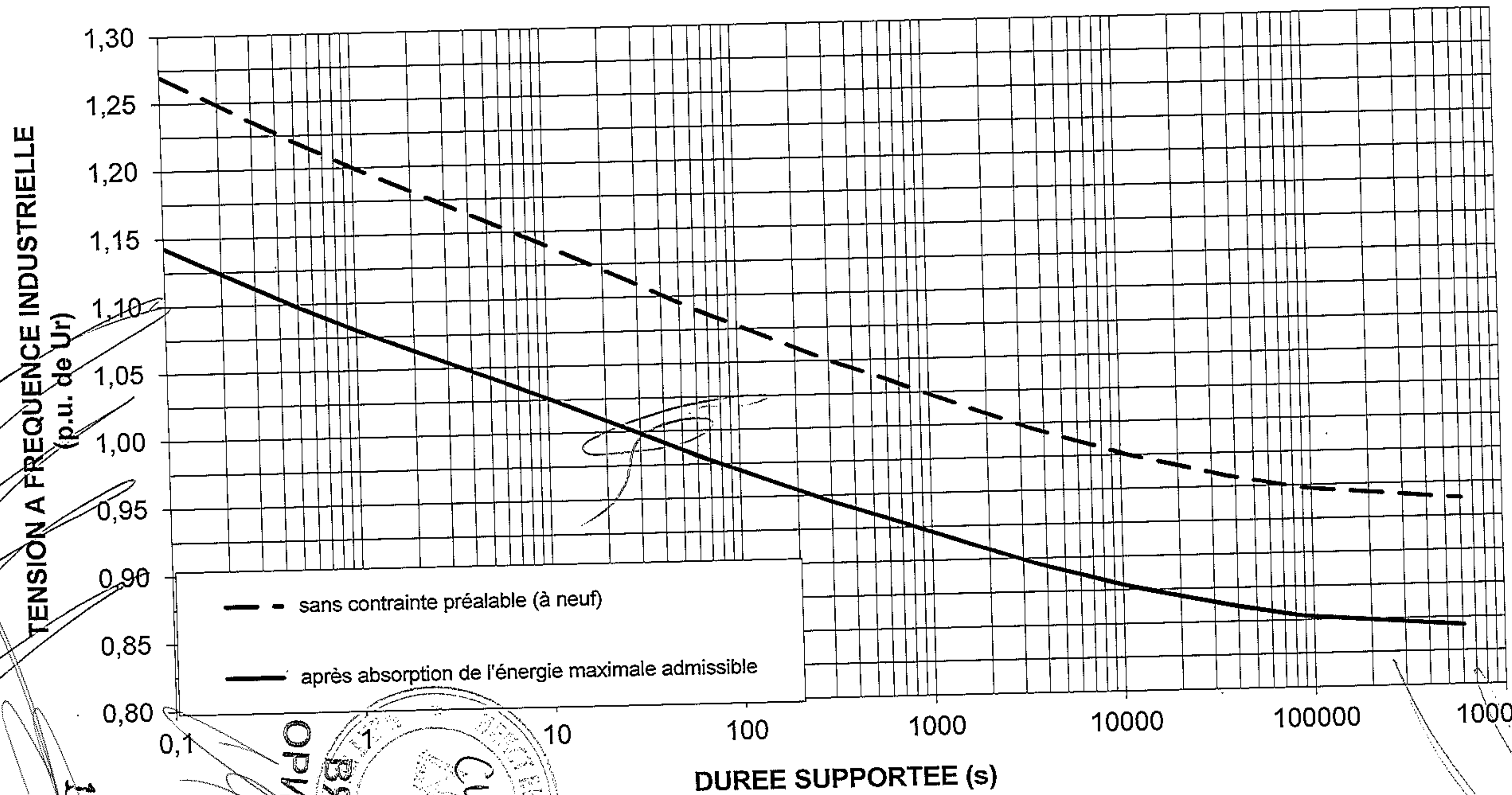
156

	p.u. de Ur		p.u. de Uc	
temps (s)	neuf	énergie max	neuf	énergie max
0,1	1,270	1,143	1,588	1,429
0,5	1,220	1,098	1,525	1,373
1	1,200	1,080	1,500	1,350
5	1,158	1,042	1,448	1,303
10	1,140	1,026	1,425	1,283
60	1,090	0,981	1,363	1,226
120	1,073	0,966	1,341	1,207
300	1,050	0,945	1,313	1,181
600	1,035	0,932	1,294	1,164
1800	1,010	0,909	1,263	1,136
3600	0,995	0,896	1,244	1,119
10800	0,975	0,878	1,219	1,097
36000	0,958	0,862	1,198	1,078
86400	0,948	0,853	1,185	1,067
604800	0,938	0,844	1,173	1,055

ВЯРНО С ОРИГИНАЛА

157

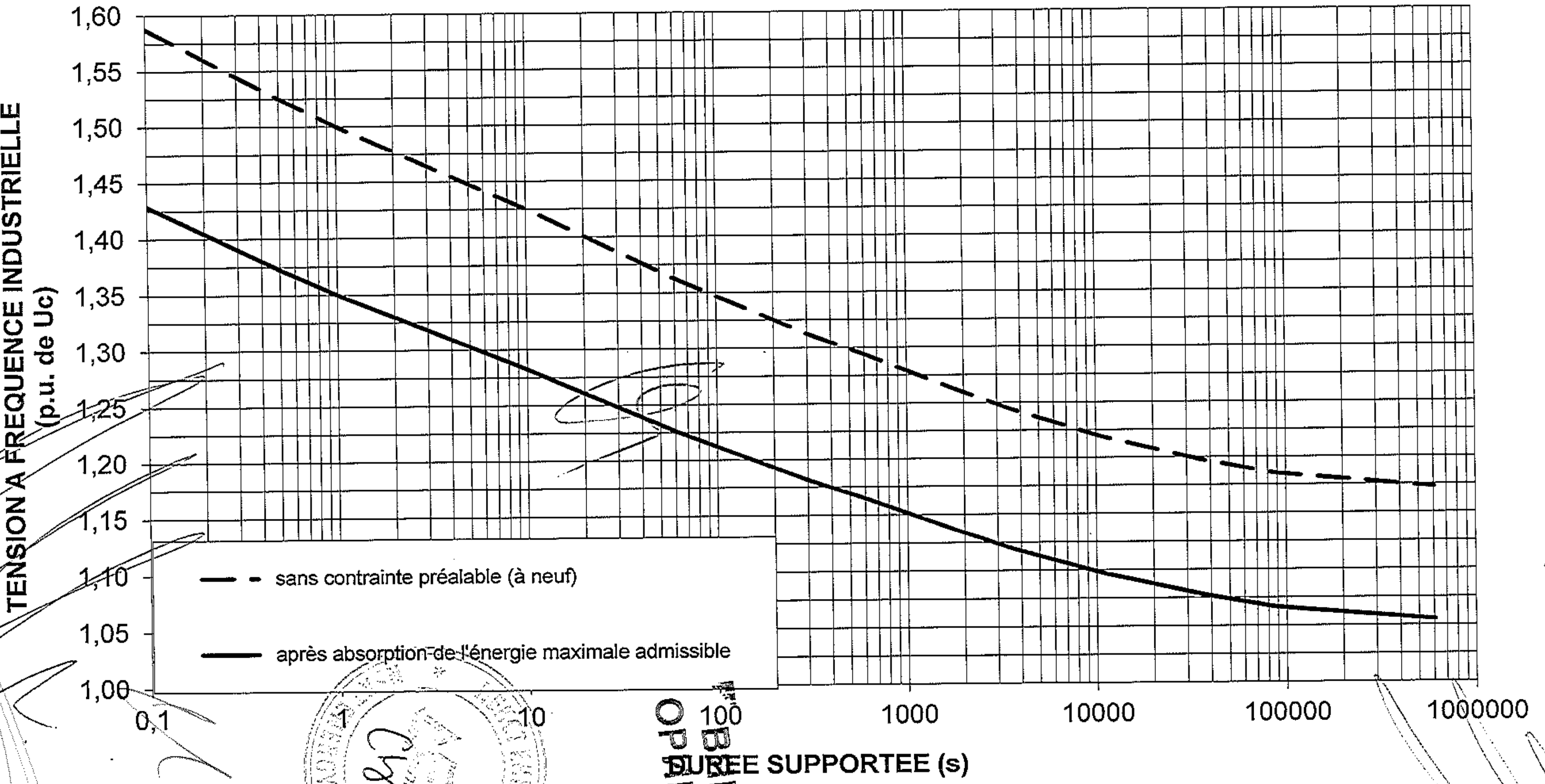
TENUE MINIMALE AUX SURTENSIONS TEMPORAIRES des parafoudres VARISIL HE-I selon Annexe D de la CEI 60099-4



Document TRIDELTA réf. UT 8982 01 XX / F rév. 00 du 26/10/2012

ВЯРНО С ОРИГИНАЛ

TENUE MINIMALE AUX SURTENSIONS TEMPORAIRES
des parafoudres VARISIL HE-I selon Annexe D de la CEI 60099-4

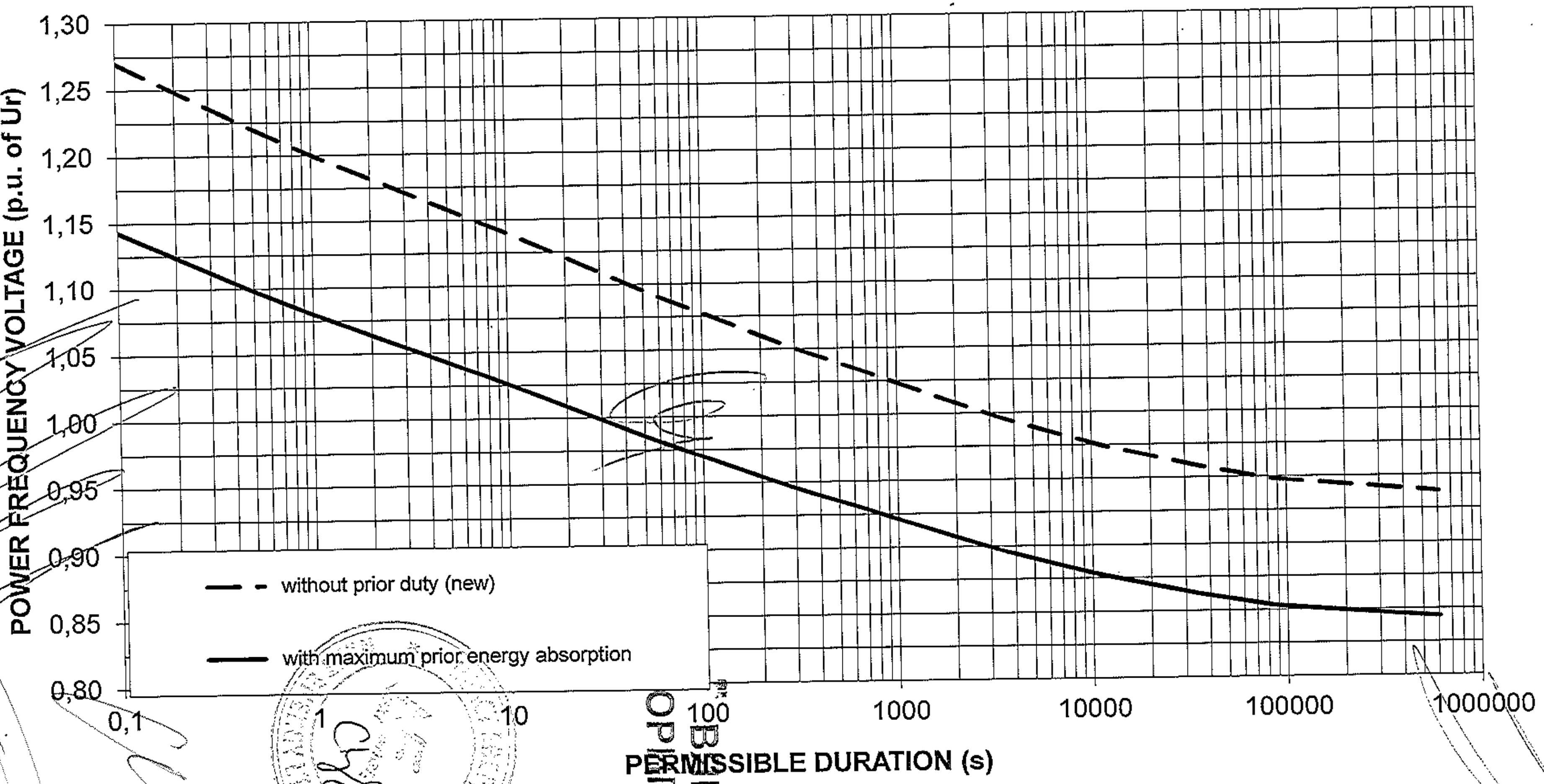


Document TRIDELTA réf. UT 8982 01 YY/ F rév. 00 du 26/10/2012

ВЯРНО С ОРИГИНАЛ

159

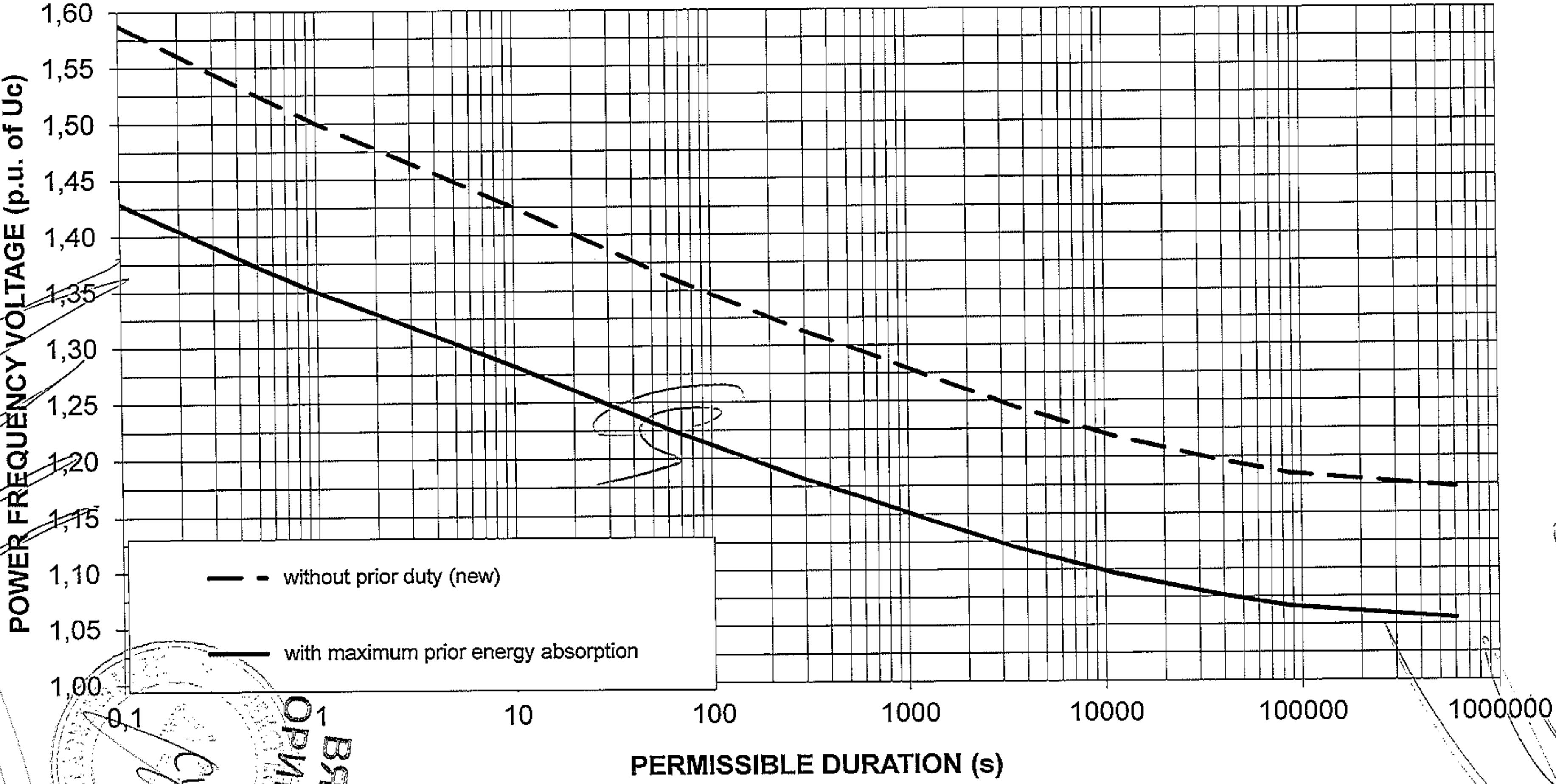
MINIMUM TEMPORARY OVERVOLTAGE WITHSTAND CAPABILITY of VARISIL Type HE-I Surge Arresters according to Annex D of IEC 60099-4



ВЯРНО С ОРИГИНАЛ

Document TRIDELTA ref. UT 8982 01 XX / E rev. 00 dated October 26, 2012

MINIMUM TEMPORARY OVERVOLTAGE WITHSTAND CAPABILITY
of VARISIL Type HE-I Surge Arresters according to Annex D of IEC 60099-4



Document TRIDELTA ref. UT 8982 01 YY / E rev. 00 dated October 26, 2012

ВЯРНО С ОРИГИНАЛ

CESI

Test Report

Client AREVA Parafoudres S.A.
Bagneres de Bigorre - FRANCE

Tested equipment Polymer-housed metal-oxide surge arresters

Tests carried out Short-circuit tests

Standards/Specifications IEC 60099-4 (2006-07)

Test date from May 20, 2008 to May 21, 2008

The results reported in this document relate only to the tested equipment.
Partial reproduction of this document is permitted only with the written permission from CESI

ВЯРНО С
ОРИГИНАЛА

No. of pages 18 **No. of pages annexed**

Issue date June 25, 2008

Prepared Unit LABORATORIES - P. Beccarini

Verified Unit LABORATORIES - D. Ronchi

Approved Unit LABORATORIES - R. Nicolini

CESI S.p.A.
Energy Division
Technical Area Components
"Testing Laboratories"
Manager

CESI
Centro Elettrotecnico
Sperimentale Italiano
Giacinto Motta spa

Via R. Rubattino 54
20134 Milano - Italia
Telefono +39 0221251
Fax +39 0221255440
http://www.cesi.it

Capitale sociale 8 550 000 Euro
interamente versato
Codice fiscale e numero
iscrizione CCIAA 00793580150

Registro Imprese di Milano
Sezione Ordinaria
N. R.E.A. 429222
P.I. IT00793580150

Tests witnessed by

Mr. F. Malpiece	AREVA Parafoudres S.A. - Bagneres de Bigorre - France
Mr. H. Sauvage	AREVA Parafoudres S.A. - Bagneres de Bigorre - France

Identification of the object Not requested.

Only for laboratory requirement, in order to reproduce the test conditions, all the laboratory data are contained in the document marked: A8014192

The measurement uncertainties of the test results reported in the document are the following:

voltage: ± 5 % ; **current:** ± 5 % ; **time:** ± 5 % ; **temperature:** ± 2 °C

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to a confidence level of about 95 %) and have to be considered as maximum values.

Receipt date of the sample May 19, 2008

ВЯРНО С ОРИГИНАЛА

163

Contents	Page	Test date
Rated characteristics of the tested object assigned by the Client	4	
Test arrangement	5	
Tests performed		
High-current short-circuit test with 20,5 kA for 0,214 s	6	May 21, 2008
High-current short-circuit test with 12,2 kA for 0,204 s	7	May 21, 2008
High-current short-circuit test with 6,50 kA for 0,204 s	8	May 20, 2008
Low-current short-circuit test with 630 A for 1,00 s	9	May 20, 2008
Test circuit	10	
Photos	11 to 18	
Pages annexed		
Oscillograms (No.7)		

164

ВЯРНО С
ОРИГИНАЛ

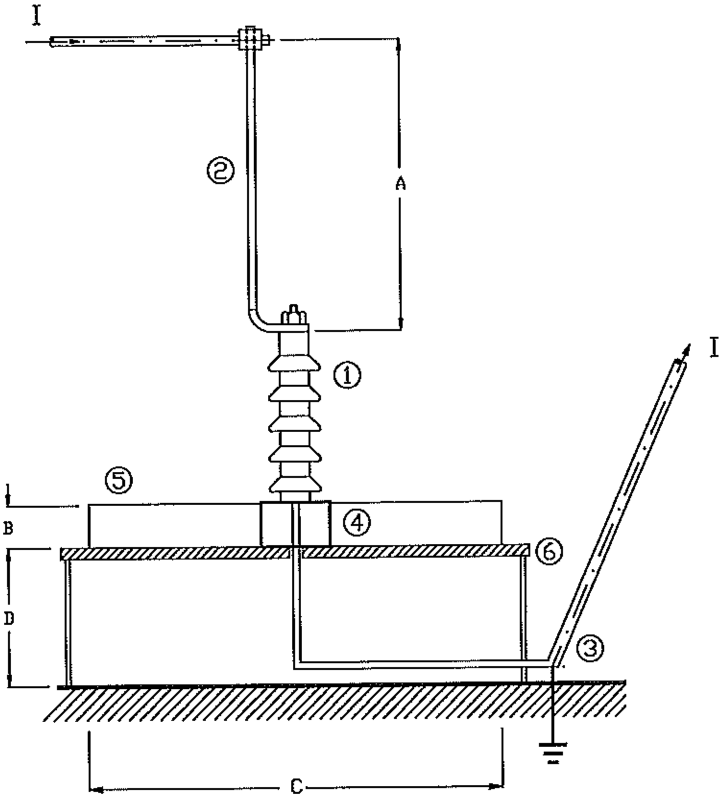
Rated characteristics of the tested object assigned by the Client

Polymer-housed metal-oxide surge arrester	
Manufacturer	AREVA Parafoudres S. A.
Type	HE / HE-S
Drawing	-
Rated voltage (Ur)	24 kV
Maximum continuous operating voltage (Uc)	20 kV
Rated frequency	50-60 Hz
Nominal discharge current (8/20 µs impulse shape)	10 kA
Line discharge class	1
Rated short circuit current	
High current	for 0,2 s ; 20,0 kA
Low current	for 1,0 s ; 0,60 kA

ВЯРНО С ОРИГИНАЛА

165

D8046 - Test arrangement



1 : Surge arrester
2 : Flexible conductor
3 : Rigid conductor
4 : Base
5 : Surrounding fence
6 : Insulating wood platform

A : 1,00 m
B : 0,40 m
C : 1,80 m
D : 1,00 m

ВЯРНО С ОРИГИНАЛА

The arrester to be tested was installed on a base at 1,40 m to ground in the middle of an enclosure of 1,80 m in side.
The enclosure was positioned on the insulating wood platform.
The live side of the supply was connected to the upper end of the arrester while the return circuit, earthed, was connected to the lower end. The live conductor was directed to the opposite direction as the earth conductor

168

High-current short-circuit test with 20,5 kA for 0,214 s

Test circuit : See D0046 Power factor : <0,15 Frequency : 50 Hz

67

ВЯРНО С ОРИГИНАЛА

Prospective test current			
Oscillogram		rms value	Peak value
No.	Sheets	kA	kA
-	-	-	-

Test arrangement : See D8046
A photo detector was used to determine the venting time.
In order to o achieve the internal discharge the surge arrester has been electrically pre-failed by means of a power frequency over-voltage application using an auxiliary low power source.
The short-circuit current of the auxiliary low power source has been set at about 20 A.
The voltage applied to the arrester was increased in order to get a current equal to 100 mA (0-peak) and kept at this value or slightly adjusted till arrester failure.
The pre-failure process duration was 2 minutes and 45 seconds.
The short-circuit test was performed 4 minutes and 01 sec after the completion of the pre-failure process.

Condition of the apparatus before the tests: new.

Date: May 21, 2008

Test	Oscillogram		Arrester under test	Duration	Test voltage	Test current		Time to flame extinction after the test	Venting time	Notes
						Peak value	rms value			
No.	No.	Sheets	No.	s	kV	kA	kA	s	ms	No.
1	30	1	4	0,214	18,0	48,6	20,5	14	1,0	-

Condition of the apparatus after the tests: see photos No.1 and 2
- There was not violent shattering.
- The arrester structure was damaged by the test.
- The arrester remained connected to the supply and return circuit.
- No fragment were found inside or outside the enclosure.

Acceptance criteria: Fulfilled.
Test result: Positive.

High-current short-circuit test with 12,2 kA for 0,204 s

Test circuit : See D0046 Power factor : <0,15 Frequency : 50 Hz

Prospective test current			
Oscillogram		rms value	Peak value
No.	Sheets	kA	kA
27	1	12,2	33,8

Test arrangement : See D8046
A photo detector was used to determine the venting time
In order to o achieve the internal discharge the surge arrester has been electrically pre-failed by means of a power frequency over-voltage application using an auxiliary low power source.
The short-circuit current of the auxiliary low power source has been set at about 20 A.
The voltage applied to the arrester was increased in order to get a current equal to 100 mA (0-peak) and kept at this value or slightly adjusted till arrester failure.
The pre-failure process duration was 2 minutes and 40 seconds.
The short-circuit test was performed 3 minutes and 50 sec after the completion of the pre-failure process.

Condition of the apparatus before the tests: new.

Date: May 21, 2008

Test	Oscillogram		Arrester under test	Duration	Test voltage	Test current		Time to flame extinction after the test	Venting time	Notes
						Peak value	rms value			
No.	No.	Sheets	No.	s	kV	kA	kA	s	ms	No.
2	28	1	3	0,204	18,0	31,0	12,2	-	1,0	-

Condition of the apparatus after the tests: see photos No.3 and 4
- There was not violent shattering.
- The arrester structure was damaged by the test.
- The arrester remained connected to the supply and return circuit.
- No fragment were found inside or outside the enclosure.

Acceptance criteria: Fulfilled.
Test result: Positive.

ВЯРНО С
ОРИГИНАЛА

108

High-current short-circuit test with 6,50 kA for 0,204 s

Test circuit : See D0046 Power factor : <0,15 Frequency : 50 Hz

169

ВЯРНО С ОРИГИНАЛА

Prospective test current			
Oscillogram		rms value	Peak value
No.	Sheets	kA	kA
25	1	6,60	18,1

Test arrangement : See D8046
A photo detector was used to determine the venting time.
In order to o achieve the internal discharge the surge arrester has been electrically pre-failed by means of a power frequency over-voltage application using an auxiliary low power source.
The short-circuit current of the auxiliary low power source has been set at about 20 A.
The voltage applied to the arrester was increased in order to get a current equal to 100 mA (0-peak) and kept at this value or slightly adjusted till arrester failure.
The pre-failure process duration was 3 minutes and 0 seconds.
The short-circuit test was performed 4 minutes and 10 sec after the completion of the pre-failure process.

Condition of the apparatus before the tests: new.

Date: May 20. 2008

Test	Oscillogram		Arrester under test	Duration	Test voltage	Test current		Time to flame extinction after the test	Venting time	Notes
						Peak value	rms value			
No.	No.	Sheets	No.	s	kV	kA	kA	s	ms	No.
3	26	1	2	0,204	18,0	16,0	6,50	-	2,0	-

Condition of the apparatus after the tests: see photos No.5 and 6
- There was not violent shattering.
- The arrester structure remained (almost) intact.
- The arrester remained connected to the supply and return circuit.
- No fragment were found inside or outside the enclosure.

Acceptance criteria: Fulfilled.
Test result: Positive.

Low-current short-circuit test with 630 A for 1,00 s

Test circuit : See D0046 Power factor : <0,15 Frequency : 50 Hz

Prospective test current			
Oscillogram		rms value	Peak value
No.	Sheets	A	A
22	1	630	1590

Test arrangement : See D8046
A photo detector was used to determine the venting time.
In order to o achieve the internal discharge the surge arrester has been electrically pre-failed by means of a power frequency over-voltage application using an auxiliary low power source.
The short-circuit current of the auxiliary low power source has been set at about 20 A.
The voltage applied to the arrester was increased in order to get a current equal to 100 mA (0-peak) and kept at this value or slightly adjusted till arrester failure.
The pre-failure process duration was 3 minutes and 05 seconds.
The short-circuit test was performed 3 minutes and 15 sec after the completion of the pre-failure process.

Condition of the apparatus before the tests: new.

Date: May 20, 2008

Test	Oscillogram		Arrester under test	Duration	Test voltage	Test current		Time to flame extinction after the test	Venting time	Notes
						Peak value	rms value			
No.	No.	Sheets	No.	s	kV	A	A	s	ms	No.
4	24	1	1	1,00	23,0	1190	630	105	8,0	-

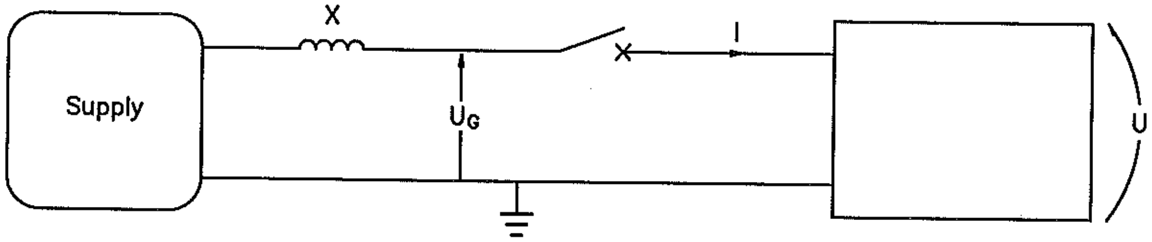
Condition of the apparatus after the tests: see photos No.7 and 8
- There was not violent shattering.
- The arrester structure was damaged by the test.
- The arrester remained connected to the supply and return circuit.
- No fragment were found inside or outside the enclosure.

Acceptance criteria: Fulfilled.
Test result: Positive.

170

ВЯРНО С ОРИГИНАЛА

Test circuit D0046



Symbols used in this diagram are the same as those on the oscillograms.

ВЯРНО С
ОРИГИНАЛА

171

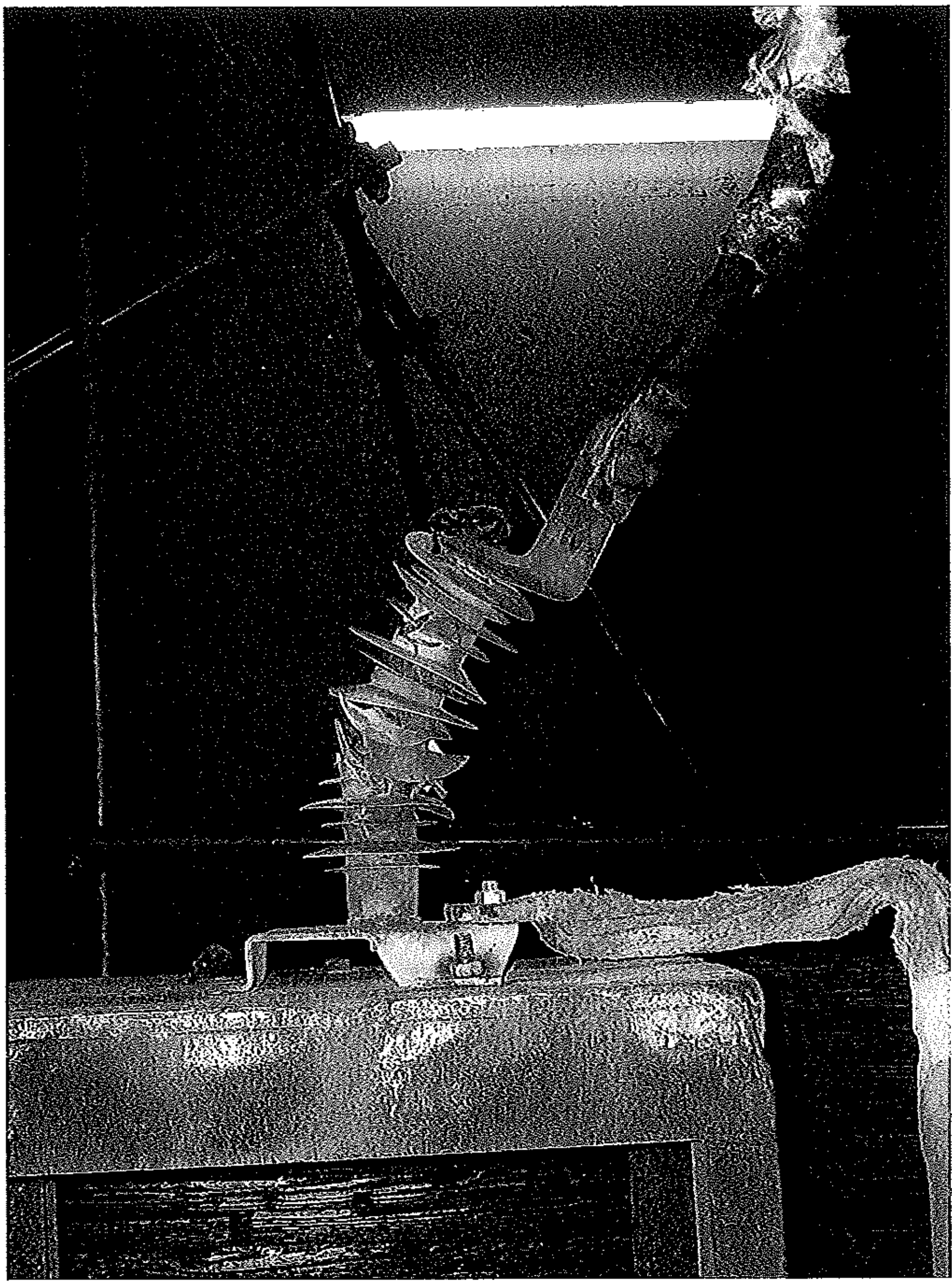


Photo No.1

ВЯРНО С ОРИГИНАЛ

172

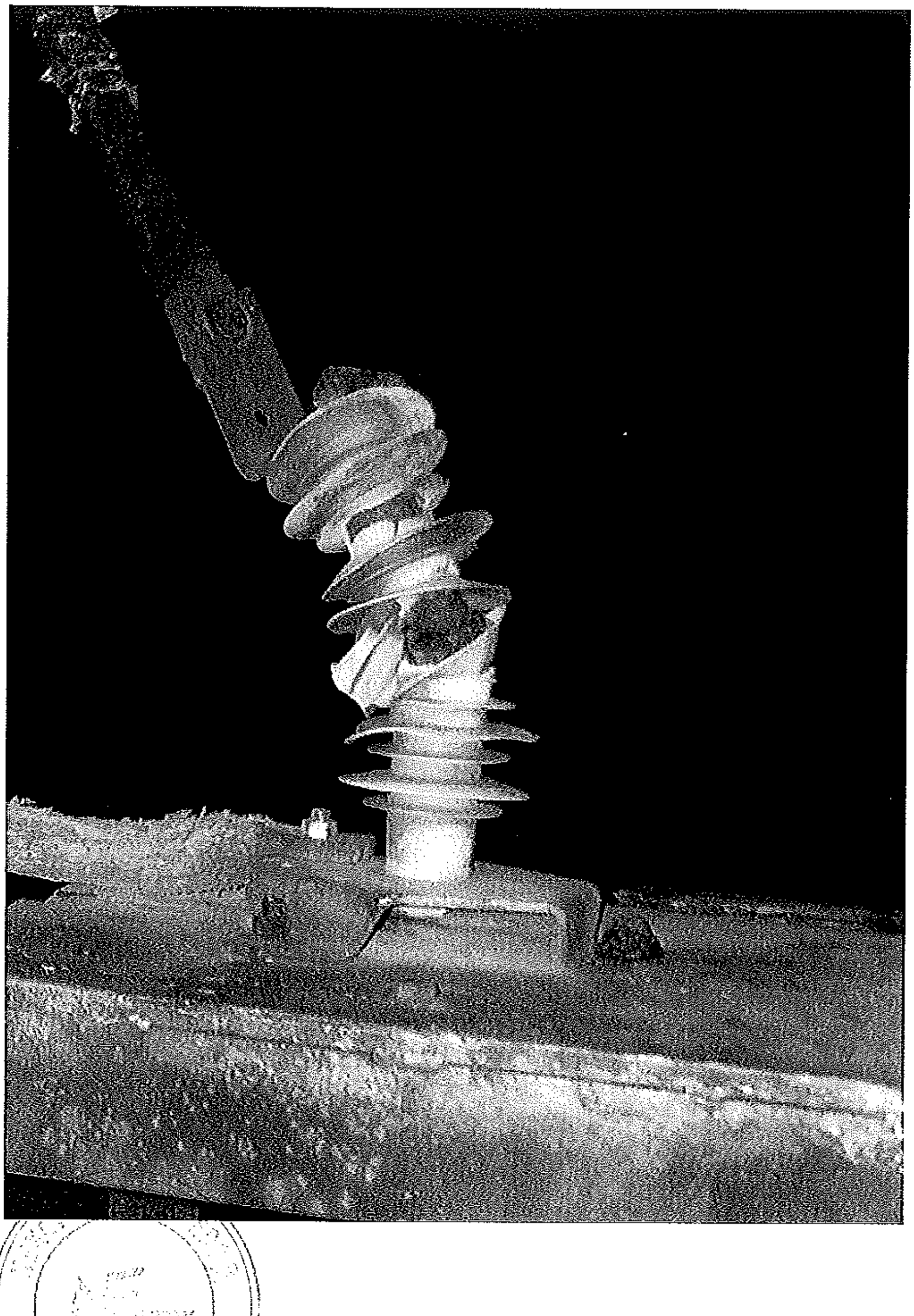
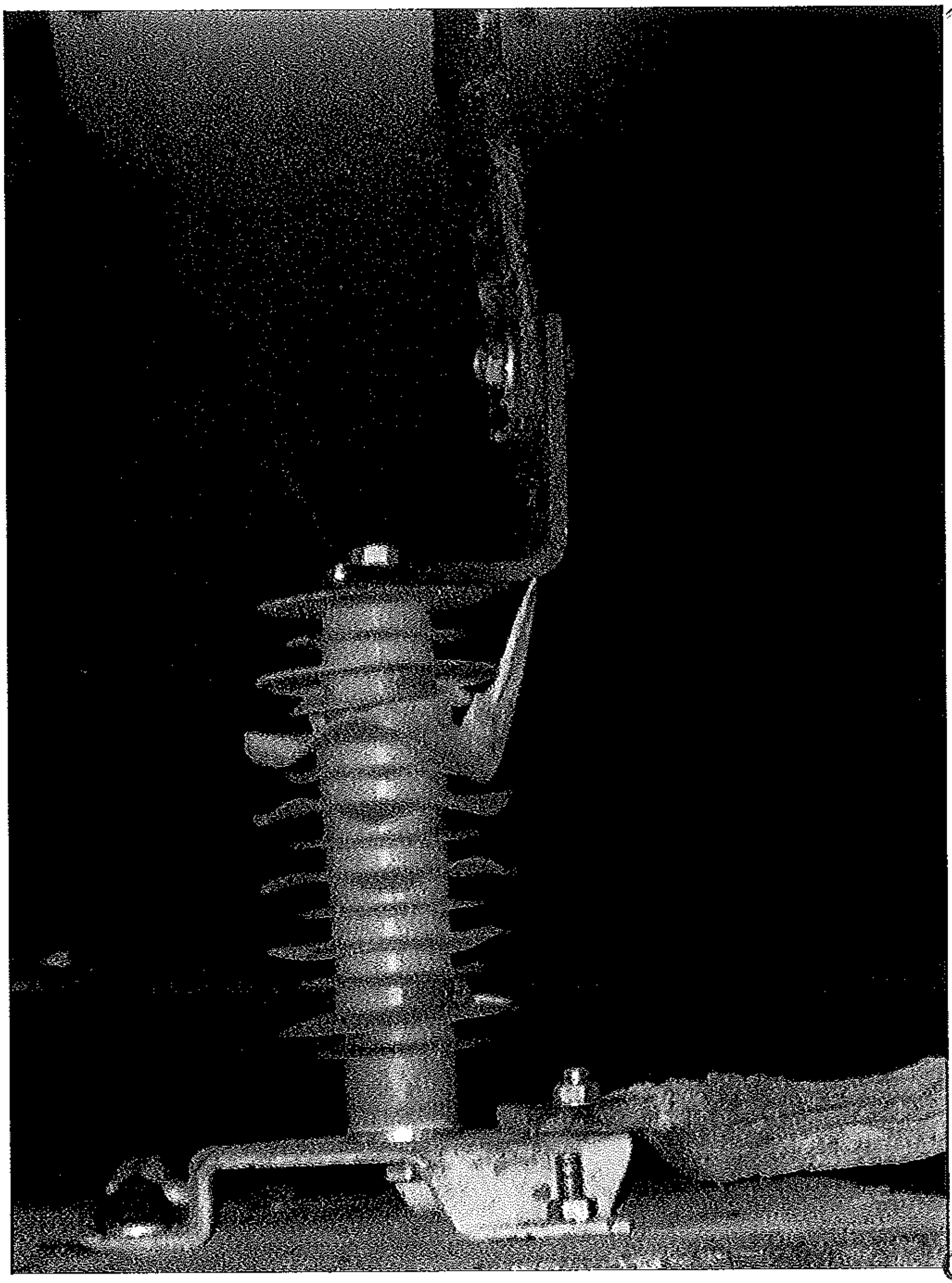


Photo No.2

ВЯРНО С ОРИГИНАЛА



ВЯРНО С
ОРИГИНАЛ

Photo No.3

174

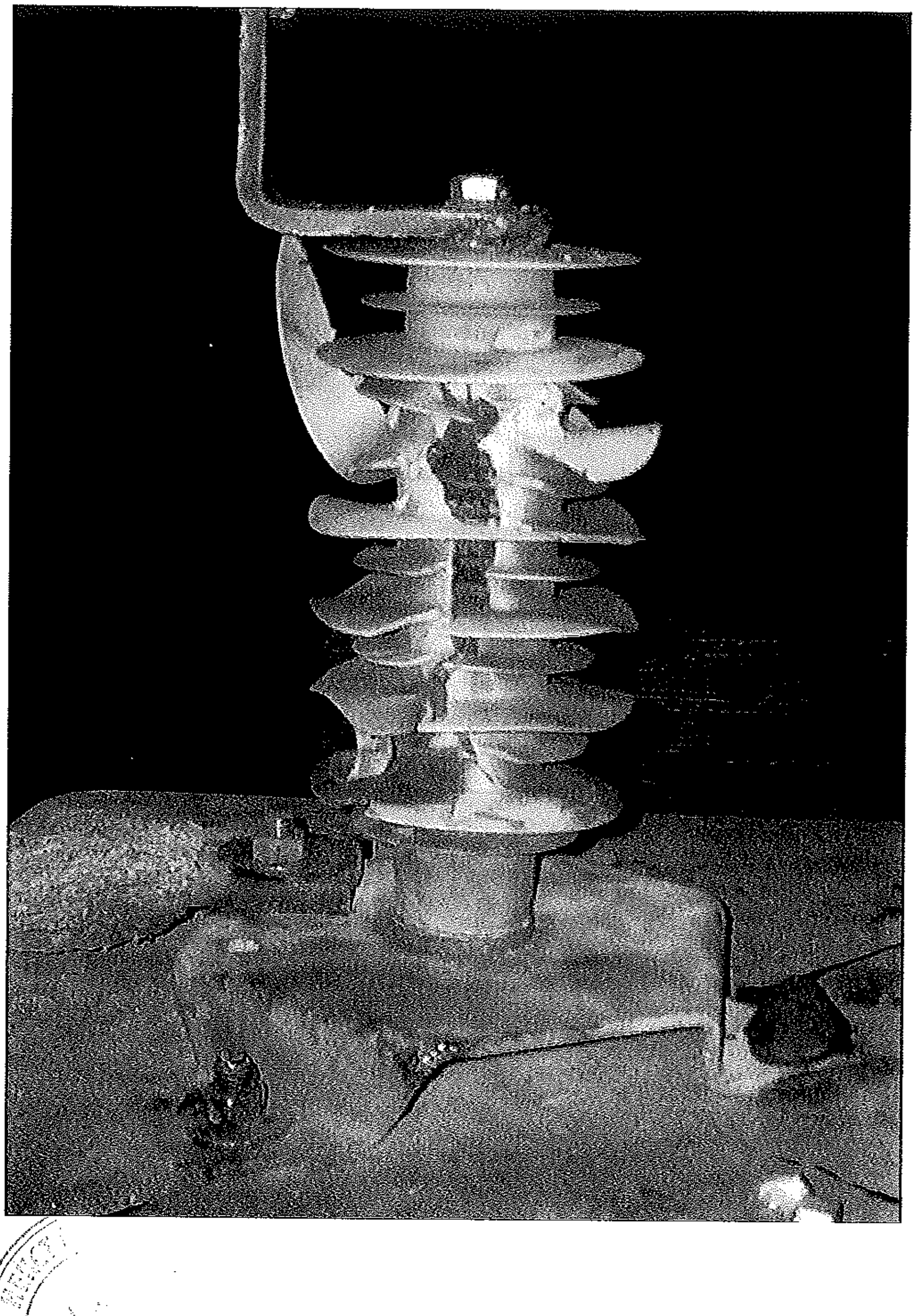


Photo No. 4

ВЯРНО С
ОРИГИНАЛА

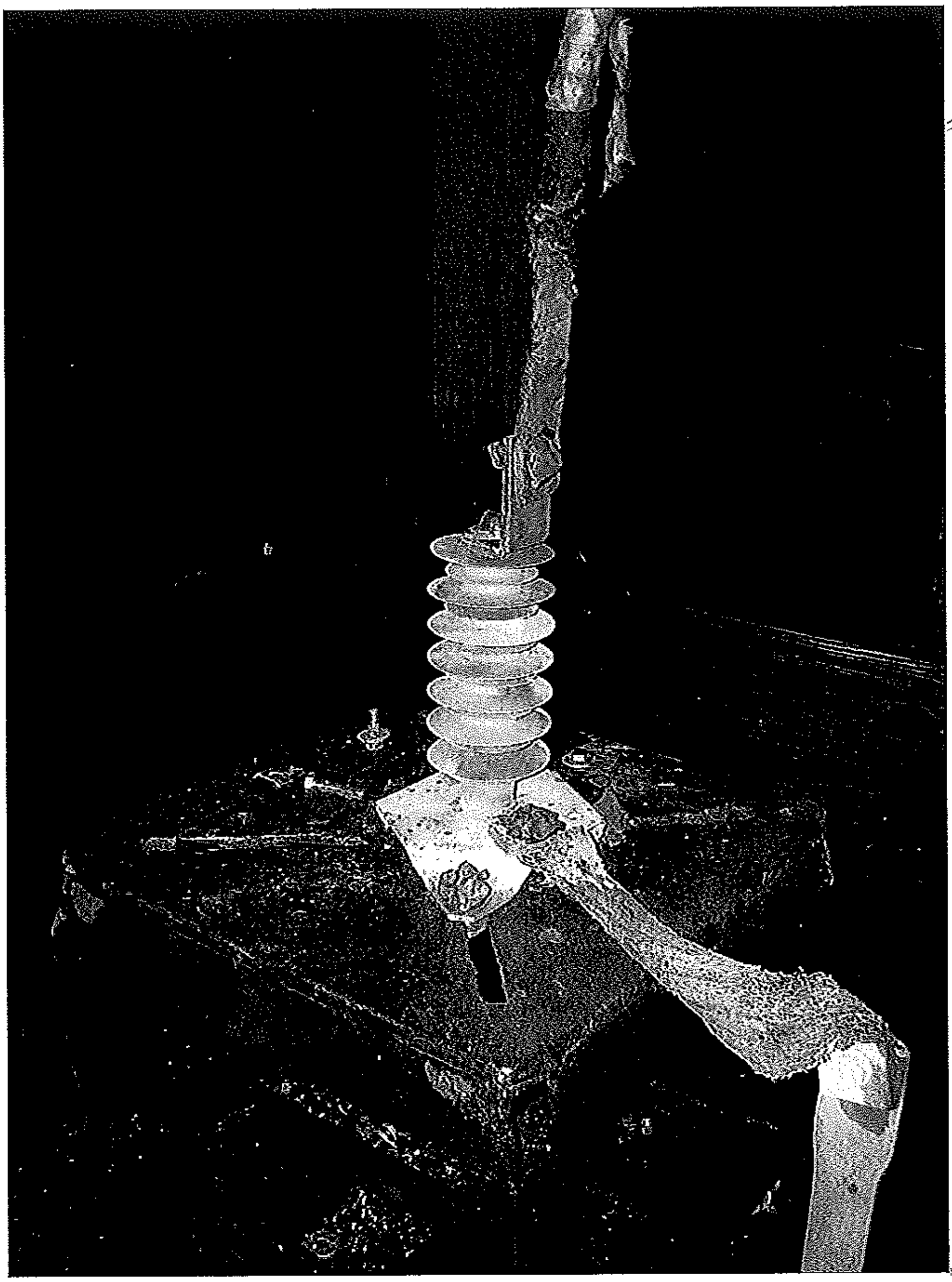
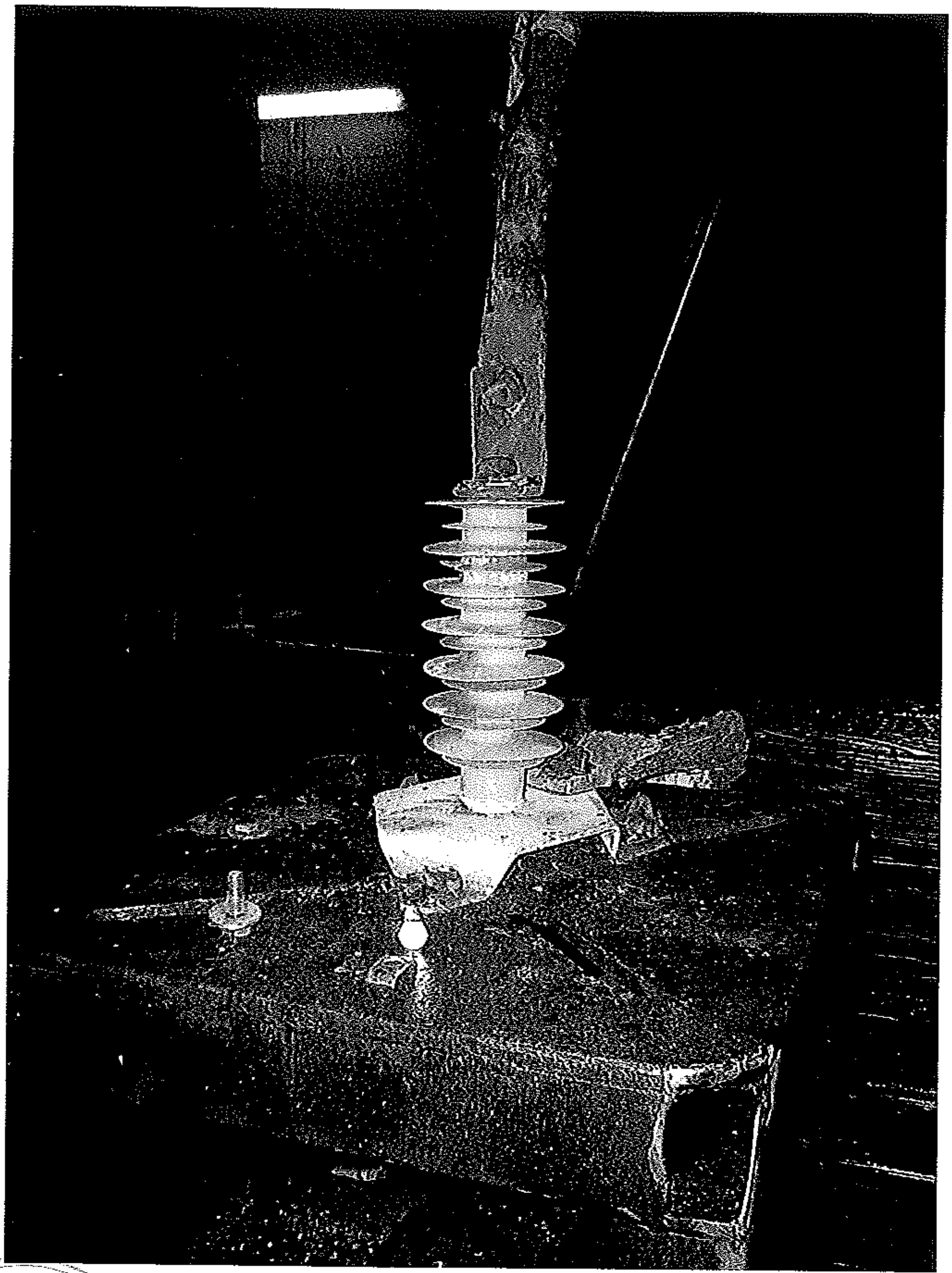


Photo No.5

ВЯРНО С
ОРИГИНА

176



ВЯРНО С ОРИГИНАЛА

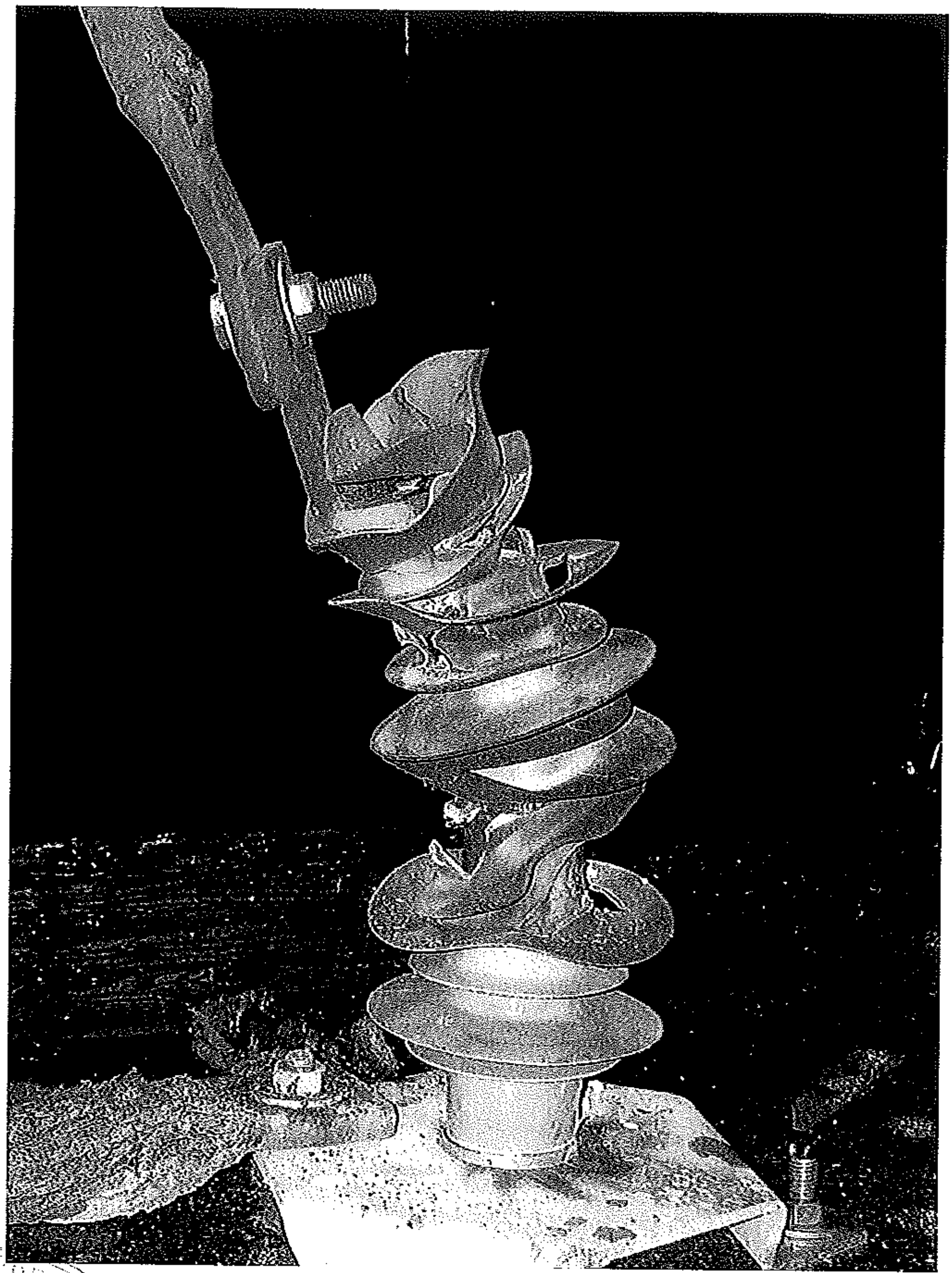
Photo No.6

177

Photo No.7

ВЯРНО С
ОРИГИНАЛ

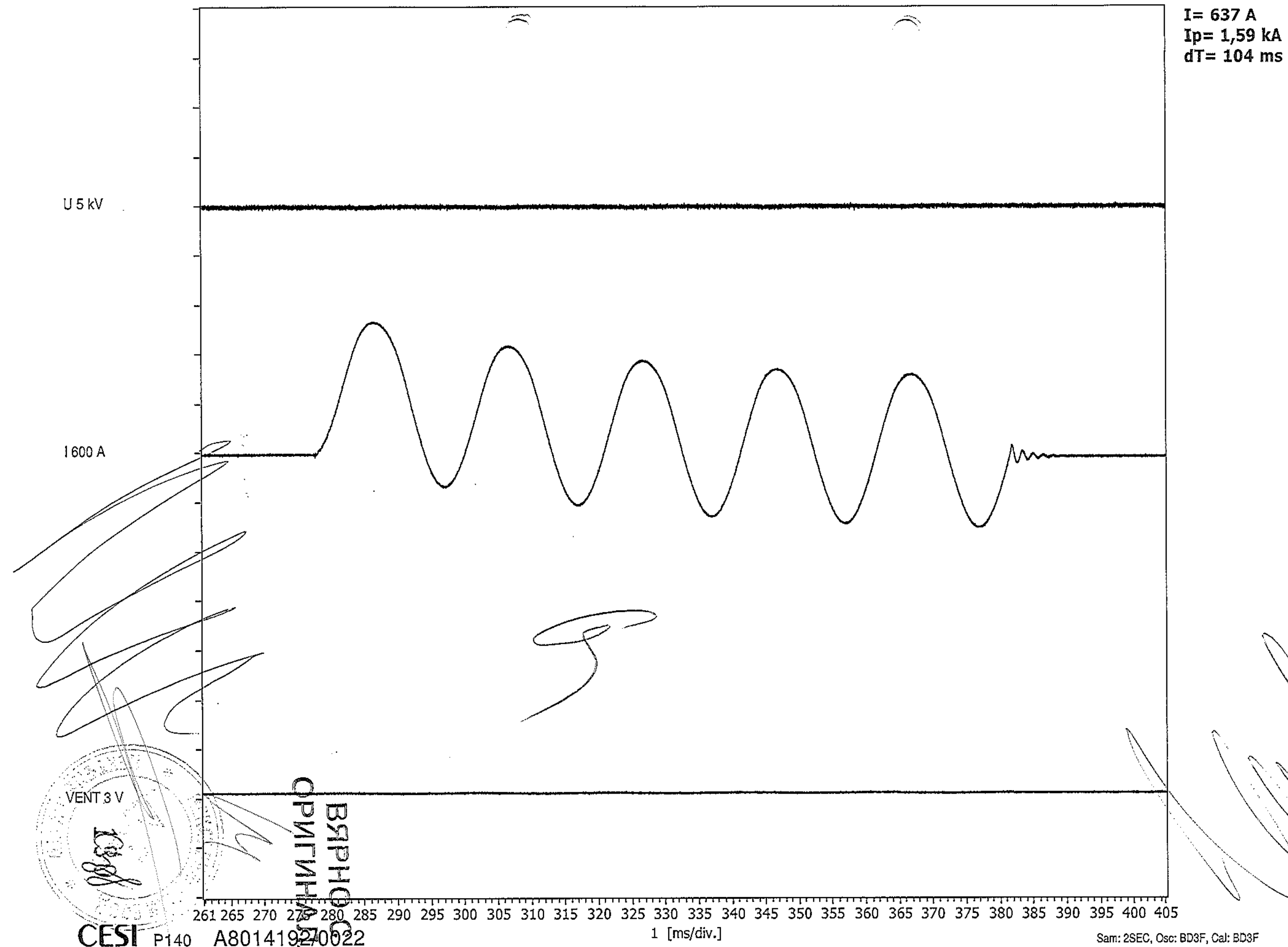
178



ВЯРНО С ОРИГИНАЛА

Photo No.8

179



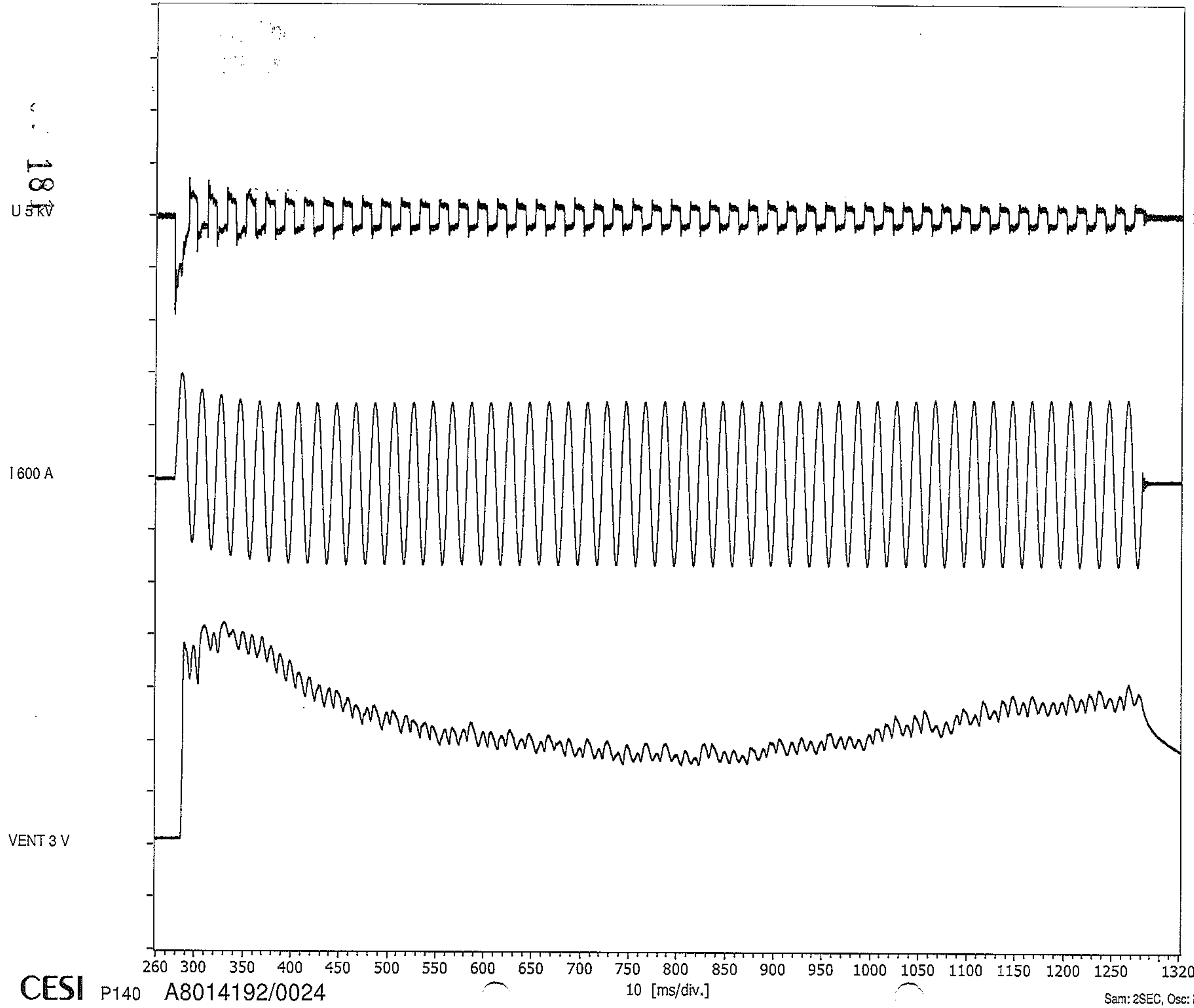
CESI P140 A801419270022

Sam: 2SEC, Osc: BD3F, Cal: BD3F

ВЯРНО С
ОРИГИНАЛА

181

I= 630 A
Ip= 1,19 kA
dT= 1 s
dT= 8,0 ms

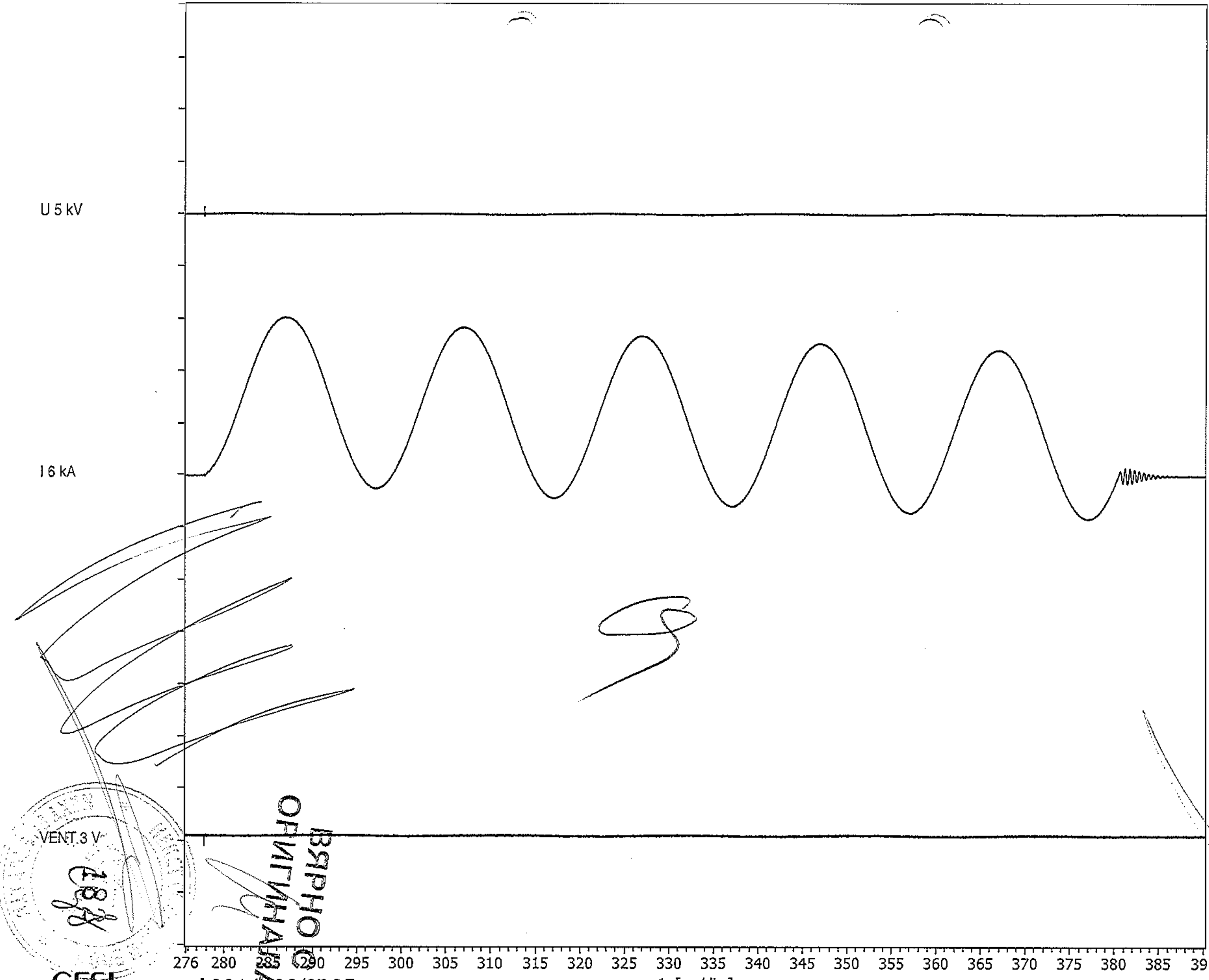


CESI P140 A8014192/0024

Sam: 2SEC, Osc: BD3F, Cal: BD3F

ВЯРНО С
ОРИГИНАЛА

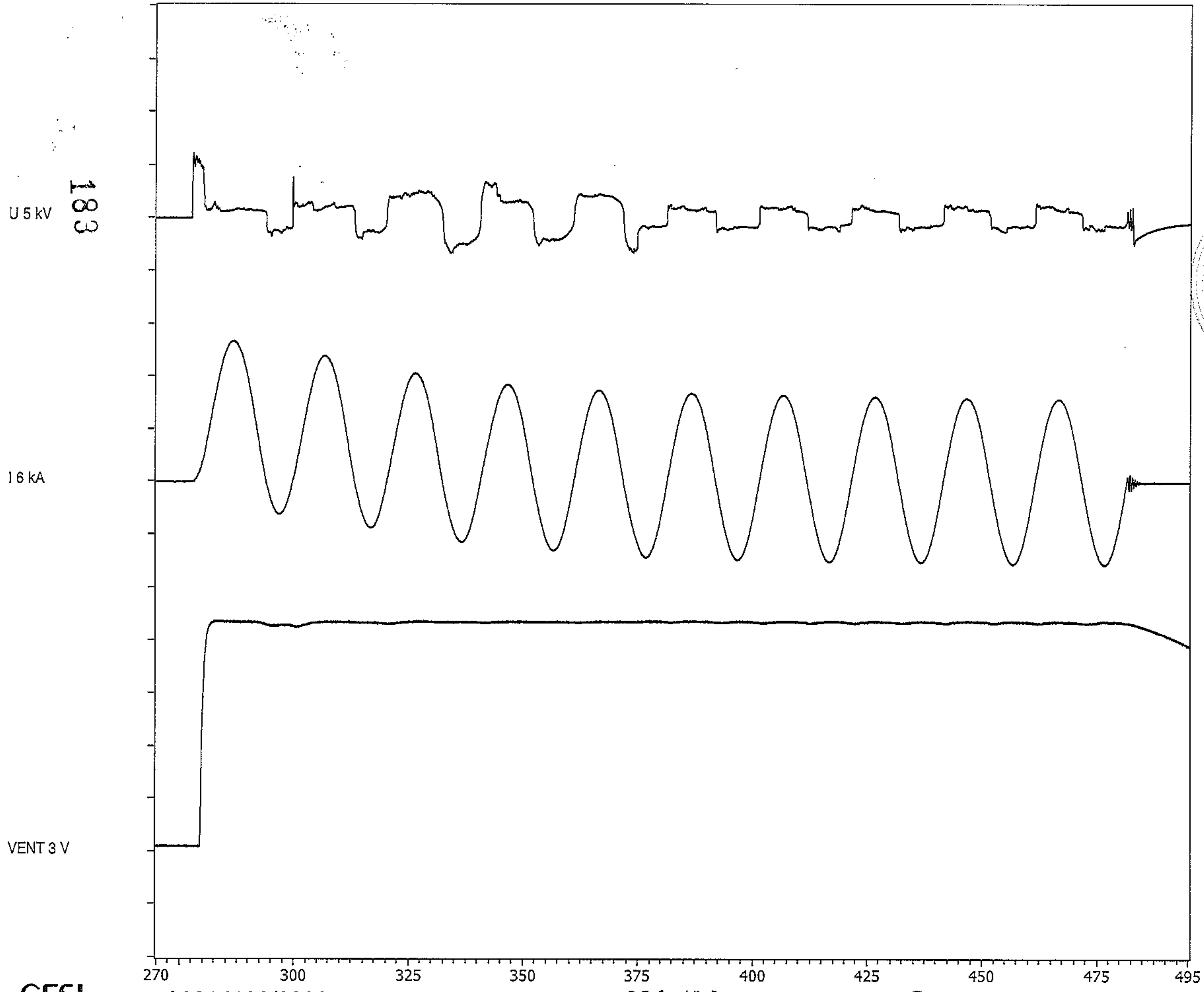
I= 6,59 kA
Ip= 18,1 kA
dT= 103 ms



ВЯРНО С ОРИГИНАЛА

CESI P140 A8014192/0025

Sam: 2SEC, Osc: BD3F, Cal: BD3F



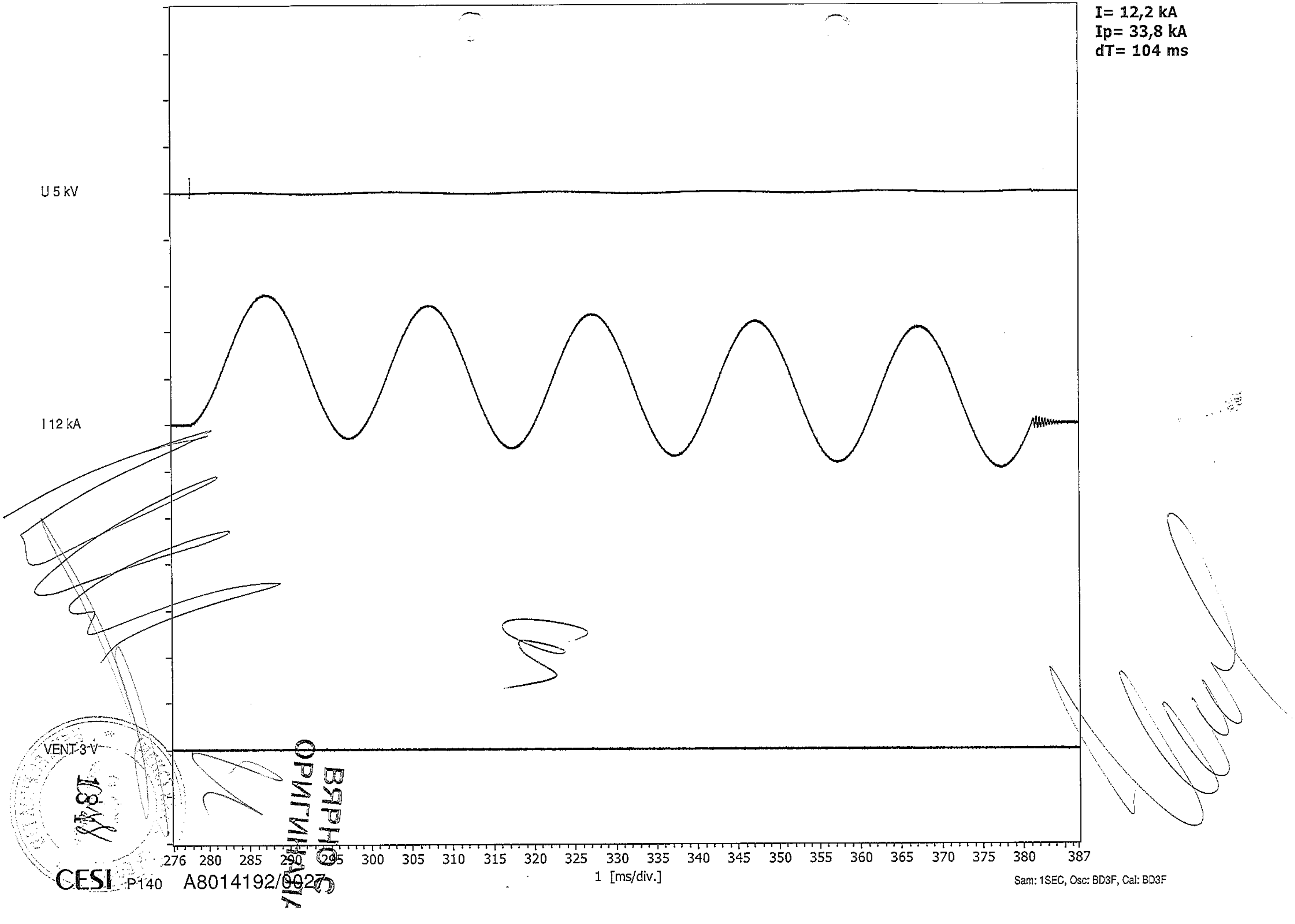
183

CESI P140 A8014192/0026

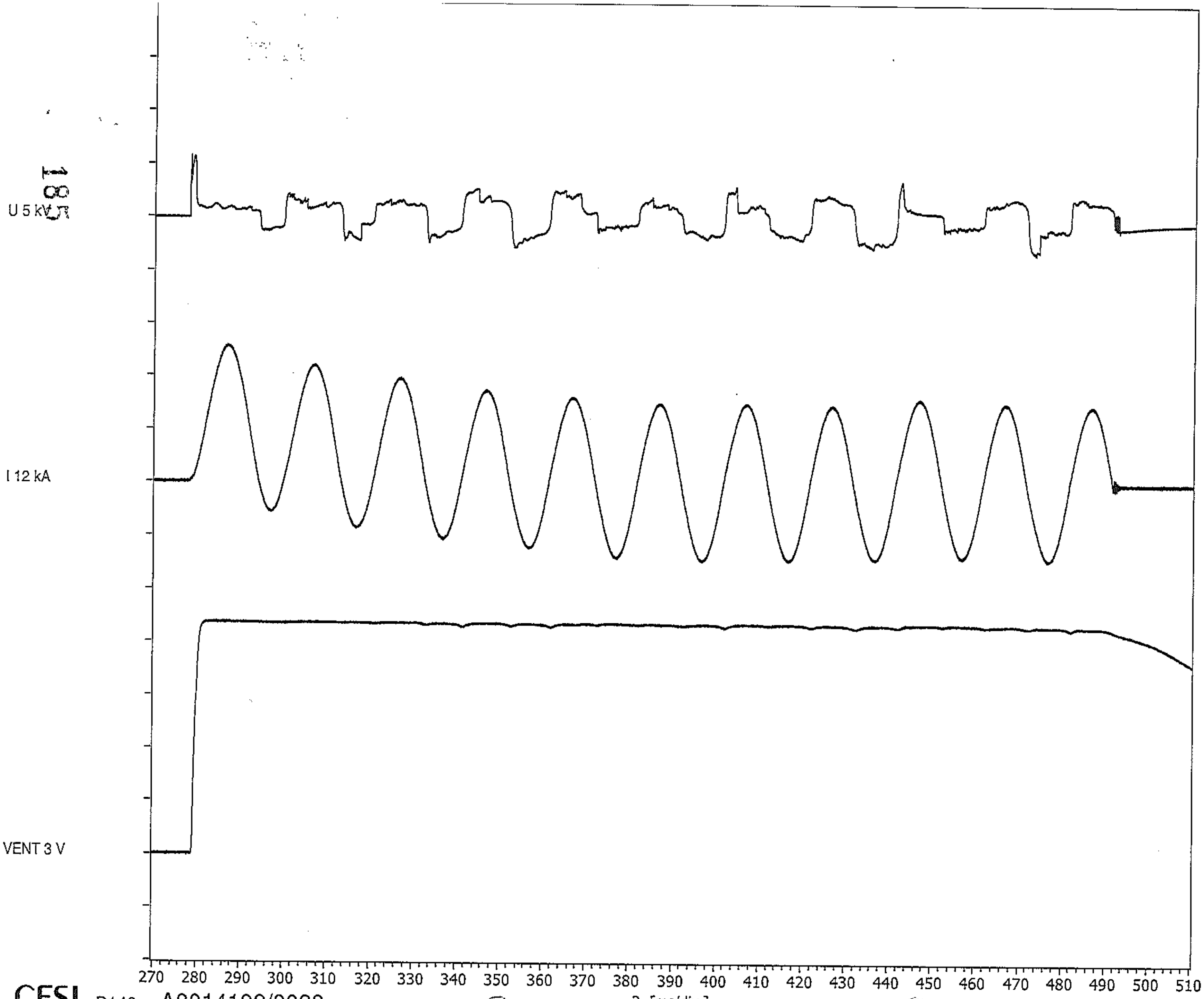
Sam: 2SEC, Osc: BD3F, Cal: BD3F

ВЯРНО С ОРИГИНАЛА

I= 12,2 kA
Ip= 33,8 kA
dT= 104 ms



I= 12,2 kA
Ip= 31 kA
dT= 214 ms
dT= 1,02 ms

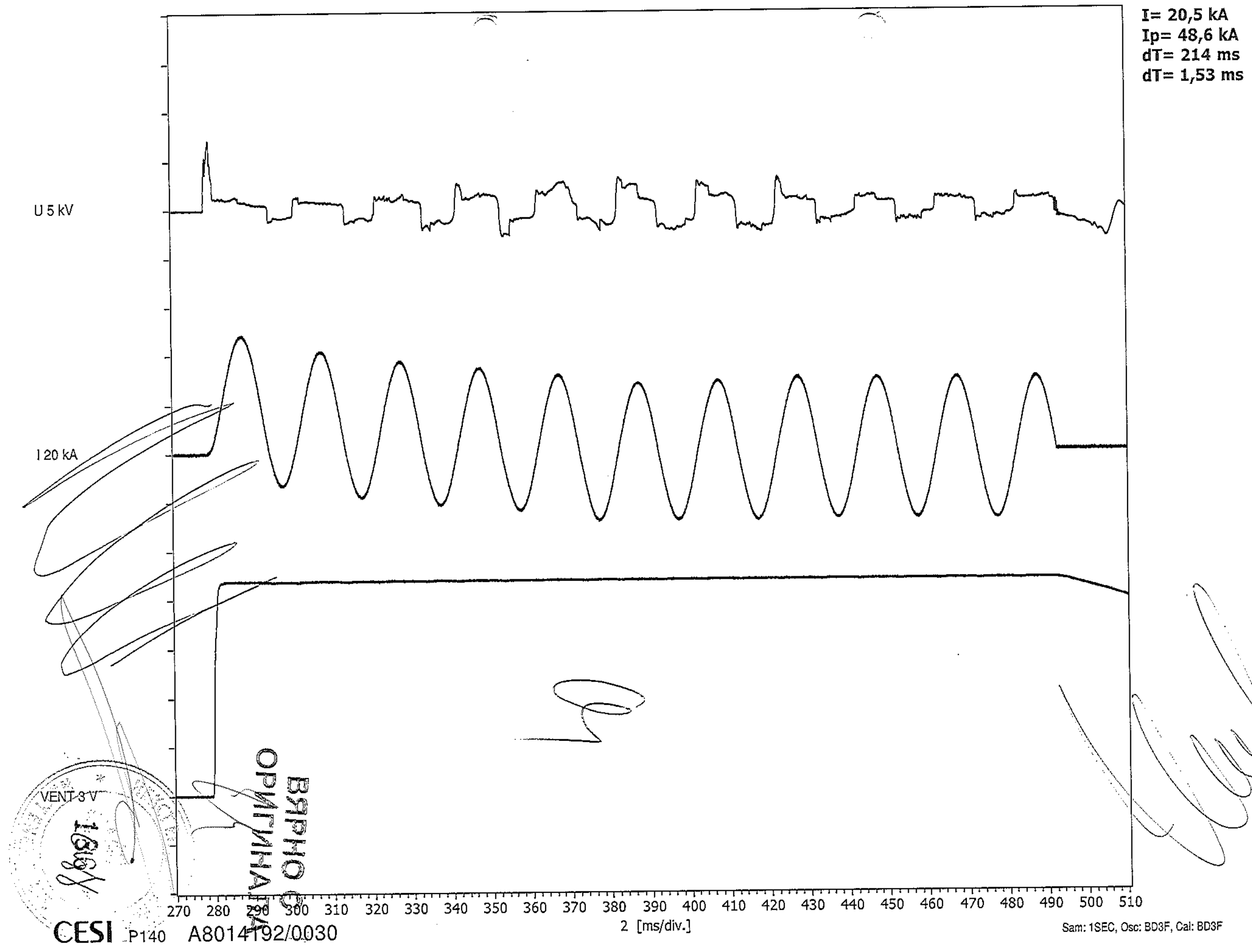


CESI P140 A8014192/0028

Sam: 1SEC, Osc: BD3F, Cal: BD3F

ВЯРНО С ОРИГИНАЛА

185



ВЯРНО С
ОРИГИНАЛА

client	**ALSTOM Parafoudres S.A. - Bagneres de Bigorre Cedex (France)**
equipment under test	three 10kA polymer housed surge arresters, type HE
tests performed	partial discharges test
normative documents	IEC 60099-4 (1991-06)
receipt date of the sample	december 15, 2000
test date	**from** december 22, 2000 to december 22, 2000

the test results relate only to the sample tested
this document shall not be reproduced except in full without the written approval of CESI
and of the accreditation body, if any

n° 0030

ВЯРНО С ОРИГИНАЛА

no. of pages	10	**no. of pages annexed**	2

issue date	december 22, 2000
prepared	PeC/TEST - C. Del Giorgio
verified	PeC/TEST - A. Sironi
approved	PeC/TEST - V. Scarioni

CESI
CENTRO ELETTROTECNICO SPERIMENTALE ITALIANO
Business Unit
Prove e Componenti
Il Responsabile del Laboratorio

tests witnessed by: Mr. F. Malpiece - ALSTOM Parafudre S.A.

identification of the object: effected

The Manufacturer guarantees that the tested object is manufactured according to the submitted drawings.

CESI checked that this drawing adequately represents in shape and dimensions the essential details and the parts of the tested object.

This drawing identified by CESI and numbered **A0/042527 no.1** is annexed to this document.

The measurement uncertainties of the test results reported in this document are the following:

- dielectric tests with impulse voltage : **peak voltage: ± 3 % ; time parameters: ± 10 %**
- dielectric tests with impulse current : **peak value: ± 3 % ; time parameters: ± 10 %**
- dielectric tests with alternating voltage : **voltage (rms): ± 3 %**
- dielectric tests with direct voltage : **voltage: ± 3 %**

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to a confidence level of about 95 %) and have to be considered as maximum values.

ВЯРНО С ОРИГИНАЛ

laboratory information

CESI testing team:	Mr. M. Amato
test laboratory:	P220 (faraday Cage)
activity code:	29380X
keywords:	12015R 23801L 31020W 41040M 53001D 62501B

183

pages annexed

Oscillogram (total pages:2)

reference document annexed

drawing no. W 8997 01 36 identified by CESI and numbered **A0/042527 no.1**

ВЯРНО С ОРИГИНАЛА

rated characteristics of the test voltage declared by the manufacturer

polymer housed surge arrester

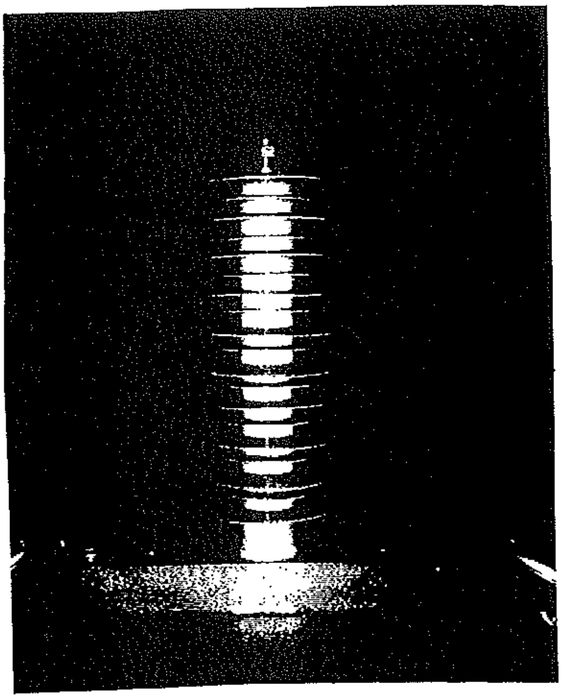
manufacturer	ALSTOM Parafudre S.A.
type	HE
drawing no.	W 8997 01 36
rated voltage (U_r)	36 kV
continuous operating voltage (U_c)	30 kV_{rms}
nominal discharge current (I_N)	10 kA
line discharge class	1
dry lightning impulse withstand voltage	170 kV_{pk}
wet power frequency withstand voltage	70 kV_{rms}

NOTE: CESI marked the three polymer housed surge arresters from no.1 to no.3

ВЯРНО С ОРИГИНАЛА

190

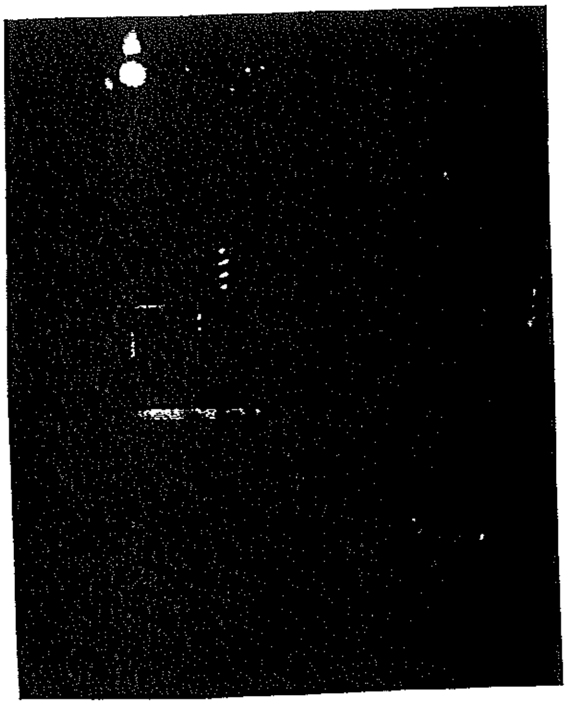
panoramic view of the test sample



ВЯРНО С ОРИГИНАЛА

191

panoramic view of the test arrangement



ВЯРНО С ОРИГИНАЛА

test voltage values

Partial discharges test

prestressing (≤10s) = U_r = 36,0 kV

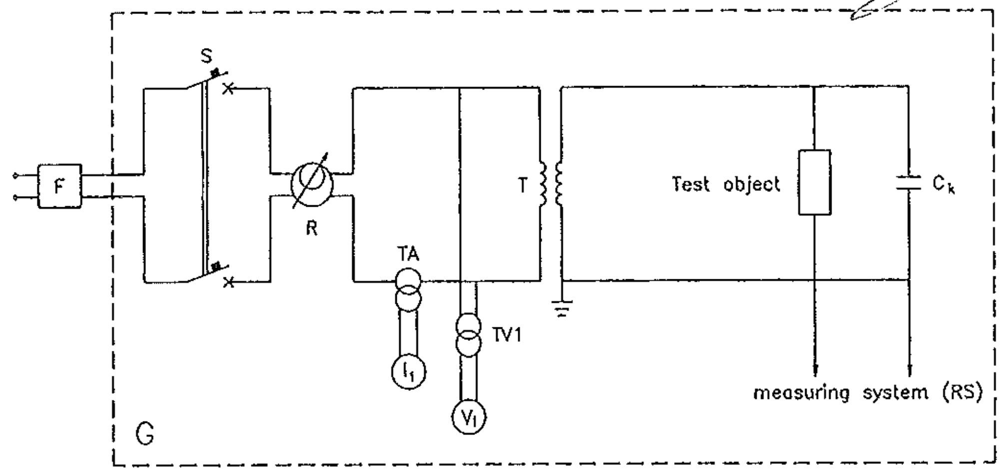
measure = 1,05xU_c = 1,05x30,0 = 31,5 kV

ВЯРНО С ОРИГИНАЛ

193

circuit A027

Plant P220. High voltage circuit
partial discharges measurement



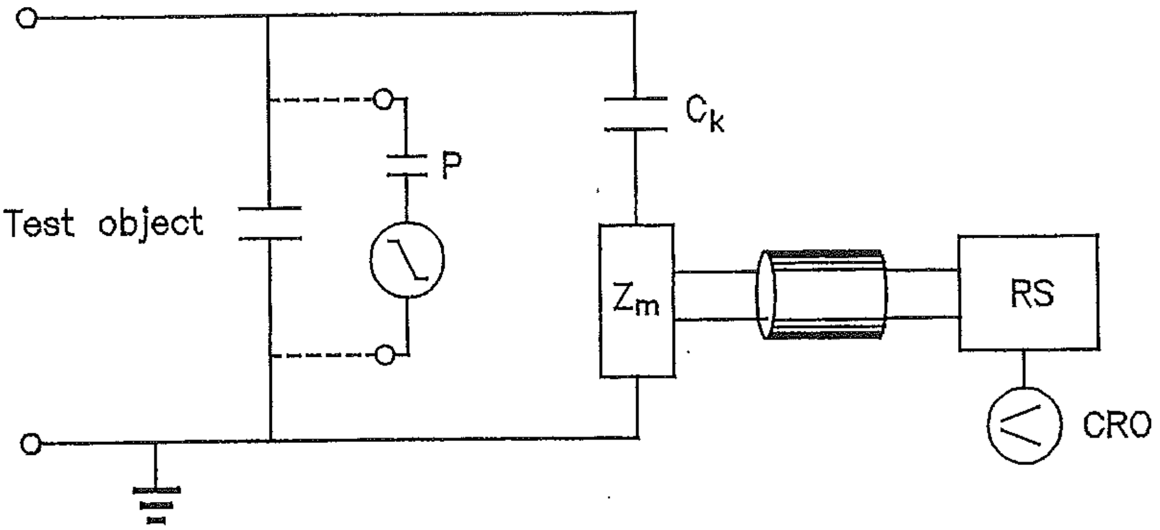
F : wide band filter TELEC; 380 V; 100 A
G : Faraday cage
S : single phase circuit breaker SACE; 600 V; 800 A
R : regulator CORMES; power 66 kVA; voltage 380 V/0 ÷ 220 V
T : booster transformer PIVI; power 250 kVA; voltage 200-400 V/250 kV
C_k : coupling capacitor PASSONI & VILLA; 300 pF; 250 kV (internat to T)
TA : current transformer CGS; ratio 150-300 A/5 A
TV_1: voltage transformer; ratio 220 V/100 V
V_1 : voltmeter CESI no. 6393
RS : partial discharge detector BIDDLE; CESI no. 09596

ВЯРНО С
ОРИГИНАЛА

circuit A022

partial discharges measurement

direct circuit
scheme 1a



C_k : coupling capacitor 300 pF; CESI no. -----
Z_m : coupling impedance
P : calibrator CESI no.02526
RS : partial discharge detector BIDDLE; CESI no.09596
CRO: oscilloscope CESI no.06351

ВЯРНО С ОРИГИНАЛА

partial discharges test

test object: polymer housed surge arresters, type HE

test circuit: A027

measurement circuit: A022 ("direct" calibration : 0,2 pC/mV, on CRO, oscillogram no.1)

arrangement: see page 6

atmospheric conditions		
b	t	h
kPa	°C	g / m^3
101,5	20,0 (13,5)	7,3

date: december 22, 2000

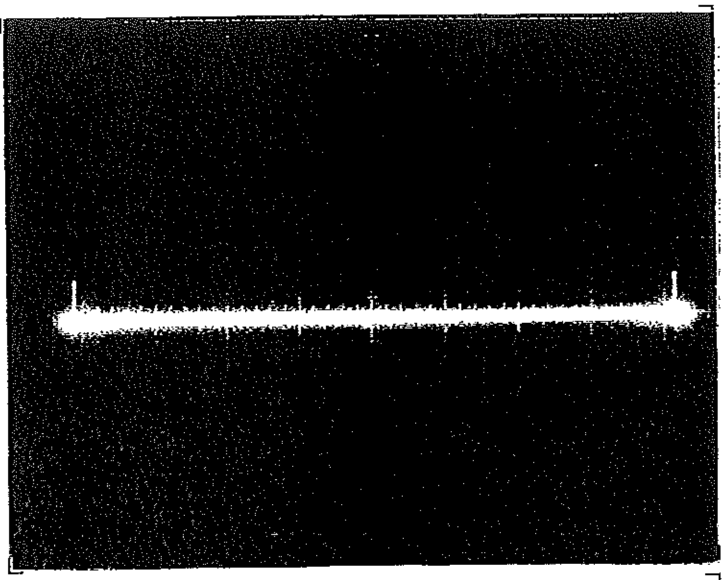
test sample	applied voltage	duration of voltage application	temperature of the test object	partial discharge measurement: voltage increase: CRO readout	voltage increase: Q max	voltage decrease: CRO readout	voltage decrease: Q max	oscillogram	note
	kV_{rms}	sec	°C	mV	pC	mV	pC	no.	
1	36,0 (U_r)	≤10	20,0	--	--	--	--	-	
	31,0 (1,05U_c)	measure	20,0	--	--	≤5	≤1	4	
2	36,0 (U_r)	≤10	20,0	--	--	--	--	-	
	31,0 (1,05U_c)	measure	20,0	--	--	≤5	≤1	5	
3	36,0 (U_r)	≤10	20,0	--	--	--	--	-	
	31,0 (1,05U_c)	measure	20,0	--	--	≤5	≤1	6	

Before the test have been made: measure of the background noise; the result: p.d. ≤5mV ≤1pC (oscillogram no.2)

Corona's effect (oscillogram no.3)

ВЯРНО С ОРИГИНАЛА

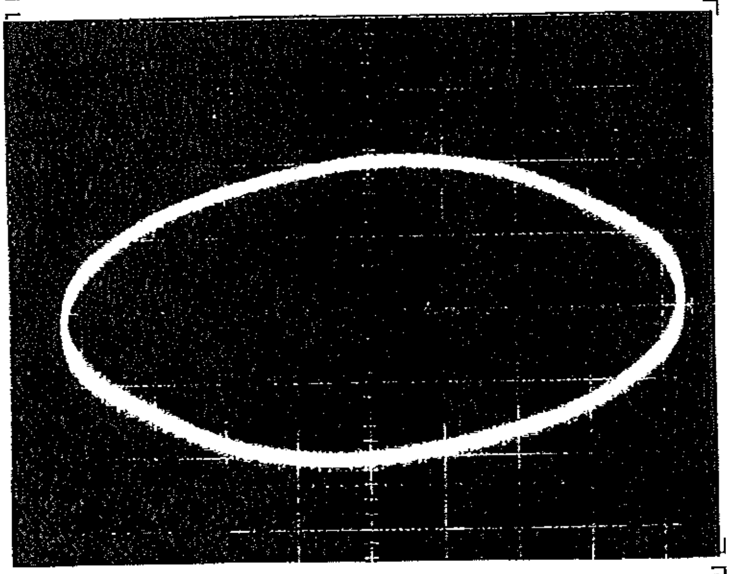
196



Oscillogram no.1

Channel 1 :
voltage : 100 mV/div

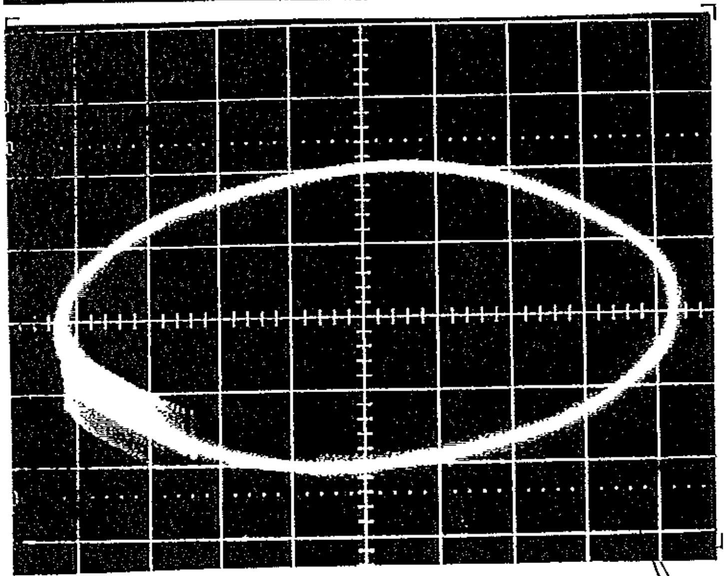
calibration of the measure circuit
q =50pC =250mV
K= 0,2pC/mV



Oscillogram no.2

Channel 1 :
voltage : 20 mV/div

measure of the background noise
p.d. ≤5mV ≤1pC

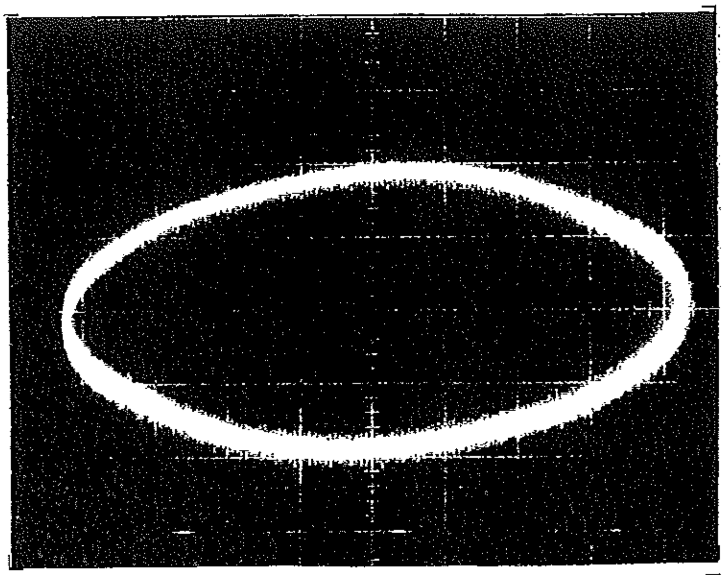


Oscillogram no.3

Channel 1 :
voltage : 100 mV/div

corona effect
negative polarity

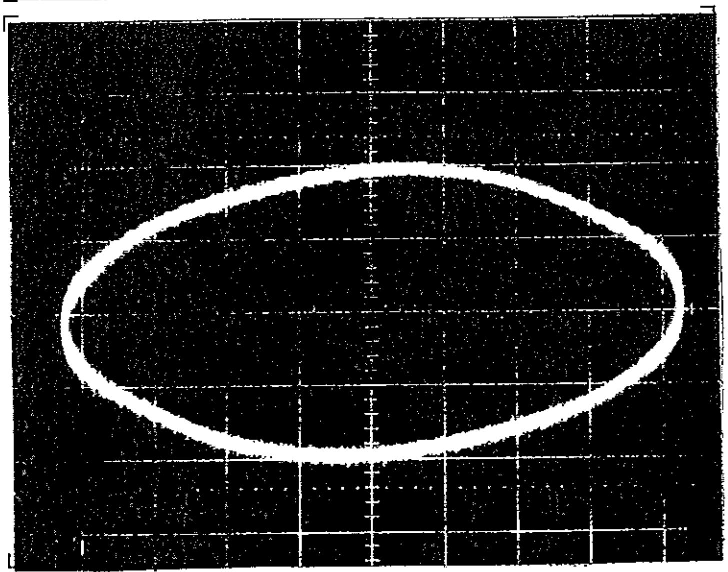
ВЯРНО С ОРИГИНАЛА



Oscillogram no.4

Channel 1 :
voltage : 20 mV/div

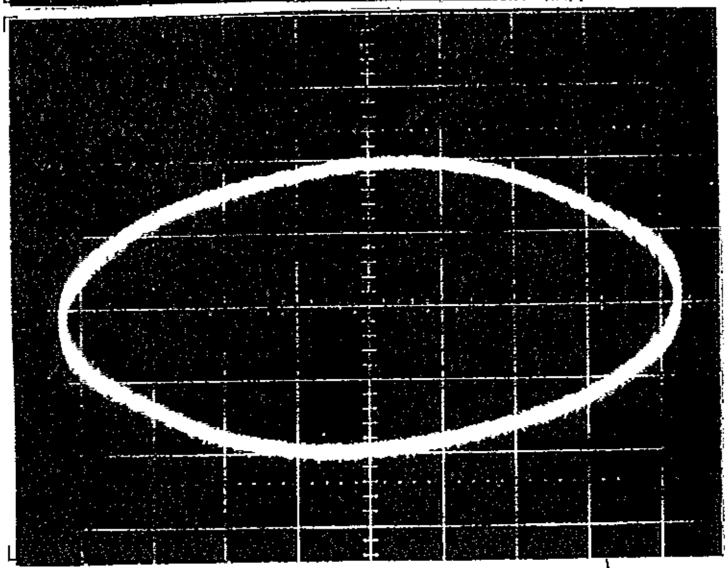
sample no.1
U =31kV
p.d. ≤5mV ≤1pC



Oscillogram no.5

Channel 1 :
voltage : 20 mV/div

sample no.2
U =31kV
p.d. ≤5mV ≤1pC

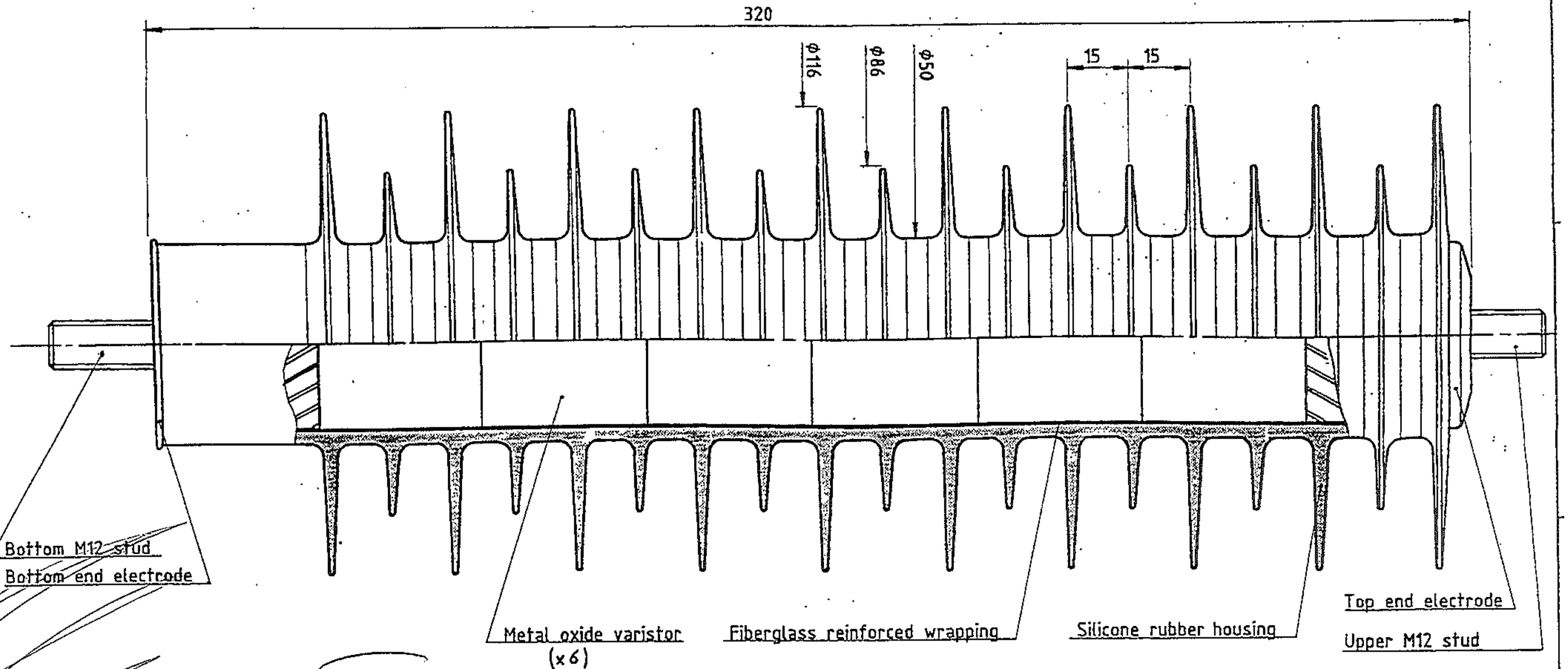


Oscillogram no.6

Channel 1 :
voltage : 20 mV/div

ВЯРНО С
ОРИГИНАЛА

sample no.3
U =31kV
p.d. ≤5mV ≤1pC



PROTOCOL A 0/ 0 4 2 2 n.0 0 1
DATA 2 2 DIC. 2000
ВЯРНО С ОРИГИНАЛА
Firma

Accessibilité du plan : Confidentiel ☐ Libre ☒

Ce plan est propriété de ALSTOM Parafoudres SA ; il ne peut être ni reproduit ni communiqué sans autorisation préalable

Modification :	Dessinateur :	Date :	Vérification :
Tolérances générales :			
Matière :			
Traitement :			
Echelle :	Dessinateur : HS	Date : 12/12/00	Vérification :

VARISIL type HE 36
surge arrester

ALSTOM
TRANSMISSION & DISTRIBUTION
Parafoudres
B.P. 256
65202 Bagnères-de-Bigorre

A3 APF W 8997 01 36

Folio : 1 / 1
Indice : 00

Type Test Report
No.: TR-E 12019BM

Equipment under test:	**Polymer housed surge arrester of line discharge class 1, type series VARISIL HE-S** **TRIDELTA Parafoudres S.A.**
Normative documents:	IEC 60099-4 Edition 2.2 clause 10.8.9 / 8.9
Test performed:	Bending moment test
Test date:	18th of October 2012 to 13th of November 2012
Number of pages:	19

First issue date: 15th of November 2012

Dipl.-Ing.	T. Hölzer	Torsten Hölzer	(Test Engineer, Tridelta)
Dipl.-Ing.	H. Klaube	H. Kl	(R&D Head, Tridelta)
Dipl.-Ing.	S. Schreib	Schreib	(Head SCUS GmbH)

Hormsdorf, 15th of November 2012

TRIDELTA Überspannungsableiter GmbH
Marie-Curie-Straße 3
07629 Hermsdorf - Deutschland
Telefon +49 (0)3 66 01/9328 300
Fax +49 (0)3 66 01/9328 301
Internet http://www.tridelta.de

ВЯРНО С
ВЯРНО С
ОРИГИНАЛА

200

subject

Test of Bending Moment
Surge Arrester Series
VARISIL HE-S

manufacturer

TRIDELTA Parafoudres S.A.
Boulevard de l'Adour – B.P. 256
F – 65202 Bagnères de Bigorre Cedex

caused by

Type Test acc. to IEC 60099-4 Ed.2.2 Item 10.8.9 (2009-05)
Confirmation of
SLL: 200 Nm
SSL: 250 Nm

Test arrangement/course of test

Test acc. to IEC 60099-4 Ed. 2.2. Item 10.8.9 (2009-05)

The test was performed on 3 arresters made of 1 mechanical unit. The arresters were attached directly to the mounting surface of the testing machine. The direction of the load was through and perpendicular to the longitudinal axis of the arrester unit.

Test procedure:

1. Sample preparation/ Initial measurements acc. to 10.8.9.2
2. Bending moment test with SSL acc. to 10.8.9.3 a on 2 arrester units
3. Mechanical/thermal preconditioning acc. to 10.8.9.3.1 on 1 arrester unit
4. Water immersion test acc. to 10.8.9.3.2 on 3 arrester units
5. Test evaluation/ Final measurements acc. to 10.8.9.4

Sample	Type
A	VARISIL HE-S 42
B	VARISIL HE-S 42
C	VARISIL HE-S 42

The surge arrester type series "VARISIL HE-S" passed all tests, acc. to IEC 60099-4 Ed. 2.2 10.8.9, successfully. SLL = 200 Nm, SSL = 250 Nm; terminal torque = 45 Nm

Coordinated by :	S. Schreib, see test report "12-137 PB2_rev1 Product test - VARISIL TM HE-S 42" from SCUS
worked out by :	T. Hölzer
checked by :	H. Klaube

ВЯРНО С ОРИГИНАЛА

201

Test results

1. **Sample preparation/ initial measurements**

Watt losses at Uc

Sample No.	Voltage kV	watt losses W
A	35	3,63
B	35	3,79
C	35	3,72

Ambient temperature 20 °C

Partial discharge test

Sample No.	voltage kV	measured value pC	max. permitted value pC	ground noise pC	evaluation/ result
A	36,75	< 2	10	< 2	passed
B	36,75	< 2	10	< 2	passed
C	36,75	< 2	10	< 2	passed

Residual voltage test

Sample No.	measured value kV	current kA
A	114,9	10,2
B	114,6	10,2
C	114,6	10,2

ВЯРНО С ОРИГИНАЛА

202

203

2. Bending Moment test with SSL

Sample No.	Cantilever mm	Force N	Bending moment Nm	maximum deflection mm	residual deflection mm
A	397	630	250	4,53	-0,55
B	397	630	250	4,72	0,52
Sample C was subjected to the mechanical/thermal preconditioning					

The residual deflection was measured in the interval 1 min to 10 min after release of the load.
There was no visible damage.

3. Mechanical/thermal preconditioning

a. Terminal torque preconditioning

The arrester terminal torque of 45 Nm was applied for duration of 30s.

Cantilever mm	Force N	Torque moment Nm
300	150	45

There was no visible damage.

b. Thermo-mechanical preconditioning

The sample was subjected to the thermo-mechanical preconditioning acc. to 10.8.9.3.1.2 with the specified long-term load (SLL) of 200 Nm.

Cantilever = 397 mm; Force = 504 N

Measured displacement:

	Start without load	Start with load	End with load	maximum deflection	End without load
Position 0° (+60°C)	0 mm	4,07 mm	11,26 mm	11,4 mm	2,57 mm
Position 180° (-25°C)	0 mm	11,89 mm	14,04 mm	14,2 mm	0,82 mm
Position 270° (+40°C)	0 mm	10,07 mm	11,97 mm	12,2 mm	0,26 mm
Position 90° (-40°C)	0 mm	11,19 mm	13,48 mm	13,7 mm	0,48 mm

4. Water Immersion test

All samples were subjected to the water immersion test acc. to 10.8.9.3.2

5. Test evaluation/ Final measurements

Watt losses at Uc

Sample No.	Voltage kV	watt losses W	Increase from initial measurement %	evaluation/ result
A	35	3,62	-0,3	passed
B	35	3,64	-4	passed
C	35	3,63	-2,4	passed

Ambient temperature 20 °C
The increase in watt losses is not more than 20% from the initial measurements. After the end of boiling, the arresters were removed from the water (50 °C) (09:15 AM; 09.11.2012) and cooled to ambient temperature. The measurement was executed within 8h after cooling (02:30 PM; 09.11.2012).
The ambient temperature does not deviate more than 3K from the initial measurements.

Partial discharge test

Sample No.	voltage kV	measured value pC	max. permitted value pC	ground noise pC	evaluation/ result
A	36,75	<2	10	<2	passed
B	36,75	<2	10	<2	passed
C	36,75	<2	10	<2	passed

Reference voltage before two impulses at nominal discharge current

Sample No.	measured value kV
A	40,7
B	40,6
C	40,7

Residual voltage test (first impulse)

Sample No.	measured value kV	current kA	Increase from initial measurement %	evaluation/ result
A	114,5	10,2	-0,3	passed
B	115,1	10,2	+0,4	passed
C	114,3	10,2	-0,3	passed

The measured values are not more than 5% different from the initial measurement.

Residual voltage test (second impulse)

Sample No.	measured value kV	current kA	Increase from initial measurement %	Increase from first impulse %	evaluation/ result
A	115,2	10,2	+0,3	+0,6	passed
B	115,4	10,2	+0,7	+0,3	passed
C	115,2	10,2	+0,5	+0,8	passed

The measured values are not more than 5% different from the initial measurement. The difference in voltage between two successive impulses at nominal discharge current does not exceed 2%. The oscillograms of voltage and current do not reveal any partial or full breakdown of the test sample.

Reference voltage after two impulses at nominal discharge current

Sample No.	measured value kV	increase %	evaluation/ result
A	41,2	+1,2	passed
B	41,2	+1,5	passed
C	41,3	+1,5	passed

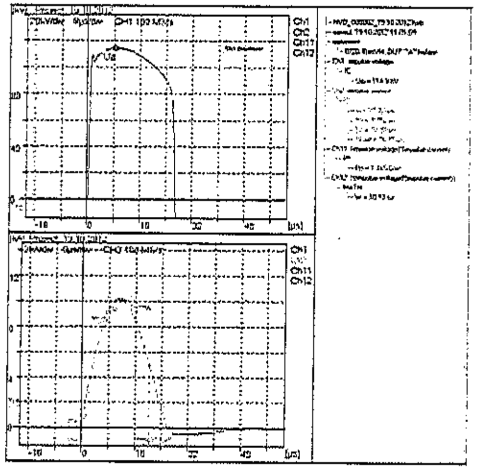
The change in reference voltage measured before and after the two residual voltage tests does not exceed 2%.

The surge arrestor type series "VARISIL HE-S" passed all tests, acc. to IEC 60099-4 Ed. 2.2 10.8.9, successfully. SLL = 200 Nm, SSL = 250 Nm and terminal torque = 45 Nm

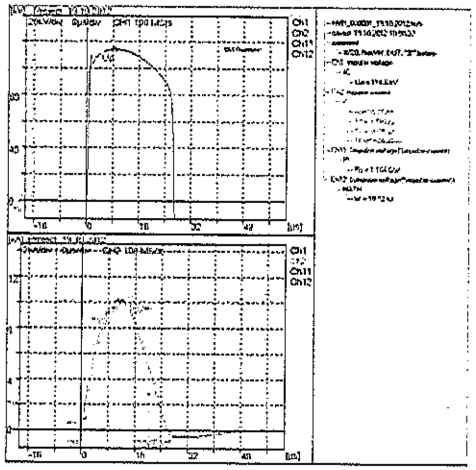
ВЯРНО С ОРИГИНАЛА

204

Appendix 1 Sample preparation/ Initial measurements

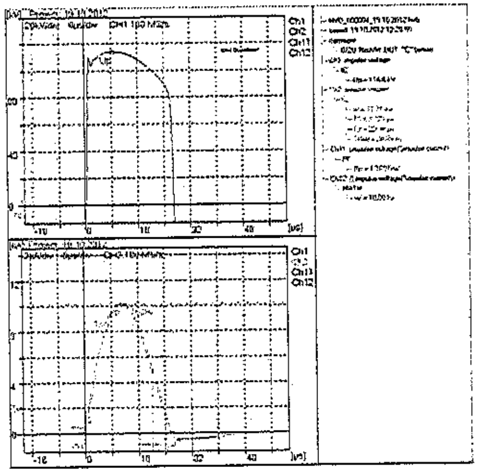


Residual voltage test of sample No.A



Residual voltage test of sample No.B

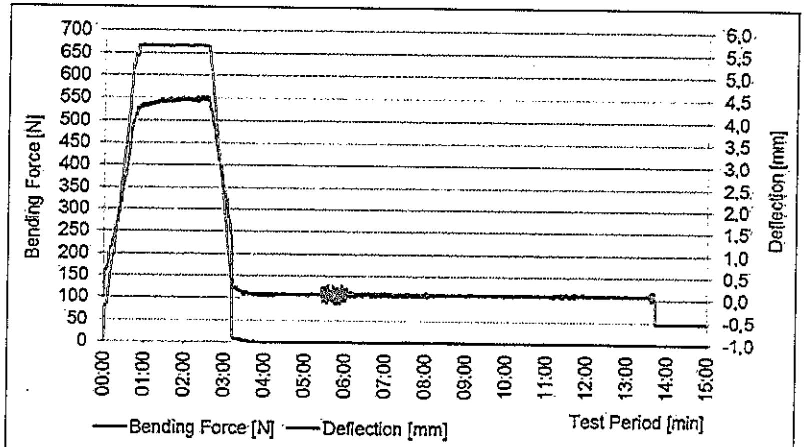
ВЯРНО С ОРИГИНАЛА



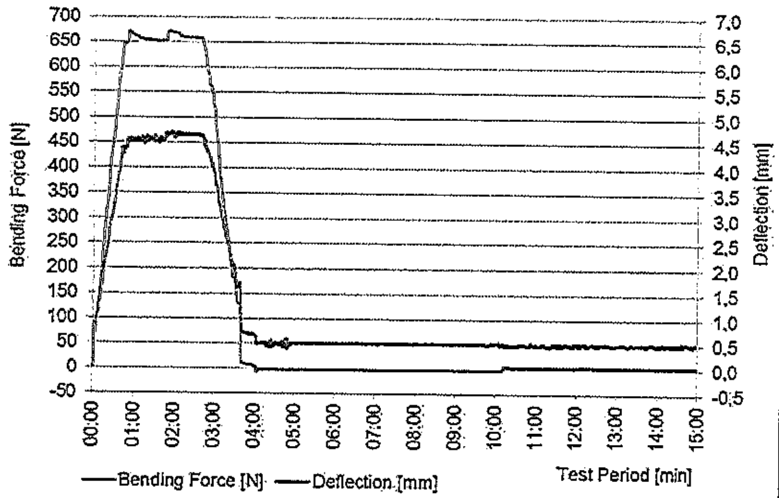
Residual voltage test of sample No.C

ВЯРНО С
ОРИГИНАЛА

Appendix 2 Bending moment test with SSL



Force vs. time and deflection vs. time of sample A

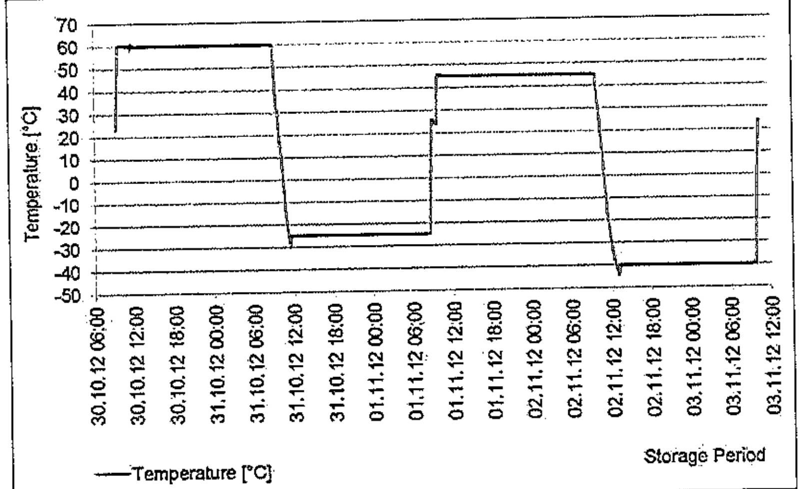


Force vs. time and deflection vs. time of sample B

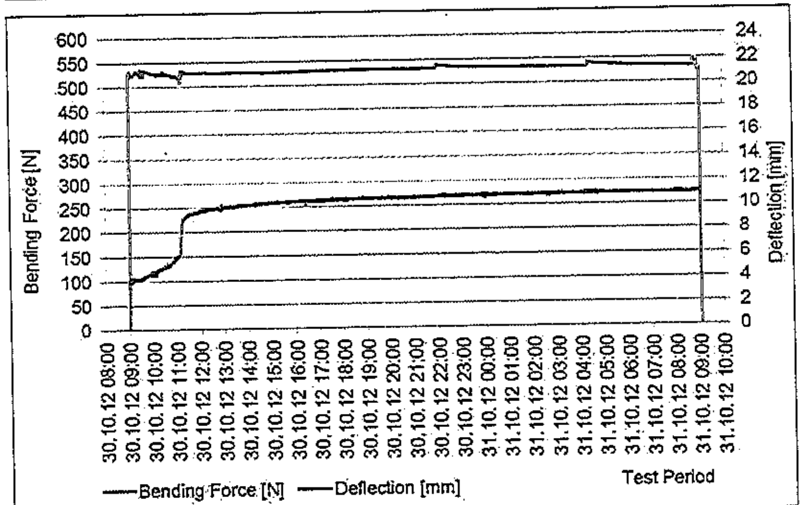
ВЯРНО С ОРИГИНАЛА

207

Appendix 3 Thermo-mechanical preconditioning



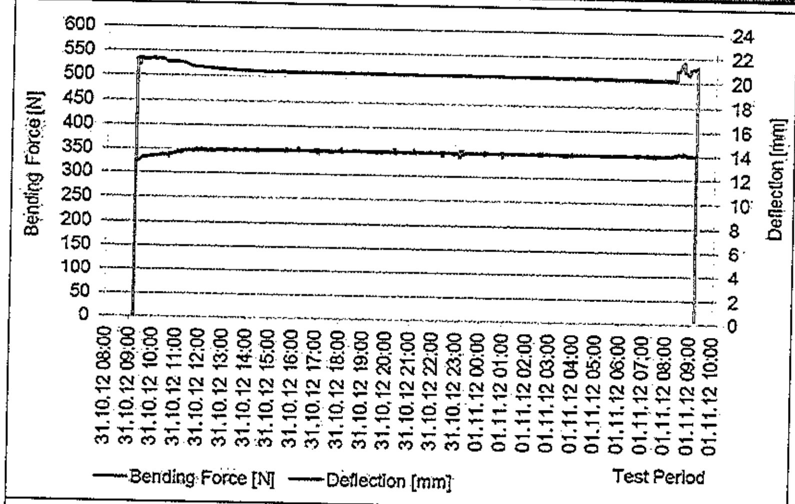
Temperature profile of Thermo-mechanical preconditioning



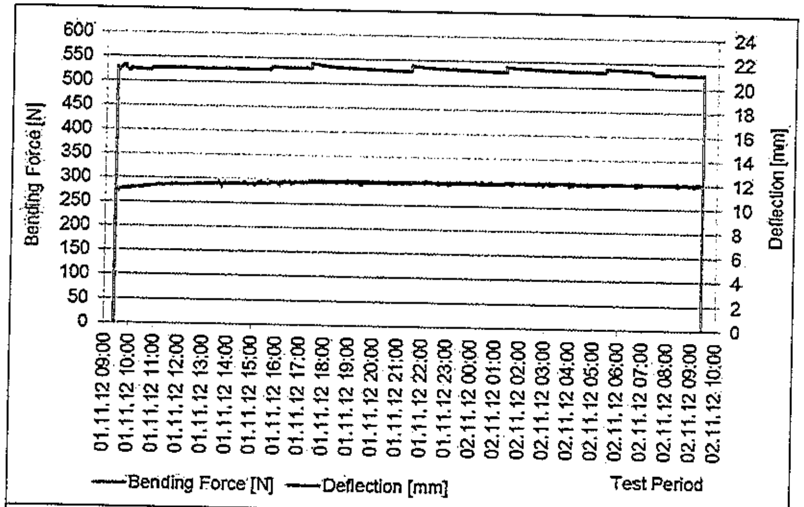
Force vs. time and deflection vs. time of sample C Position 0°

ВЯРНО С ОРИГИНАЛА

208



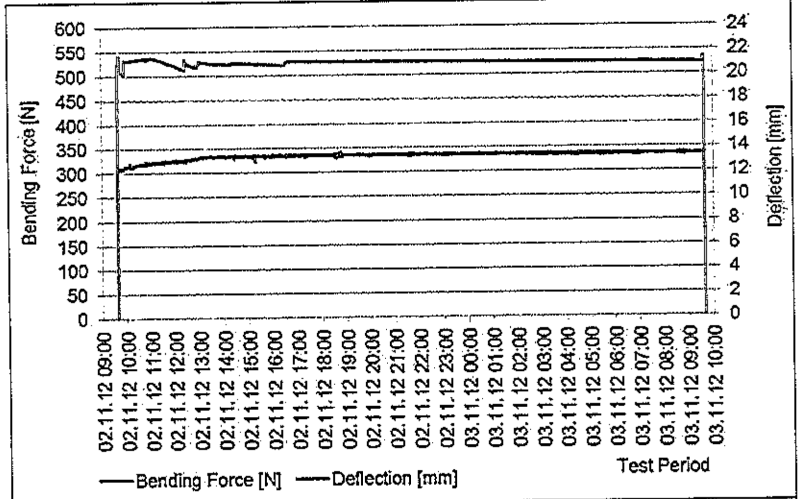
Force vs. time and deflection vs. time of sample C Position 180°



Force vs. time and deflection vs. time of sample C Position 270°

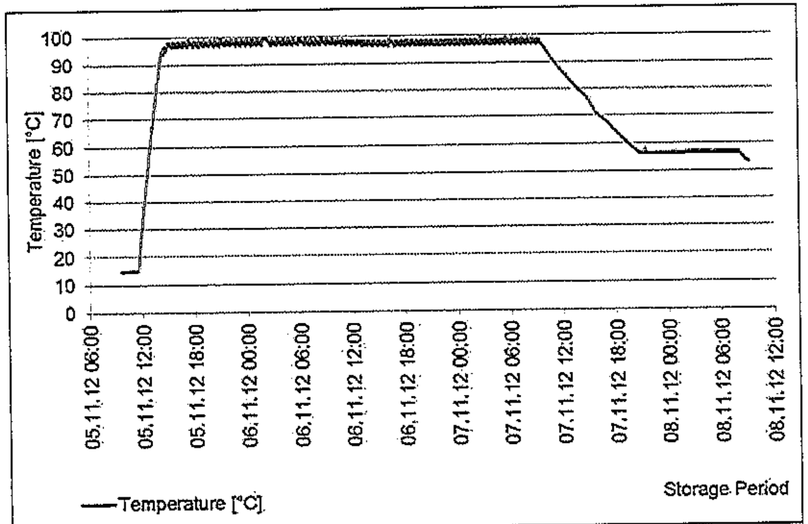
ВЯРНО С ОРИГИНАЛА

209



Force vs. time and deflection vs. time of sample C Position 90°

Appendix 4 Water Immersion test

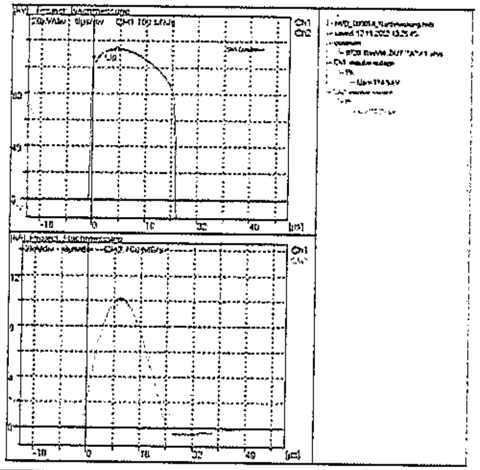


Temperature vs. time

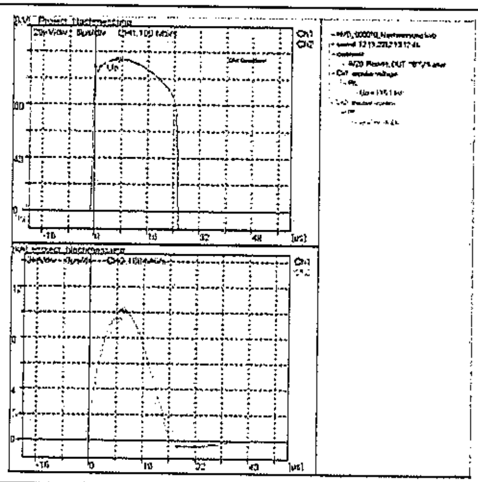
ВЯРНО С ОРИГИНАЛА

210

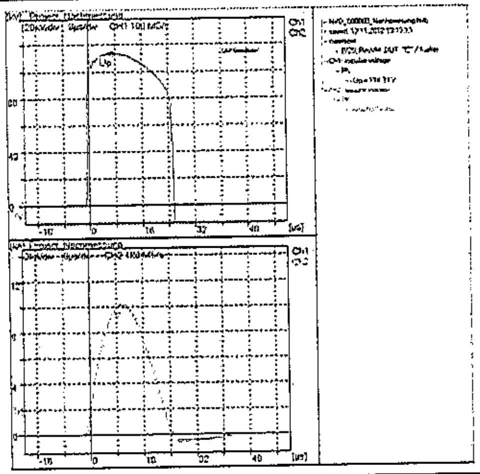
Appendix 5 Test evaluation/ Final measurements



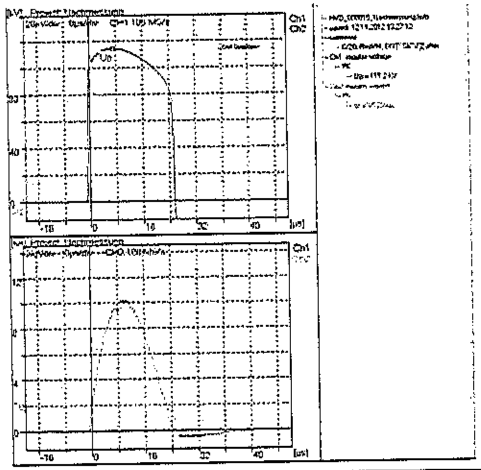
Residual voltage test of sample No. A (first impulse)



Residual voltage test of sample No. B (first impulse)



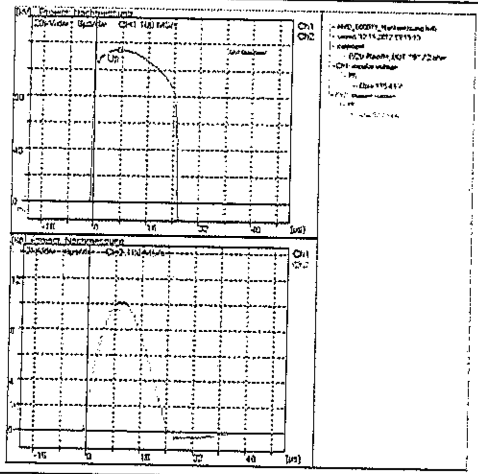
Residual voltage test of sample No. C (first impulse)



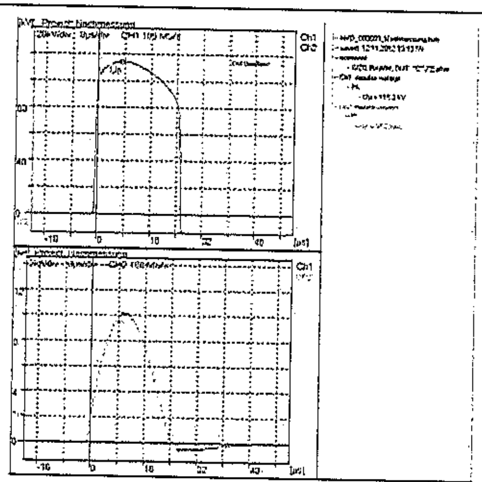
Residual voltage test of sample No. A (second impulse)

ВЯРНО С ОРИГИНАЛА

212



Residual voltage test of sample No. B (second impulse)

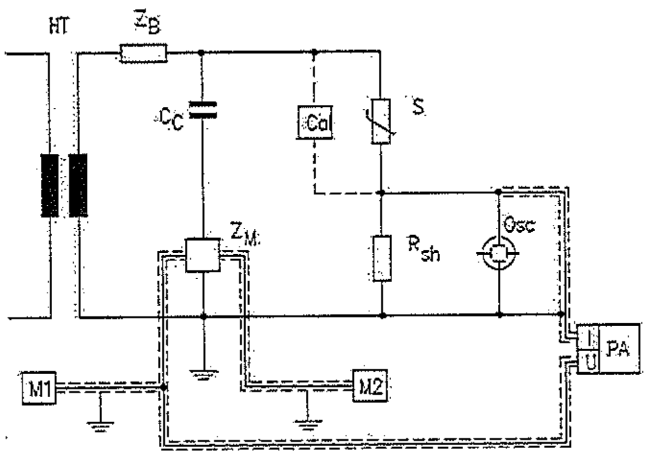


Residual voltage test of sample No. C (second impulse)

ВЯРНО С ОРИГИНАЛА

213

Appendix 6 Test arrangement

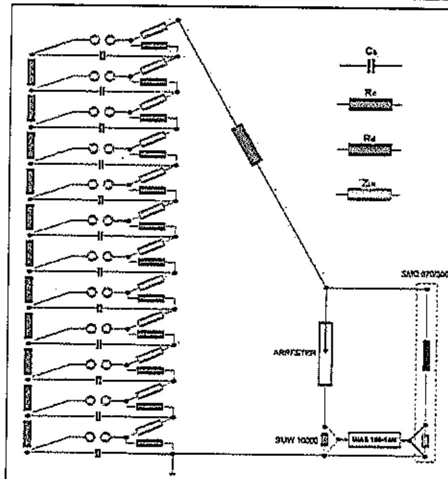


HT	Test transformer	PEO 8/100 A/K-2
M1	AC peak voltmeter	MU 14
M2	Partial discharge detector	MTE 3
Osc	Oscilloscope	Philips PM 3208
R_{sh}	Shunt resistor	1000Ω
Z_B	Blocking impedance	40mH
C_C	Coupling capacity	C 06
Z_M	Measuring impedance	H 322
Cal	Calibrator	PET 2-1
TS	Test sample	
PA	Power Analyzer	ZES ZIMMER LMG95

Test circuit for measurement of reference voltage and partial discharges

ВЯРНО С ОРИГИНАЛА

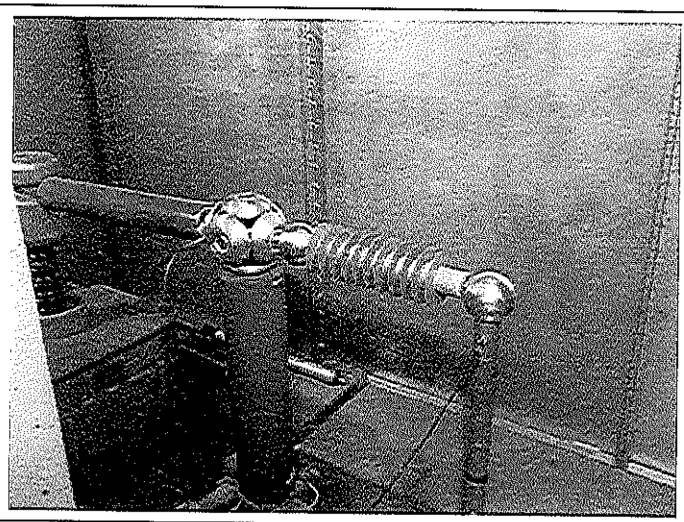
214



GENERAL INFORMATION				
Impulse Generator IP 120/1200 M:				
• Number of stages:	n		12	
• Capacitance per stage	C_s		2000nF	
• Max. lightning current impulse	I_{ns}	≤	10	kA
• Total charging energy	W	≤	120	kJ
Individual Components:				
• Charging resistor R_c (18 kΩ)	n		12	
• Discharge resistors R_d (1,05 kΩ)	n		12	
• Front impedance Z_{se} (32 µH; 1,3 Ω)	n		12	
• Controlled capacitive LIV divider	SMC 070/300			
• 10 kA Shunt	SMW 10000			
• Digital impulse voltage measuring system	MIAS 100-14/4			

Test circuit for residual voltage

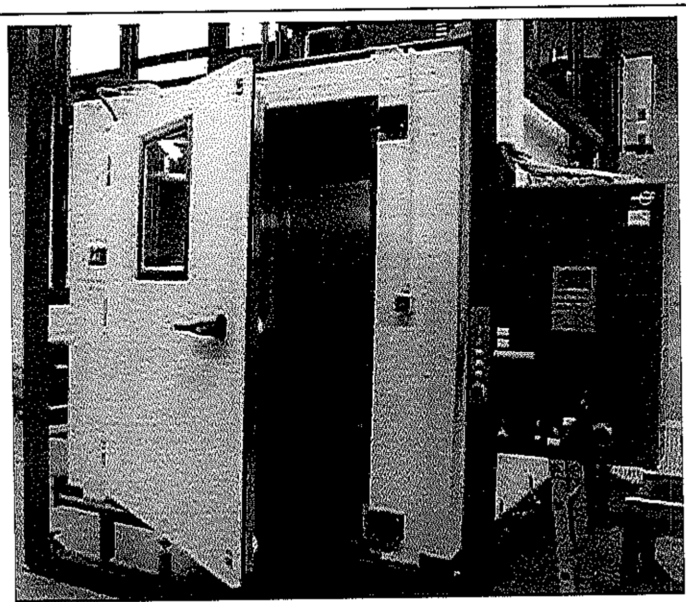
Appendix 7 Photos



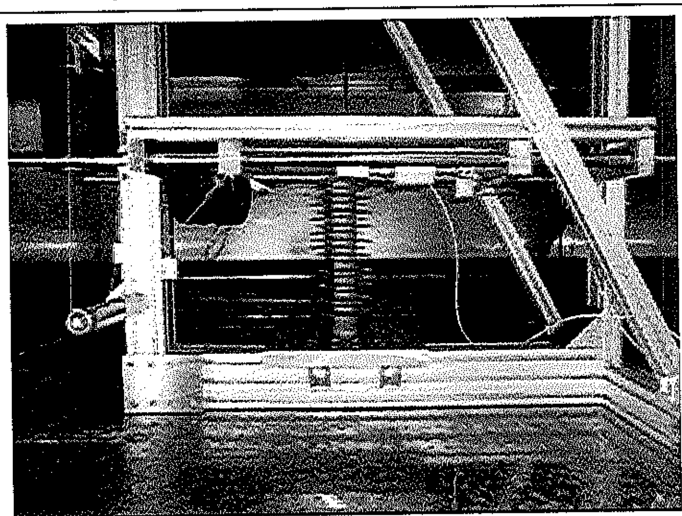
test arrangement for measuring of partial discharge, reference voltage and power losses

ВЯРНО С
ОРИГИНАЛА

215



climatic chamber for bending moment test and thermo-mechanical preconditioning

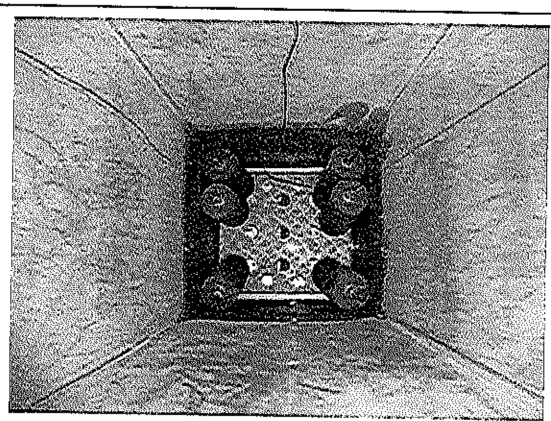


test arrangement inside the climatic chamber for bending moment test and thermo-mechanical preconditioning

ВЯРНО С ОРИГИНАЛА

216

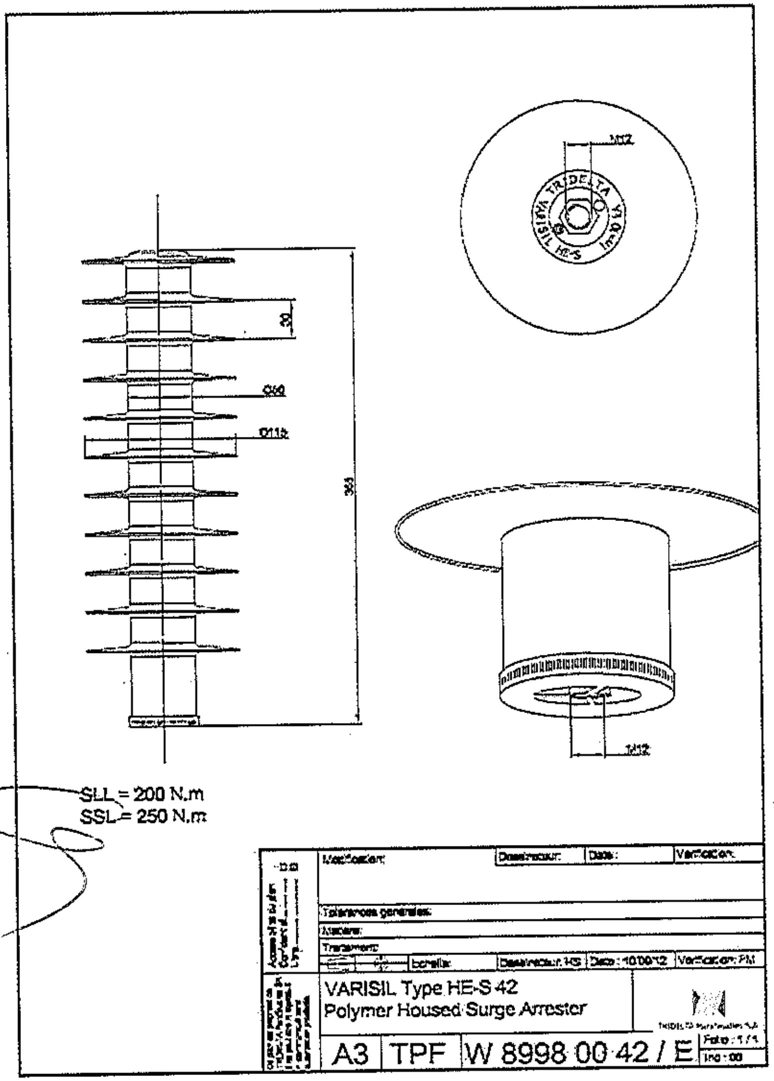
Water Immersion test arrangement / boiling tank



Water immersion test arrangement / boiling tank with arrester

ВЯРНО С ОРИГИНАЛА

217



ВЯРНО С
ОРИГИНАЛА

218

WEATHER AGEING

client	ALSTOM Parafoudres S.A. - Bagneres de Bigorre (France)
equipment under test	Polymer housed metal-oxide surge arrester type VARISIL HE 36
tests performed	Weather ageing test - Test series A
normative documents	IEC 60099-4 (2001-12) edition 1.2
receipt date of the sample	July 18, 2002
test date	from August 07, 2002 to October 18, 2002

no. of pages	23	no. of pages annexed	4
issue date	December 18, 2002		

ВЯРНО С ОРИГИНАЛА

prepared	PeC/TEST - M. Bonomelli
verified	PeC/TEST - A. Sironi
approved	PeC/TEST - V. Scarioni

tests witnessed by: /

identification of the object: The manufacturer guarantees that the tested object is manufactured according to the submitted drawings.
CESI checked that drawing adequately represents in shape and dimension the essential detail and the parts of the tested object.
The drawing identified by CESI and numbered A2/016115 is annexed to this document.

The measurement uncertainties of the test results reported in this document are the following:

- dielectric tests with impulse voltage : peak voltage: ± 3 % ; time parameters: ± 10 %
- dielectric tests with impulse current : peak value: ± 3 % ; time parameters: ± 10 %
- dielectric tests with alternating voltage : voltage (rms): ± 3 %

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to a confidence level of about 95 %) and have to be considered as maximum values.

ВЯРНО С ОРИГИНАЛА

laboratory information

CESI testing team: Mr. M. Bonomelli
Mr. M. Gregori - Mr. L. Podavitte

test laboratory: P177 - surge arrester laboratory
test laboratory: P189 - weather ageing laboratory
activity code: 33618J
keywords: 12015R, 22360O, 31020W, 44060J, 53001D, 62570N

contents	page	test date
Test object characteristics	4	
Reference standard	5	
Test procedure	6	
Summary of test result	7	
Initial measurement	8÷9	07 August 2002
Visual examination	10	28 August ÷ 10 October
Final measurement	11÷12	11 October 2002
Photos	13÷20	
Technical data of the test circuit	21÷23	

ВЯРНО С
ОРИГИНАЛА

Page annexed: oscillogram n. 08

Reference document annexed: ALSTOM drawing W 8997 01 36

221

18.DEC.2002 18:58

Test object characteristics

type: Metal-oxide surge arrester type HE 36 (sample #1)

electrical characteristics (claimed by the client)

manufacturer's name	ALSTOM Parafoudres S.A.
nominal discharge current - I_N [kA]	10,0
rated voltage - U_r [kV]	36
continuous operating voltage - U_c [kV]	30,0
minimum reference voltage - [$kV_{pk/\sqrt{2}}$]	34,1
maximum residual voltage - [kV_{pk}]	97,5
rated frequency - [Hz]	50 - 60

geometrical characteristics (measured on the test sample)

total height [mm]	325
number of large sheds	10
number of small sheds	9
shed large diameter [mm]	115
shed small diameter [mm]	85
shed spacing [mm]	30
core diameter [mm]	50
creepage distance [mm]	1200

ВЯРНО С ОРИГИНАЛА

other characteristics

housing material	polymeric
housing color	grey

222

Reference Standard

IEC 60099-4 (2001-12) edition 1.2 Clause 9.7.9
" Metal-oxide surge arrester without gaps for a.c. system"

Test carried out

test carried out	number of sample tested
initial measurements	One sample The sample was identified by the manufacturer as sample #1
weather test series A - 1000 hours	
final measurements and visual inspection	

A view of the test object is shown at page 14 (aged sample)

ВЯРНО С ОРИГИНАЛА

223

Test procedure

Initial measurement

- The reference voltage have been measured at reference current equal to 1 mA_{pk}
- Internal partial discharge have been measured.
  The application voltage has been increased up to rated voltage (U_r) and maintained for 10 sec. Then the voltage has been decreased to 1,05 times the continuous operating voltage (U_c) and the partial discharge level has been measured according to the reference standard.

Test series A - 1000 hours

The test specimens have been mounted inside the test chamber in vertical position.
The test specimens has been energized at U_{test} = 20.8 kV_{rms} and kept for a total duration of 1000 hours in the test chamber filled with salt fog in the following conditions:
- salinity of the water solution: 10 kg/m3 for the first 445 hours, 5 kg/m3 for the last 555 hours
- water flow rate 0.4 ± 0.1 l/h*m³
The fog was not directly sprayed against the test specimens.

A view of the test configuration is shown on page 13

Final measurement

- The reference voltage have been measured at reference current equal to 1 mA_{pk}
- Internal partial discharge have been measured.
  The application voltage has been increased up to rated voltage (U_r) and maintained for 10 sec.The voltage has been decreased to 1,05 times the continuous operating voltage (U_c) and the partial discharge level has been measured according to the reference standard.
- The test samples have been visually inspected

Note The test was carried out in parallel with other two specimens with different design

ВЯРНО С
ОРИГИНАЛА

224

Summary of test result

Test series A - 1000 hours

No overcurrent trip out occurred during the test.

Visual inspection

No tracking, shed puncture or significant erosions have been evidenced by the visual inspection carried out at the end of the test.

Variation of the reference voltage

	before test	after test	variation
	kV	kV	%
sample #1	33.93	34.09	+ 0.47

Acceptance criteria: variation before/after less than 5 %

Partial discharge level

	before test	after test
	pC	pC
sample #1	< 1	< 1

Acceptance criteria: partial discharge level less than 10 pC

ВЯРНО С ОРИГИНАЛА

All acceptance criteria according to the reference standard are satisfied and therefore the results is to be considered positive.

225

Measurement of the reference voltage - initial

test object: Metal-oxide surge arrester
test circuit: A019

date: August 07, 2002

				sample #1		
oscill.	voltage	current	current	current	power	3rd harmonic amplitude
no.	kV	$+ mA_{cr}$	$- mA_{cr}$	mA_{rms}	W	µA
01	33,93	1,00	1,09	0,58	9.18	161,87

ВЯРНО С ОРИГИНАЛА

226

Measurement of partial discharges - initial

test object: Metal-oxide surge arrester

test circuit circuit: A012

measurement circuit: A022 ("direct" calibration : 0,2 pC/mV, on CRO, see oscillogram n. ...)

arrangement: —

atmospheric conditions		
b	t	h
kPa	°C	g / m³
	22	

date: August 07,2002

test condition	applied voltage	duration of voltage application	temperature of the test object	partial discharge measurement: voltage increase: CRO readout	voltage increase: Q max	voltage decrease: CRO readout	voltage decrease: Q max	oscillogram	note
	kV_{rms}	sec	°C	mV	pC	mV	pC	no.	
sample #1	Calibration of the test circuit			250	50			04	
sample #1	36	10	26	≤ 5	≤ 1				
	31,5					≤ 5	≤ 1	05	

Note: background noise ≤ 1 pC, see oscillogram n. 03

ВЯРНО
ОРИГИНА.

22

Visual examination

The housing of the specimen has been inspected visually.
See photos from page 15 to 20.

No tracking, shed puncture or significant erosions have been evidenced by the visual inspection carried out at the end of the test.

ВЯРНО С ОРИГИНАЛА

228

Measurement of the reference voltage - final

test object: Metal-oxide surge arrester
test circuit: A019

date: October 11, 2002

			sample no. #1			
oscill.	voltage	current	current	current	power	3rd harmonic amplitude
no.	kV	+ mA_{cr}	- mA_{cr}	mA_{mea}	W	µA
02	34,09	0,99	0,99	0,35	8,11	141,89

ВЯРНО С
ОРИГИНА

229

MOD.A1173G

Measurement of partial discharges - final

test object: Metal-oxide surge arrester

test circuit: A012

measurement circuit: A022 ("direct" calibration : 0,2 pC/mV, on CRO, see oscillogram n. ...)

arrangement: ---

atmospheric conditions		
b	t	h
kPa	°C	g / m^3
	20	

date: October 11, 2002

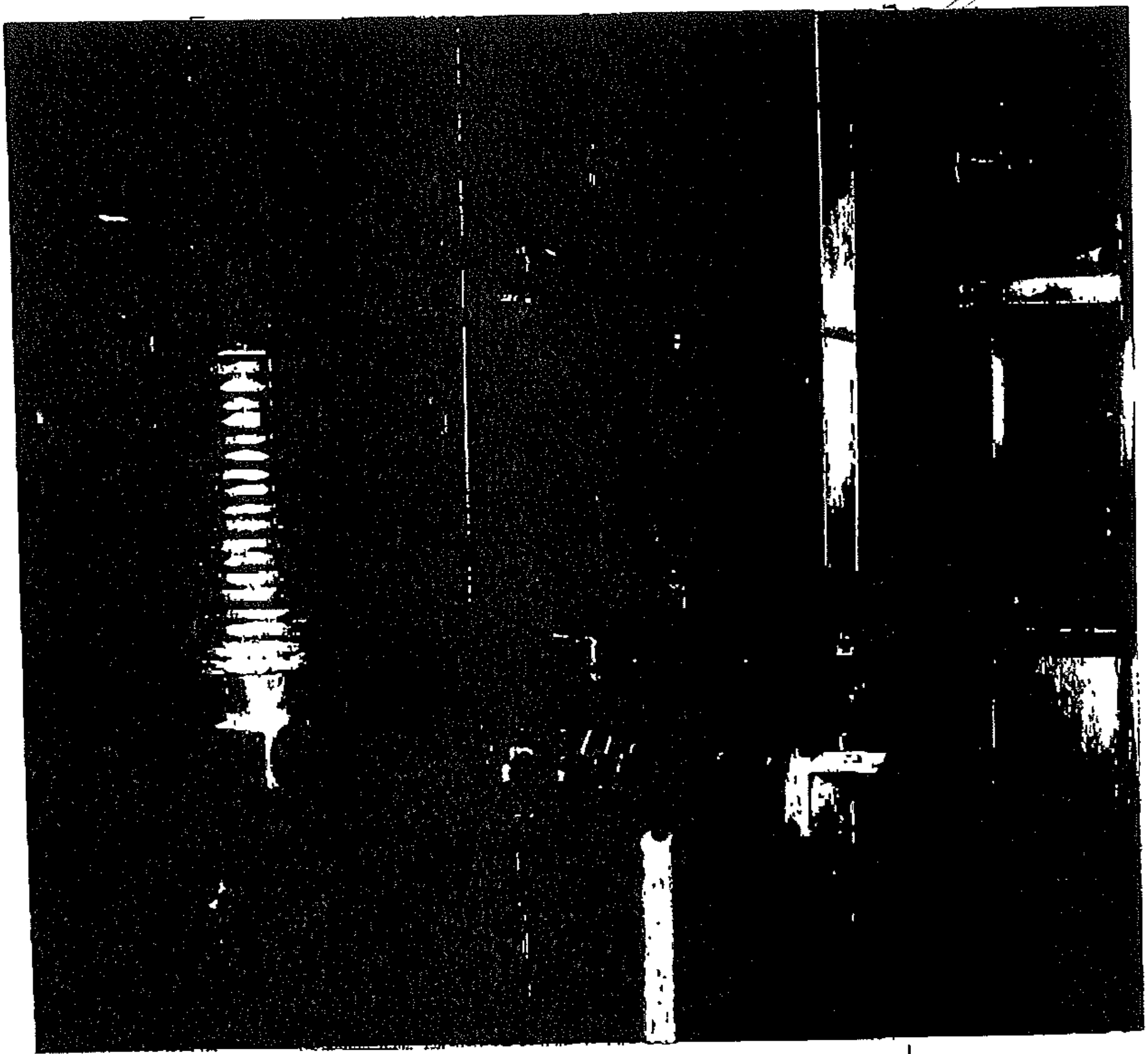
test condition	applied voltage	duration of voltage application	temperature of the test object	partial discharge measurement: voltage increase, CRO readout	voltage increase, Q max	voltage decrease, CRO readout	voltage decrease, Q max	oscillogram	note
	kV_{rms}	sec	°C	mV	pC	mV	pC	no.	
sample #1	Calibration of the test circuit			250	50			07	
sample #1	36	10	20	≤ 5	≤ 1				
	31,5		20			≤ 5	≤ 1	08	

Note: background noise ≤ 1 pC, see oscillogram n. 06

230

ВЯРНО С ОРИГИНАЛА

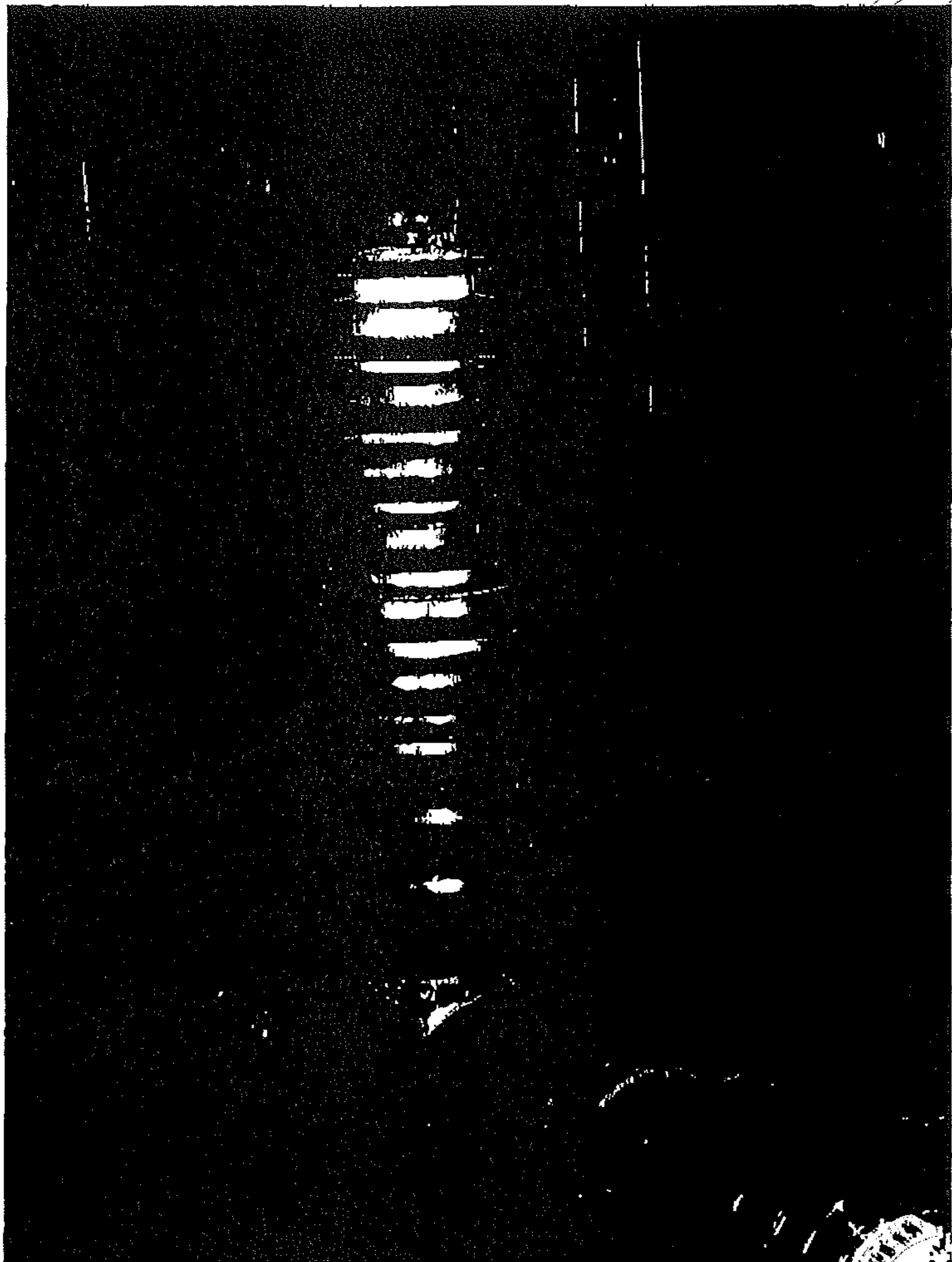
Photo n. 1: test configuration



ВЯРНО С ОРИГИНАЛА

231

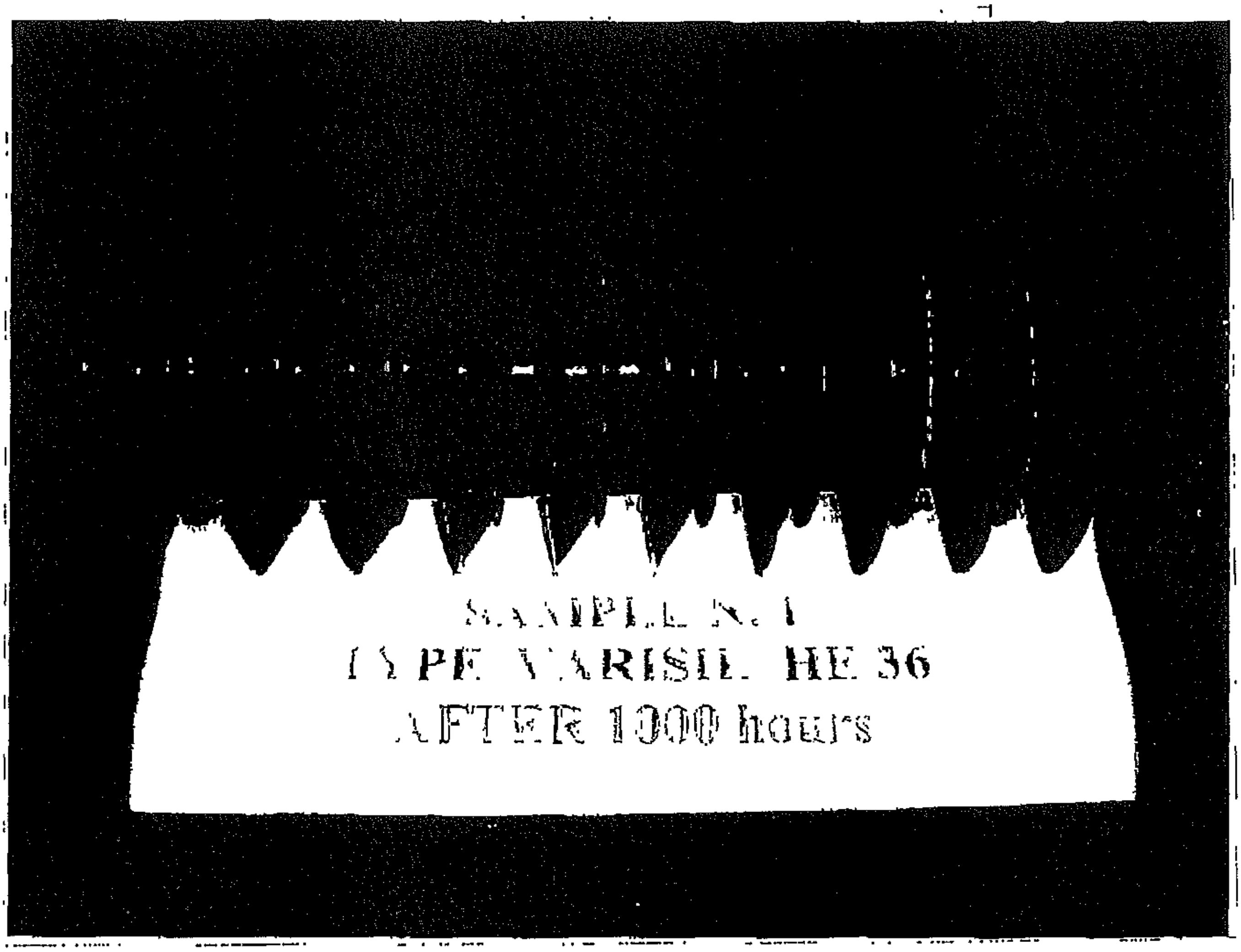
Photo n. 2 - sample #1 after the test



ВЯРНО С
ОРИГИНАЛ

232

Photo n. 3 - sample #1 after the test



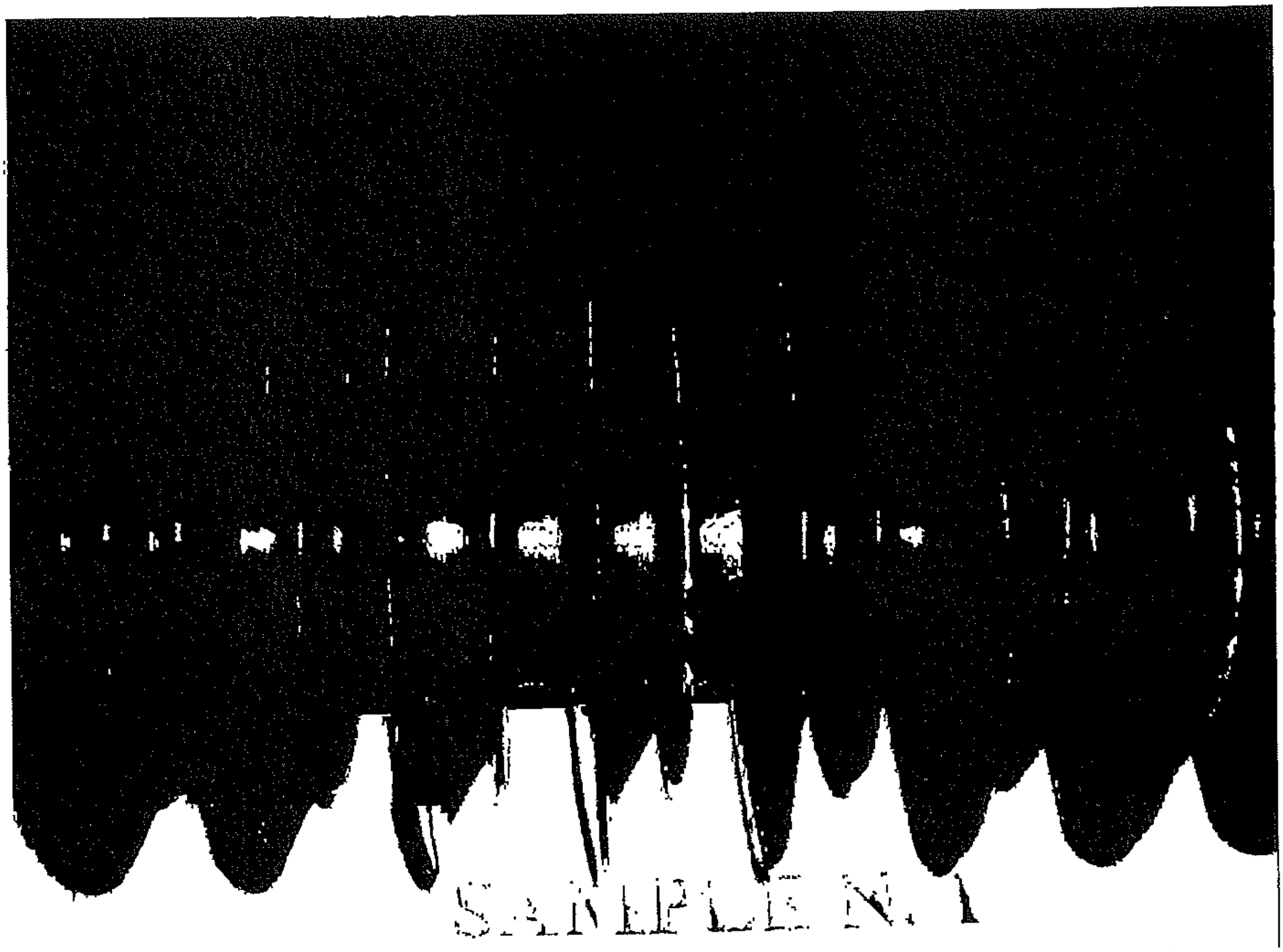
ВЯРНО С
ОРИГИНАЛА

233

Photo n. 4 - sample #1 after the test

ВЯРНО С ОРИГИНАЛА

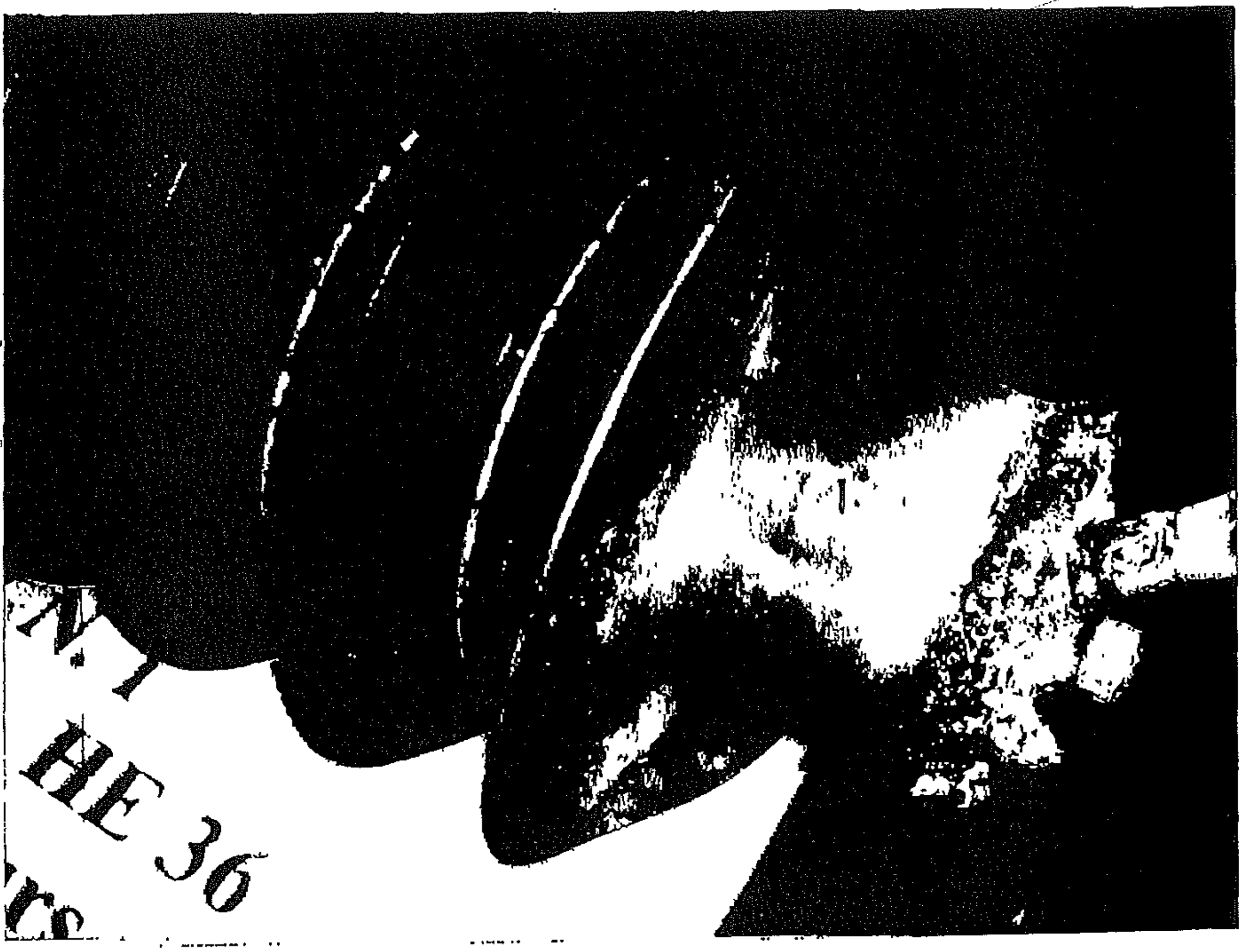
Photo n. 5 - sample #1 after the test



ВЯРНО С
ОРИГИНАЛА

235

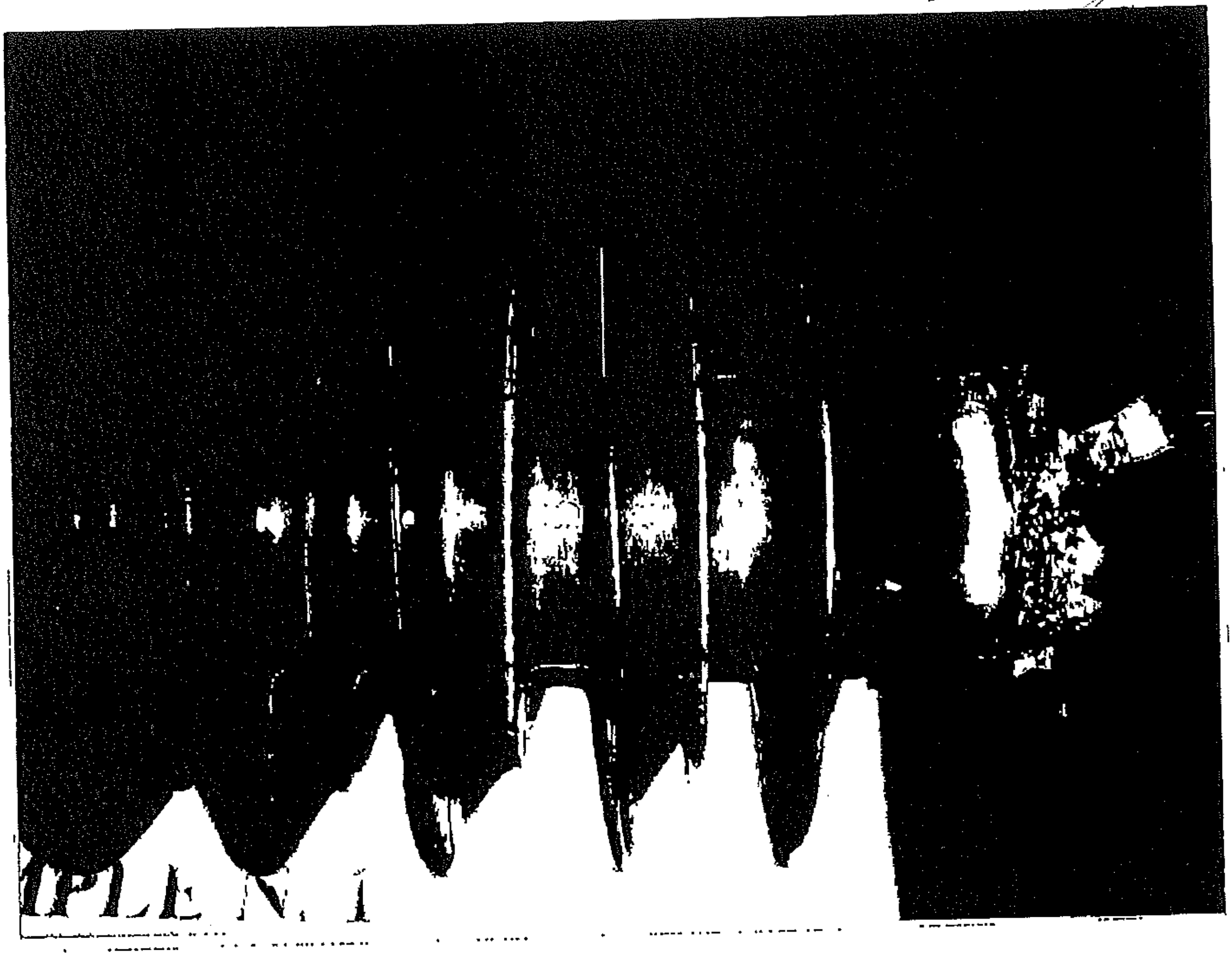
Photo n. 6 - sample #1 after the test



ВЯРНО С
ОРИГИНАЛА

236

Photo n. 7 - sample #1 after the test



ВЯРНО С
ОРИГИНАЛ

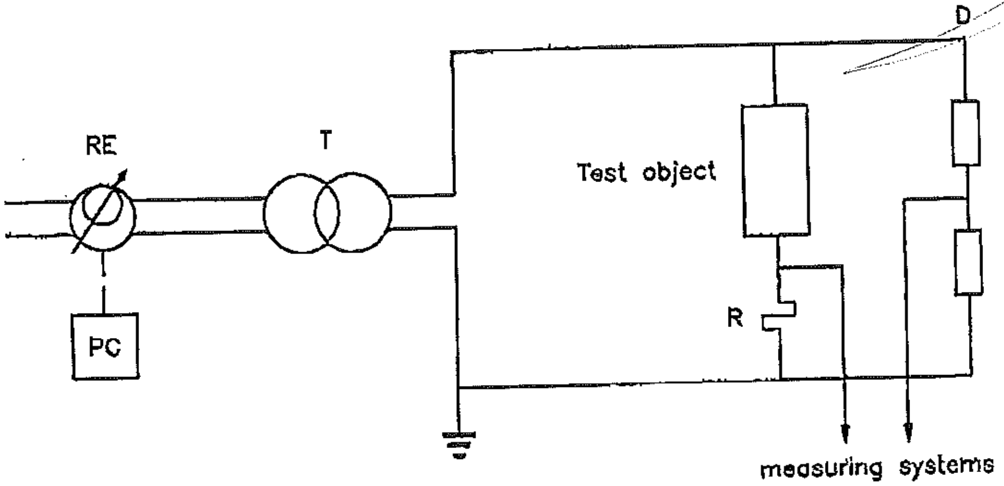
237

Photo n. 8 - sample #1 after the test

ВЯРНО С
ОРИГИНАЛ

238

circuit A019



power frequency supply

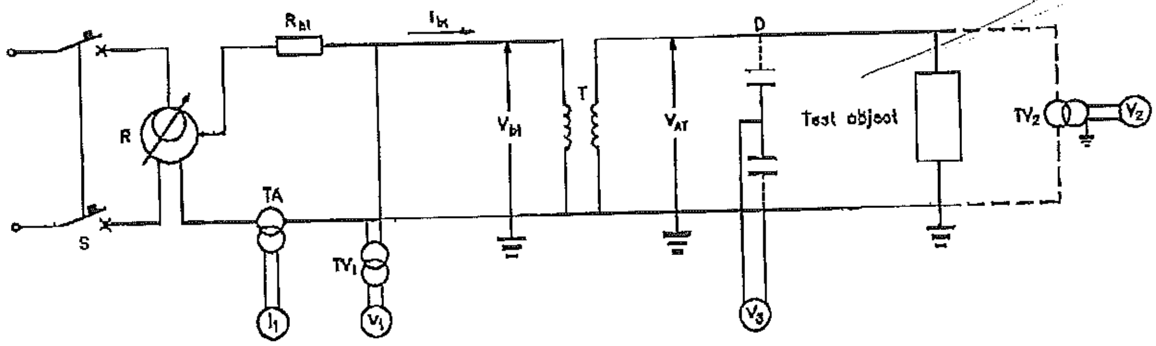
RE : programmable supply CESI no. 9889 ; type 3H series 3000
PC : personal computer
T : transformer type PIVI; voltage 200 V/ 50 kV

current shunt (R) CESI no.11537 ; R = 1034 Ω
oscilloscope CESI no. 4552
type Data Precision DATA 6000

voltage divider (D) CESI no.11120 K=1010
electro optical system CESI no. 11519/520
oscilloscope CESI no. 4552
type Data Precision DATA 6000

ВЯРНО С ОРИГИНАЛА

circuit A012



power frequency test circuit

R : regulator type CORMES;power 66 kVA ; voltage 380 V/0 - 0,22 kV
TA : current trasformer CGS; ratio 150-300/5
I_1 : amperometer direct reading INDEX
TV_1: voltage transformer CGS ; ratio 220-440/100
V_1 : voltmeter direct reading TSE
R_{bt} : protection resistor --- Ω
T ; booster transformer PIVI ; power 250 kVA ; voltage 200-400 V/250 kV
TV_2: voltage transformer type CGS ; CESI no. 287; ratio 30000/100
V_2 ; voltmeter CESI no. 6393

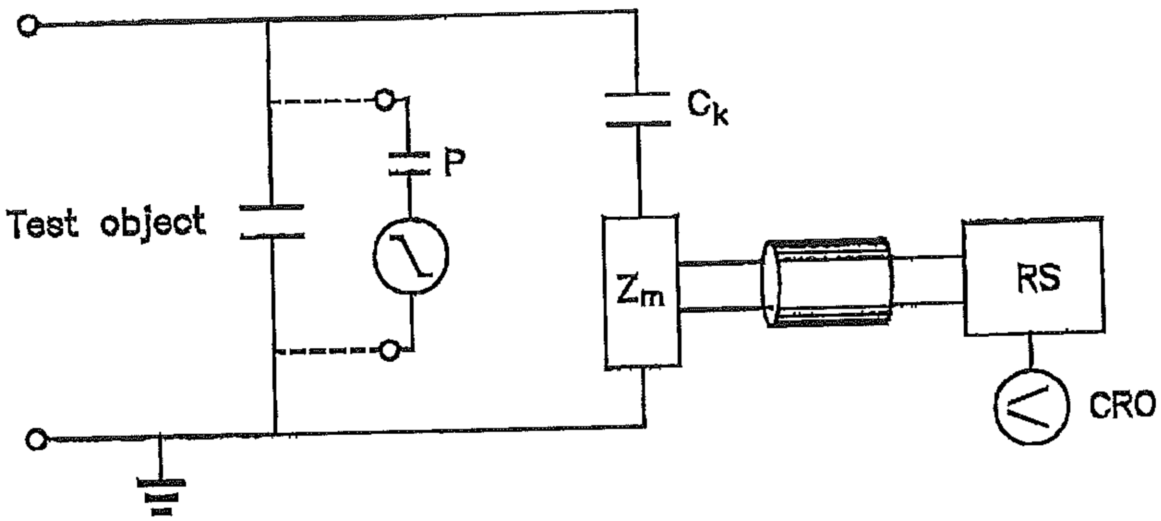
ВЯРНО С ОРИГИНАЛ

210

circuit A022

partial discharges measurement

direct circuit
scheme 1a

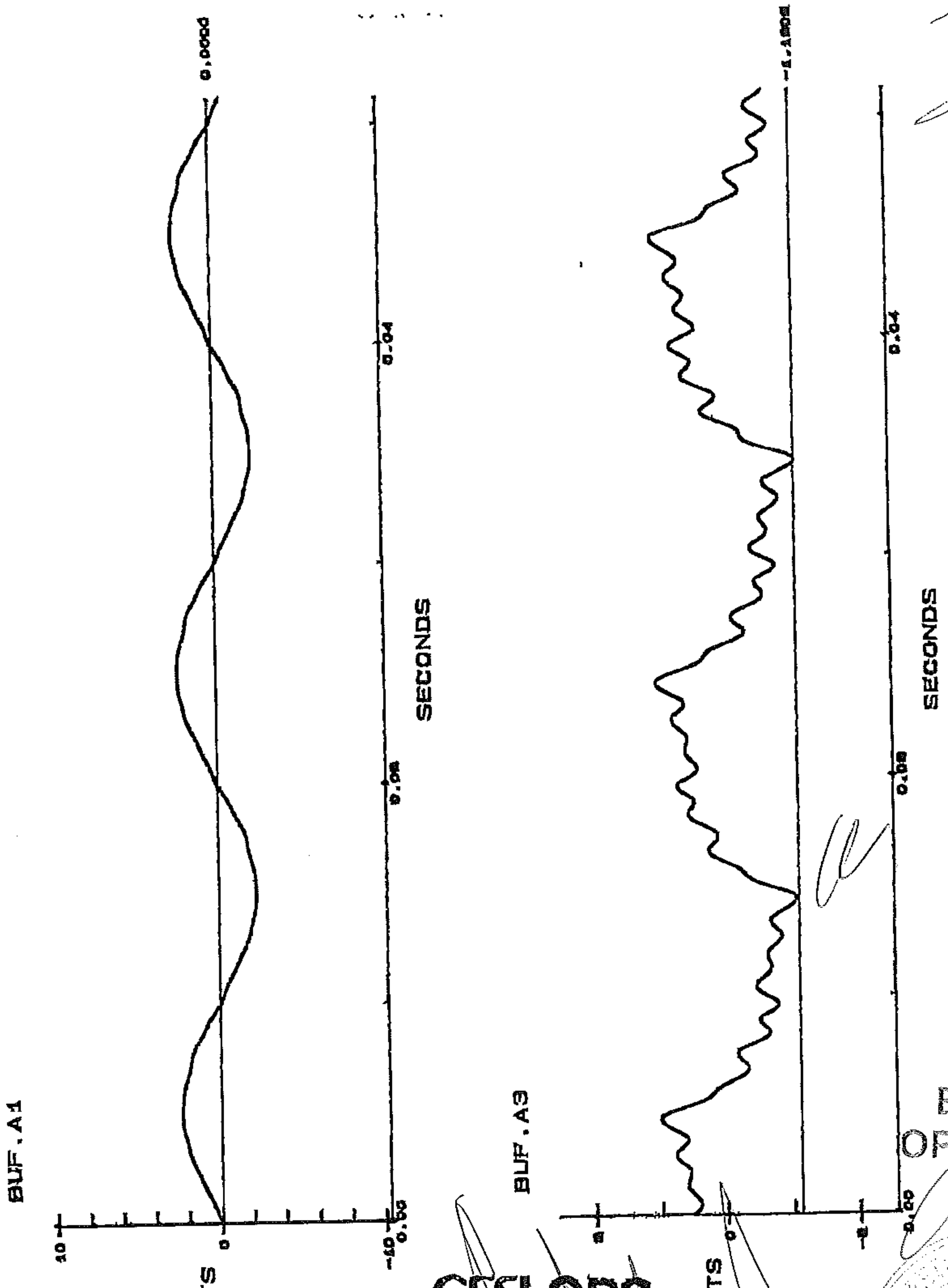


C_k : coupling capacitor 0,3 nF
Z_m : coupling impedance
P : calibrator no.Cesi 3466
RS : partial discharge detector Biddle; no. CESI 9595
CRO: oscilloscope no. CESI 6353

ВЯРНО С
ОРИГИНАЛ

CESI GPS

A2/032924-0



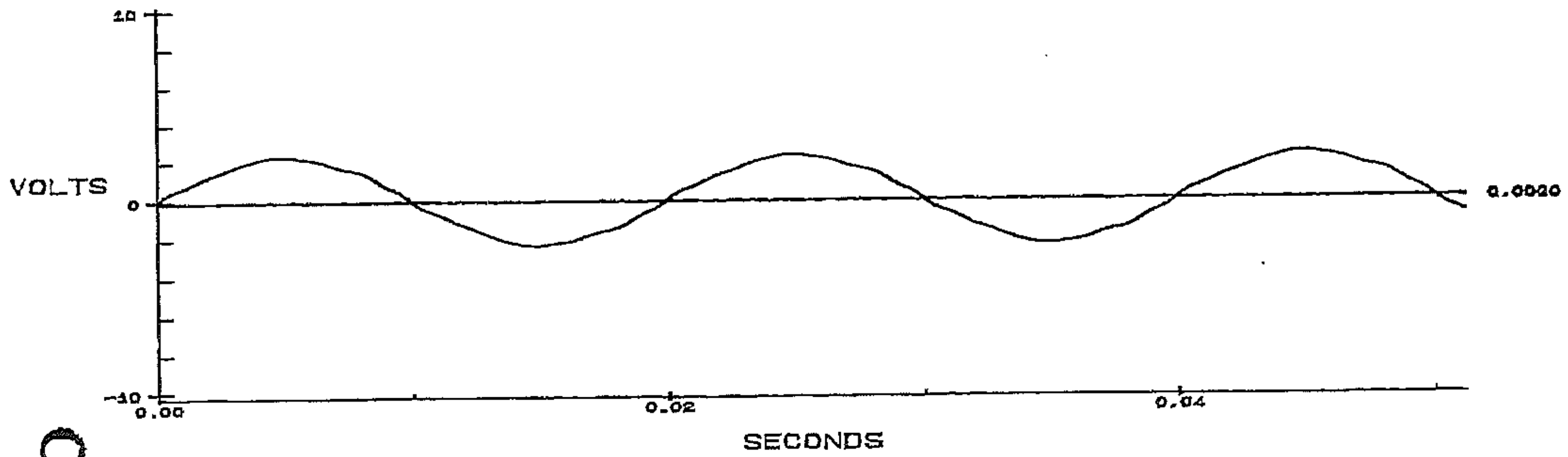
CESI GPS

A2/032924-001

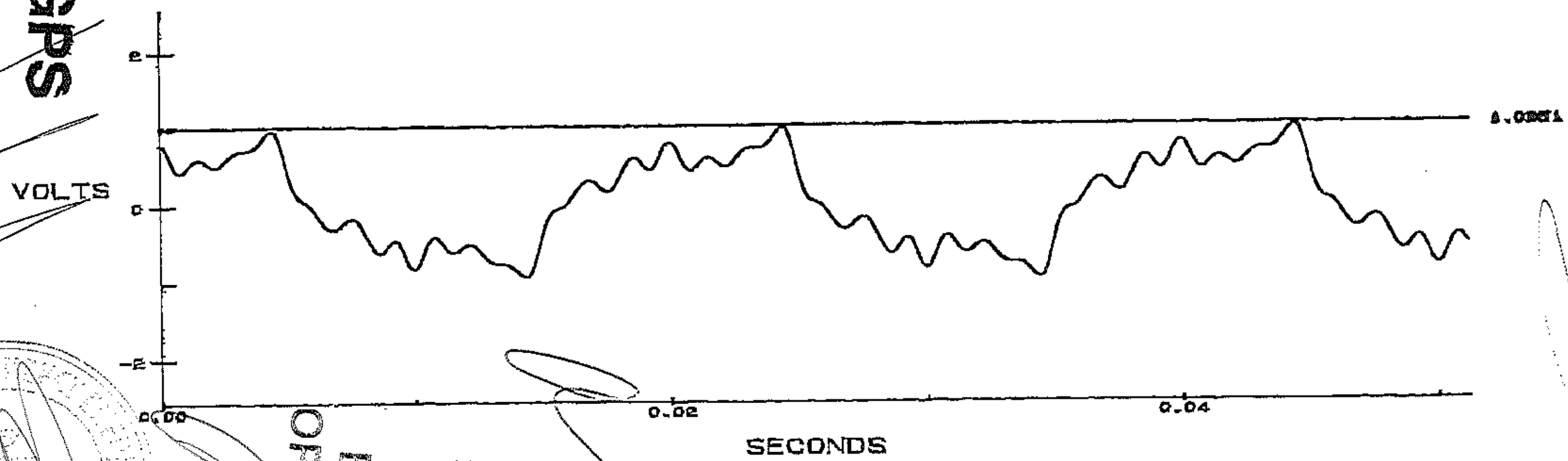
ВЯРНО С ОРИГИНАЛ

212

BUF.A1



BUF.A3

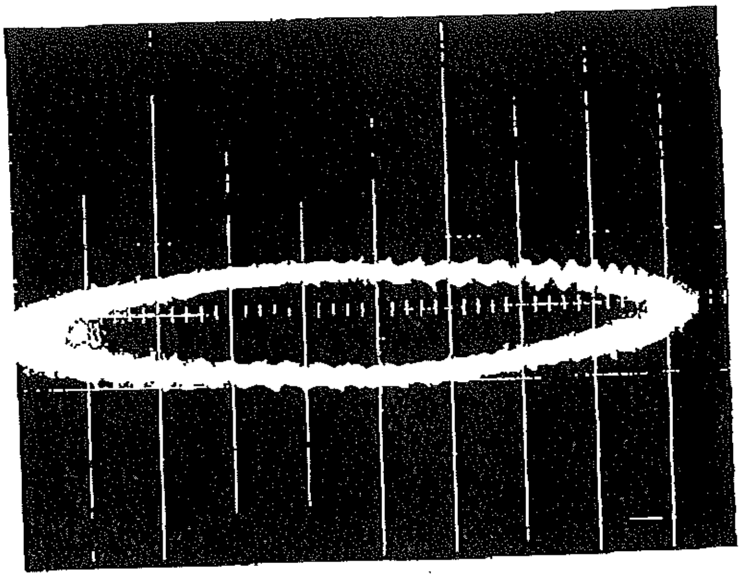


CESI GPS

A2/032924-002

ВЯРНО С
ОРИГИНАЛ

213

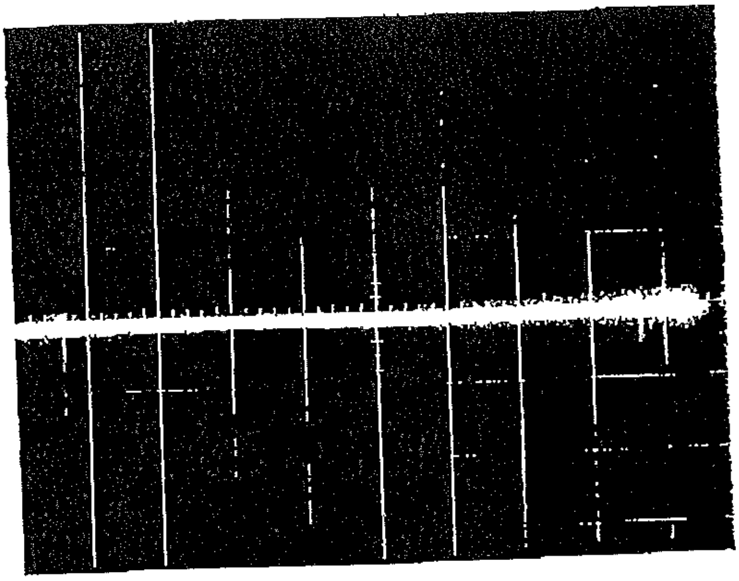


Oscillogram no. 06

Channel 1 :
voltage : 5 mV/div.
time : s

Channel 2 :
voltage : V
time : s

background noise of the circuit
Qmax ≤ 1pC

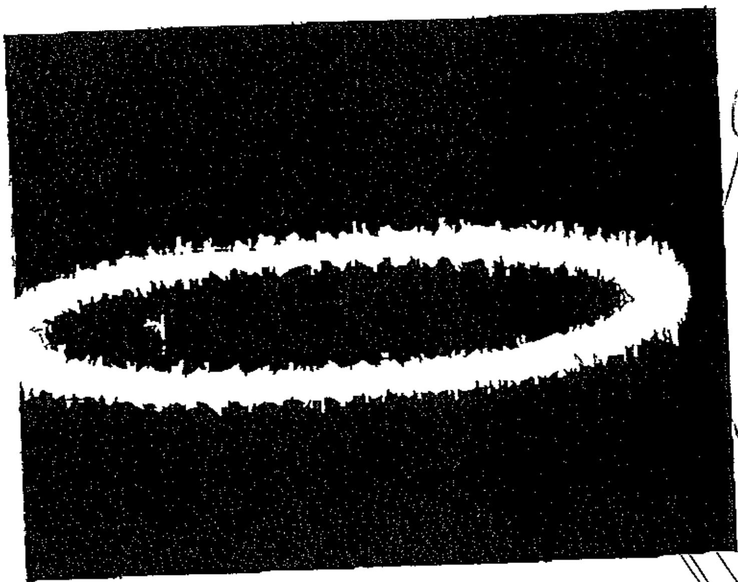


Oscillogram no. 07

Channel 1 :
voltage : 100 mV/div.
time : s

Channel 2 :
voltage : V
time : s

calibration of the test circuit
50 pC/250 mV = 0,2 pC/mV



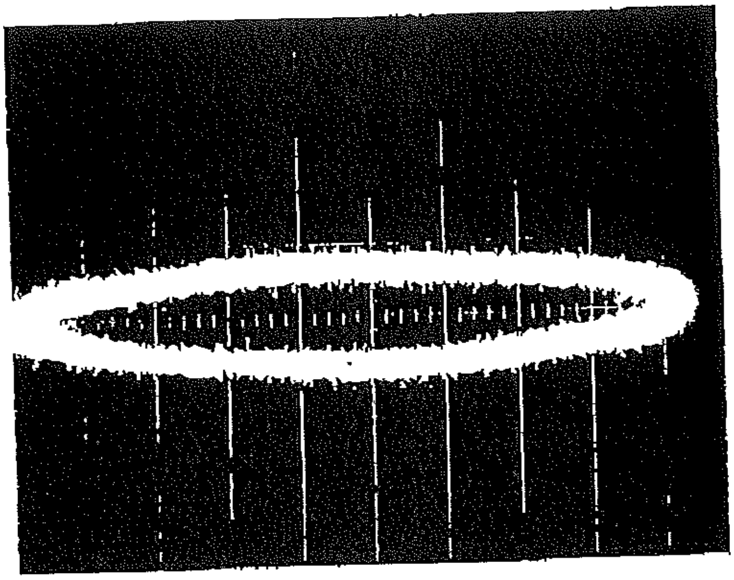
Oscillogram no. 08

Channel 1 :
voltage : 5 mV/div.
time : s

Channel 2 :
voltage : V
time : s

Sample no. 01 before the test
U = 31,5 kV
Qmax ≤ 1 pC

ВЯРНО
ОРИГИНА

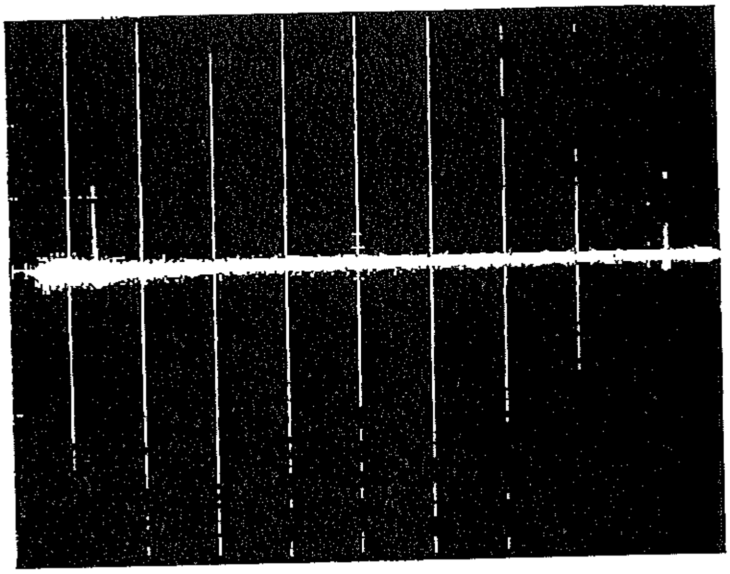


Oscillogram no. 03

Channel 1 :
voltage : 5 mV/div.
time : s

Channel 2 :
voltage : V
time : s

background noise of the circuit
Qmax ≤ 1pC

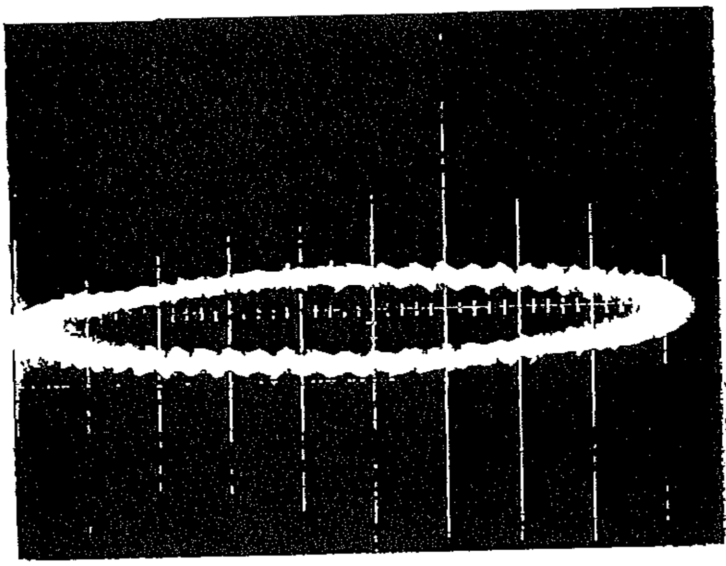


Oscillogram no. 04

Channel 1 :
voltage : 100 mV/div.
time : s

Channel 2 :
voltage : V
time : s

calibration of the test circuit
50 pC/250 mV = 0,2 pC/mV



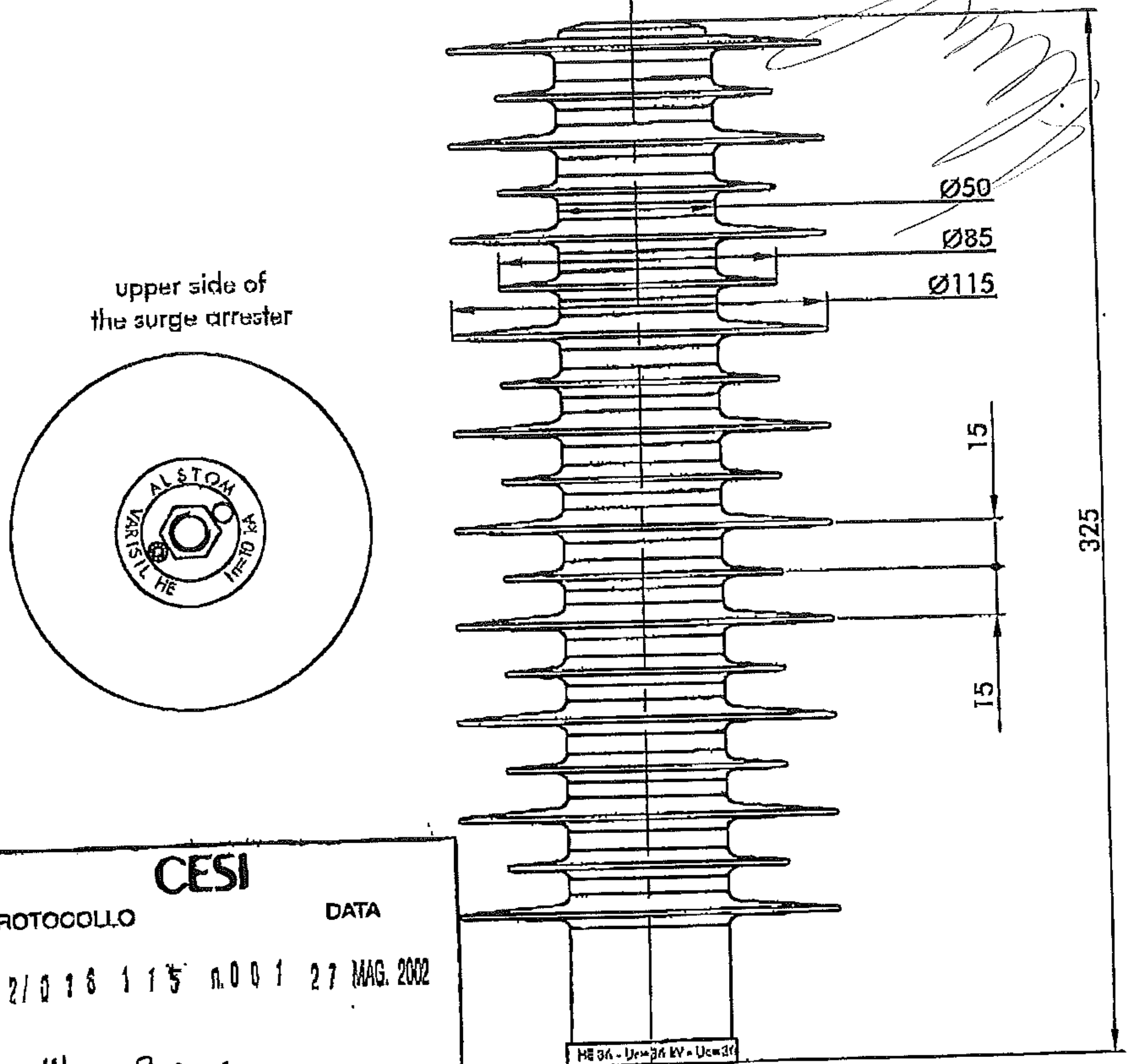
Oscillogram no. 05

Channel 1 :
voltage : 10 mV/div.
time : s

Channel 2 :
voltage : V
time : s

ВЯРНО С
ОРИГИНАЛ

Sample no. 01 before the test
U = 31,5 kV
Qmax ≤ 1 pC



CESI

PROTOCOLLO A 2/016 115 n.001

DATA 27 MAG. 2002

Firma Marco Gregori

ВЯРНО С ОРИГИНАЛА

Accessibilité du plan: Confidentiel ☐ Libre ☒	Modification:	Dessinateur:	Date:	Vérification:
	Tolérances générales:			
	Matière:			
	Traitement:			
	Echelle :	Dessinateur: HS	Date: 03/05/02	Vérification:

Ce plan est propriété de ALSTOM Parafoudres SA. Il ne peut être ni reproduit ni communiqué sans autorisation préalable.

VARISIL Type HE 36
Surge Arrester

ALSTOM
TRANSMISSION & DISTRIBUTIO
Parafoudres
B.P 256
65202 Bagnères-de-Bigor

A4	APF	W 8997 01 36	Folio : 1 / Ind : 02

18.DEC.2002 19:04

NO.932 P.20

CESI

Vs. rif.

Ns. rif. PeC – A3/001926

Data 21-01-2002

Messrs.
ALSTOM transmission & distribution
Parafoudres
65202 Bagnères-de-Bigorre
Att. Mr. Frederic Malpiece

Subject: **Weather ageing test according to IEC standard 60099-4 (2001-12) on one polymer housed surge arrester type HE 24**

Dear Sirs,

With reference to your request and awaiting to get ready the test report relevant to the subject we wish to send you here below a summary of the test carried out and of the relevant results

1. TEST OBJECTS

One polymer housed surge arrester type HE 24 (drawing W 8997 01 24)

The following ratings were assigned by the manufacturer:

- *Rated voltage: 24 kV*
- *Continuous operating voltage: 20 kV*
- *Nominal discharge current: 10 kA*

ВЯРНО С ОРИГИНАЛА

2. NORMATIVE REFERENCES

IEC 600994 (2001-12): "Surge arresters – metal oxide surge arresters without gaps for a.c. systems"

Mod. 001/W

CESI
Centro Elettrotecnico
Sperimentale Italiano
Giacinto Motta SpA

Via R. Rubattino 54
20134 Milano - Italia
Telefono +39 022125.1
Fax +39 0221255440
www.cesi.it

Capitale sociale 8 550 000 Euro
Interamente versato
Codice fiscale e numero
Iscrizione CCIAA 00793580150

Registro Imprese di Milano
Sezione Ordinaria
N. R.E.A. 429222
P.I. IT00793580150

3. TEST PLAN

The test was carried according to IEC 60099-4 at item 9.7.10 test series B
The surge arrester, mounted in vertical position, was energized at a power frequency voltage equal to 13.9 kV for 5000 hours while submitted to the various environmental stresses as specified in figure 9 of the standard.
Before and after the test the partial discharges and the reference voltage were measured for comparison.
Note that, according to Alstom request, the test voltage was $24/\sqrt{3}$ = 13.9 kV while the continuous operating voltage specified for the surge arrester is 20 kV

4. TEST RESULTS

No overcurrent trip-out occurred during the test.
No tracking, shed puncture, deep erosions or other significant damages were observed at the end of the test.
The partial discharge level measured before and after the test was less than 1 pC
The reference voltage measured before and after the test were respectively 23.16 kV and 22.93 kV with a decreasing of about 1%.

5. CONCLUSION

All the acceptance criteria specified by the standard at item 9.7.10.3 are satisfied and therefore the test result is to be considered positive.

ВЯРНО С
ОРИГИНАЛА

Mod. 003/w

Am

client ALSTOM Parafoudres S.A. - Bagneres de Bigorre (France)

equipment under test Polymer housed metal-oxide surge arrester type VARISIL HE 24

tests performed Weather ageing test - Test series B

normative documents IEC 60099-4 (2001-12) edition 1.2

receipt date of the sample 02 May, 2002

test date from 15 May, 2002 to 15 December, 2002

ВЯРНО С ОРИГИНАЛА

no. of pages 23 no. of pages annexed 4

issue date 27 March 2003

prepared PeC/TEST - M. Bonomelli

verified PeC/TEST - A. Sironi

approved PeC/TEST - V. Scarioni

M. Bonomelli
Albert. Sironi

CESI
CENTRO ELETTROTECNICO SPERIMENTALE ITALIANO
Business Unit
Prove e Componenti
Il Responsabile del Laboratorio

249

tests witnessed by: /

Identification of the object: The manufacturer guarantees that the tested object is manufactured according to the submitted drawings.
CESI checked that drawing adequately represents in shape and dimension the essential detail and the parts of the tested object.
The drawing identified by CESI and numbered A3/011332 is annexed to this document.

ВЯРНО С ОРИГИНАЛА

The measurement uncertainties of the test results reported in this document are the following:
- dielectric tests with impulse voltage : peak voltage: ± 3 % ; time parameters: ± 10 %
- dielectric tests with impulse current : peak value: ± 3 % ; time parameters: ± 10 %
- dielectric tests with alternating voltage : voltage (rms): ± 3 %

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to a confidence level of about 95 %) and have to be considered as maximum values.

laboratory information

CESI testing team: Mr. Bonomelli
Mr. M. Gregori - Mr. L. Podavitte

test laboratory: P177 - surge arrester laboratory
test laboratory: P189 - weather ageing laboratory
activity code: 33618J
keywords: 12015R, 22360D, 31020W, 44060J, 53001D, 62570N

250

contents	page	test date
Test object characteristics	4	
Reference standard	5	
Test procedure	6	
Summary of test result	9	20.05.2002 ÷ 15.12.2002
Initial measurement	10 ÷ 11	03.07.2002
Visual examination	12	
Final measurement	13 ÷ 14	09.12.2002
Photos	15 ÷ 23	

Page annexed: oscillogram n. 04.

Reference document annexed: ALSTOM drawing A1/011332 n. 1

251

ВЯРНО С ОРИГИНАЛА

Test object characteristics

type: Metal-oxide surge arrester type VARISIL HE 24

electrical characteristics (claimed by the client)

manufacturer's name	ALSTOM Parafoudres S.A.
nominal discharge current - I_n [kA]	10,0
rated voltage - U_r [kV]	24
continuous operating voltage - U_c [kV]	20
rated frequency - [Hz]	50 - 60

geometrical characteristics (measured on the test sample)

total height [mm]	245
number of large sheds	7
number of small sheds	7
shed large diameter [mm]	110
shed small diameter [mm]	80
shed spacing [mm]	30 (large-large), 15 (large-small)
core diameter [mm]	50
creepage distance [mm]	800

ВЯРНО С
ОРИГИНАЛА

other characteristics

housing material	silicon
housing color	grey

252

Reference Standard

IEC 60099-4 (2001-12) edition 1.2 at clause 9.7.10
" Metal-oxide surge arrester without gaps for a.c. system"

Test carried out

test carried out	number of sample tested
initial measurements	One sample identified as sample #8
weather test series 0 - 5000 hours	
final measurements and visual inspection	

A view of the test object is shown at page 16.

ВЯРНО С
ОРИГИНАЛА

253

Test procedure

Initial measurement

- The reference voltage have been measured at reference current equal to 1 mA_{pk}
- Internal partial discharge have been measured.
  The application voltage has been increased up to rated voltage (U_r) and maintained for 10 sec. Then the voltage has been decreased to 1,05 times the continuous operating voltage (U_c) and the partial discharge level has been measured according to the reference standard.

Test series A - 5000 hours

The test specimen has been installed in the test chamber in vertical position.
The test specimen has been kept energized at the voltage U_{test} = 13.9 kV_{rms} while submitted to the daily multi-stress environmental cycle as specified below.
The multi-stress environmental cycle was repeated 208 times for a total duration of 5000 hours.
The main characteristics of the different environmental stresses applied during the test are reported in the following table:

environmental stress	daily duration (h)	total duration (h)	severity
salt fog	8	1664	7 g/l - 0,4 l/h/m³
humidification	4	832	98 %
rain	2	416	100 Ωm - 1,5 mm/min
U.V. radiation	12	2496	50 mW/cm²
heating	10	2080	50 °C

A scheme of the daily cycle is shown at page 7.
A scheme of the test configuration is shown at page 8.
A view of the test configuration is shown on page 17.

ВЯРНО С ОРИГИНАЛА

Note The test was carried out in parallel with other specimens with different design

Note According to client request the test voltage was 24/√3 = 13.9 kV while the specified continuous operating voltage is 20 kV

Final measurement

- The reference voltage have been measured at reference current equal to 1 mA_{pk}
- Internal partial discharge have been measured.
  The application voltage has been increased up to rated voltage (U_r) and maintained for 10 sec.The voltage has been decreased to 1,05 times the continuous operating voltage (U_c) and the partial discharge level has been measured according to the reference standard.
- The test samples have been visually inspected

254

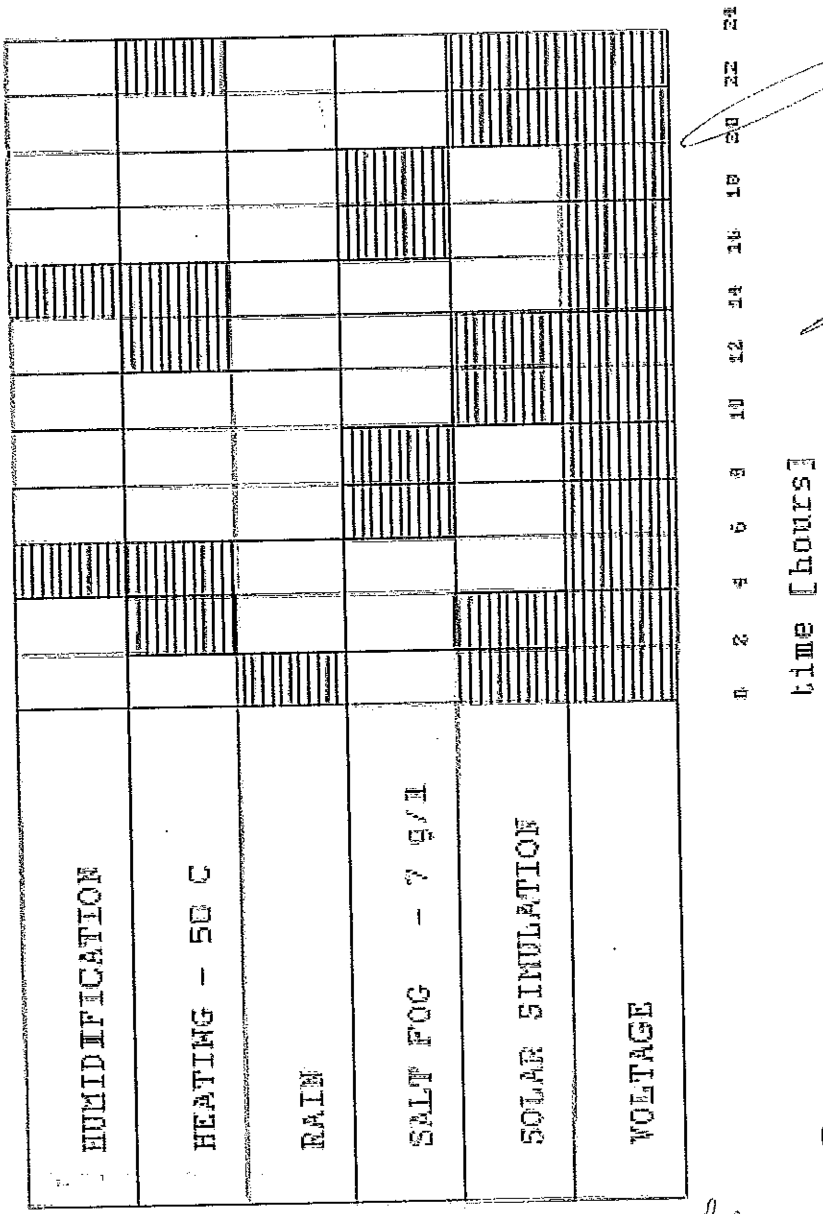


Fig. 4 - Daily cycle

ВЯРНО С
ОРИГИНАЛА

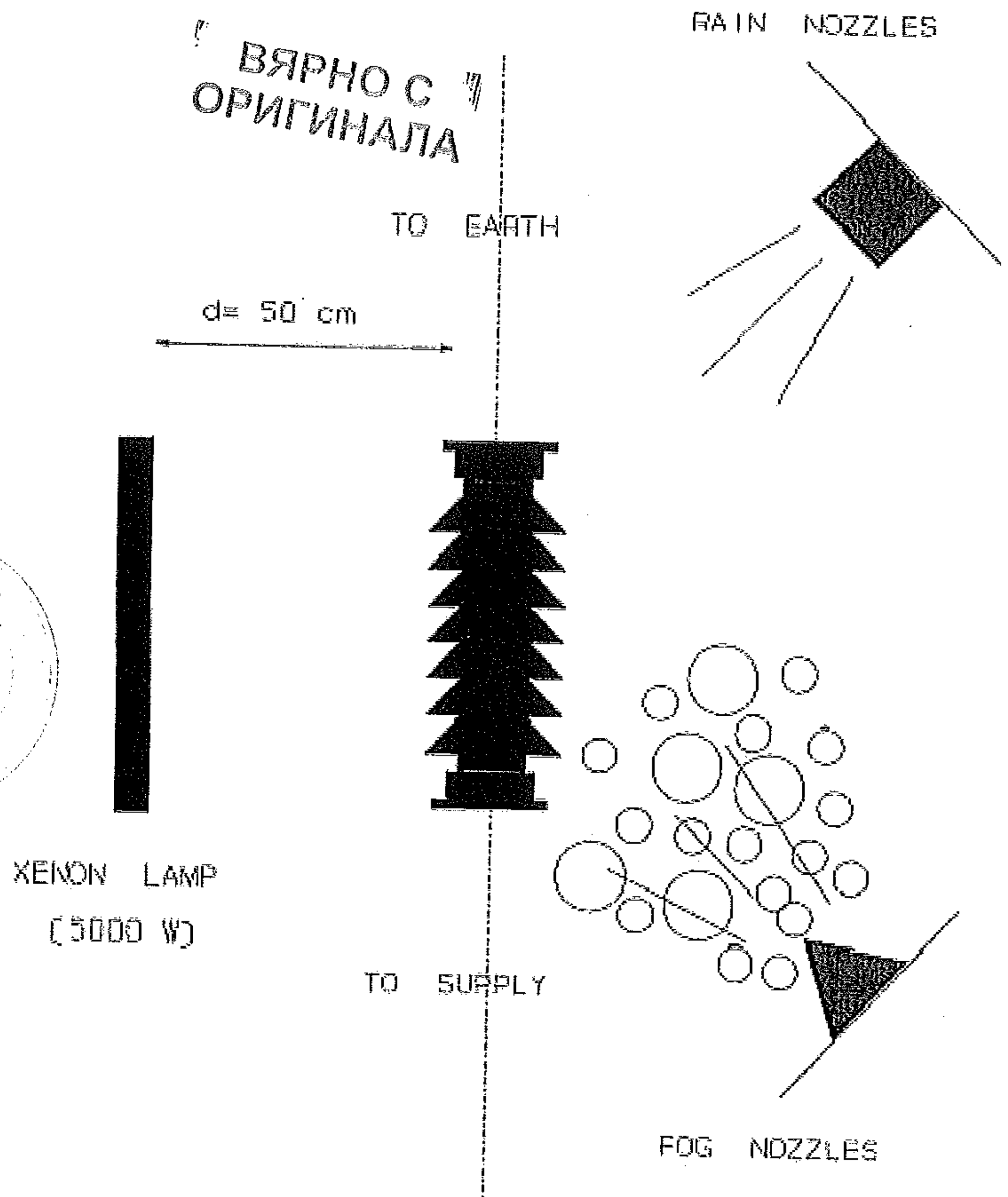


Fig. 6 - Scheme of the test configuration

256

Summary of test result

Test series B - 5000 hours

No flashover occurred during the test

Visual inspection

No tracking, shed puncture, erosion or any significant deterioration has been evidenced by the visual inspection carried out at the end of the test.

Variation of the reference voltage

	before test	after test	variation
	kV	kV	%
sample #5	23,16	22,93	- 1,0

Acceptance criteria: variation before/after less than 5 %

Partial discharge level

	before test	after test
	pC	pC
sample #5	< 1	< 1

ВЯРНО С ОРИГИНАЛА

Acceptance criteria: partial discharge level less than 10 pC

All acceptance criteria according to the reference standard are satisfied and therefore the results is to be considered positive.

25

Measurement of the reference voltage - initial

test object: Metal-oxide surge arrester

date: 09 March, 2002

			sample #2			
oscill.	voltage	current	current	current	power	3rd harmonic amplitude
no.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	µA
1	23,16	1,0	0,98	0,69	7,78	1,76

ВЯРНО С
ОРИГИНАЛА

[illegible]

Measurement of partial discharges - initial

test object: Metal-oxide surge arrester

arrangement: ---

atmospheric conditions		
b	t	h
kPa	°C	g / m³

date: 03 March, 2002

test condition	applied voltage	duration of voltage application	temperature of the test object	partial discharge measurement: voltage increase: CRO readout	partial discharge measurement: voltage increase: Q max	partial discharge measurement: voltage decrease: CRO readout	partial discharge measurement: voltage decrease: Q max	oscillogram	note
	kV_{rms}	sec	°C	mV	pC	mV	pC	no.	
sample #5	24		20	≤5	≤1				
	21					≤9	≤1	05	

Note: background noise ≤ 1 pC, see oscillogram n. 03.

ВЯРНО С ОРИГИНАЛА

Visual examination

The housing of the specimen has been inspected visually.
No tracking, shed puncture, erosion or any significant deterioration has been evidenced by the visual inspection carried out at the end of the test.
See photos from page 18 to 23.

ВЯРНО С ОРИГИНАЛА

Аи

Measurement of the reference voltage - final

test object: Metal-oxide surge arrester

date: 09 December, 2002

			sample no. #5			
oscill.	voltage	current	current	current	power	3rd harmonic amplitude
no.	kV	+ mA_{p}	- mA_{p}	mA_{rms}	W	µA
2	22,93	0,66	1,04	0,65	---	—

ВЯРНО С ОРИГИНАЛА

Measurement of partial discharges - final

test object: Metal-oxide surge arrester

arrangement: —

atmospheric conditions		
b	t	h
kPa	°C	g / m³

date: 03 December, 2002

test condition	applied voltage	duration of voltage application	temperature of the test object	partial discharge measurement: voltage increase: CRO readout	voltage increase: Q max	voltage decrease: CRO readout	voltage decrease: Q max	oscillogram	note
	kV	sec	°C	mV	pC	mV	pC	no.	
	24		15	≤5	≤1				
	21					≤5	≤1	06	

Note: background noise ≤ 1 pC.

ВЯРНО С ОРИГИНАЛА

ПРОТОКОЛИ ОТ ТИПОВИ ИЗПИТАНИЯ за VARISIL HE-S тип вентилни отводи с полимерна външна изолация

Проведени типови изпитания	Референтни стандарти	Изпитани мостри	ИЗПИТАТЕЛНИ ПРОТОКОЛИ			Допълнителна информация
			Справка	Дата	Език	
Изпитания за издържливост на външната изолацията	IEC 60099- 4 §10.8.2	Външна изолация стойност12kV, 24&36kV	CESI AT-A1/025452	Септември 3,2001	Английски	
		Външна изолация стойност 18kV, тип S3 изолационна конзола	CESI AT-A1/025961	Септември 5,2001	Английски	
Изпитания на остатъчното напрежение със стръмен мълниев и превключвателен токов импулс	IEC 60099- 4 §10.8.3	Напрежение 6 кV	CESI AT-A0/041526	Януари 25, 2001	Английски	Волт-амперни характеристични криви VI8998 01 XX/E rev.01/януари 04, 2010, англ./
Изпитания за издържливост на продължителен токов импулс	IEC 60099- 4 §10.8.4	HE 6 kV S1D2	CESI A5/046538	Януари 22, 2013	Английски	
Изпитване в експутационен режим с висок токов импулс	IEC 60099- 4 §10.8.5	HE 6 kV S1D2	CESI A5/055428	Март 7, 2013	Английски	
Напрежено-времева /VS/характеристична крива	IEC 60099- 4 §6.10	HE-S обсег			Английски	Волт-амперни характеристични криви VI8998 01 XX/E rev.01/януари 04, 2010, англ./

207

Тест на разединител	IEC 60099- 4 §8.6.2.1	Тип S3D2 разединител	CESI B1027449	Септември 14, 2011	Английски	
	IEC 60099- 4 §8.6.2.2		CESI B1027448	Септември 14, 2011	Английски	
	IEC 60099- 4 §8.6.3		CESI B1027905	Септември 13, 2011	Английски	
Изпитания при късо съединение	IEC 60099- 4 §10.8.7	HE-S 24 вентилни отводи	CESI A8018577	Юни 25 , 2008	Английски	
Изпитания за частични разряди	IEC 60099- 4 §10.8.8	HE-36 вентилни отводи	CESI AT-A0/042489	Декември 22,2000	Английски	
Изпитания на момент на огъване	IEC 60099- 4 §10.8.13	HE- S 42 вентилни отводи	Tridelta TR/SCUS TR-E1219BM	Ноември 15, 2012	Английски	
Изпитване за стареене	IEC 60099- 4 §10.8.14.2.1/ 1000 часа изпитание/	HE 36 вентилни отводи	CESI AT-A2/032924	Декември 18, 2002	Английски	
	IEC 60099- 4 §10.8.14.2.2/ 5000 часа изпитание/	HE 24 вентилни отводи	CESI AT-A3/007530	Март 27, 2003	Английски	

264

TRIDELTA Parafoudres S.A.

TYPE TEST REPORTS relating to
VARISIL™ HE-S polymer housed surge arresters & associated accessories

TYPE TESTS PERFORMED	REFERENCE STANDARD	SAMPLES TESTED	TEST REPORT			ADDITIONAL INFORMATION
			Reference	Date	Language	
Insulation withstand tests on the housings & the insulating bracket	IEC 60099-4 § 10.8.2	Housings rated 12 kV, 24 kV & 36 kV	**CESI AT-A1/025452**	September 3, 2001	English	see **Note 2**
		Housing rated 18 kV & Type S3 insulating bracket	**CESI AT-A1/025961**	September 5, 2001	English	see **Note 2**
Steep, lightning and switching current impulse residual voltage tests	IEC 60099-4 § 10.8.3	HE 6 kV prorated sections	**CESI AT-A0/041526**	January 25, 2001	English	see **Note 2** & Voltage vs current characteristic curve **VI 8998 01 XX / E rev. 01** (January 4, 2010, English)
Long duration current impulse withstand test	IEC 60099-4 § 10.8.4	HE 6 kV S1D2 prorated sections	**CESI A5/046538**	September 28, 2005	English	see **Note 2**
High current impulse operating duty test	IEC 60099-4 § 10.8.5	HE 6 kV S1D2 prorated sections	**CESI A5/055428**	December 14, 2005	English	see **Note 2**
Voltage vs time characteristic curve	IEC 60099-4 § 6.10	HE-S range				Curve **UT 8998 01 XX / E rev. 01** (January 4, 2010, English)
Tests on disconnector	IEC 60099-4 § 8.6.2.1	Type S3D2 disconnector	**CESI B1027449**	September 14, 2011	English	Test carried out in series with a HE 6 kV S3D2 section
	IEC 60099-4 § 8.6.2.2		**CESI B1027448**	September 14, 2011	English	Test carried out in series with a HE 6 kV S3D2 section
	IEC 60099-4 § 8.6.3		**CESI B1027905**	September 13, 2011	English	Current vs time characteristic curve **CT 8997 09 9X / E rev. 02** (September 14, 2011, English)

ВЯРНО С ОРИГИНАЛ

TYPE TESTS PERFORMED	REFERENCE STANDARD	SAMPLES TESTED	TEST REPORT			ADDITIONAL INFORMATION
			Reference	Date	Language	
Short circuit tests	IEC 60099-4 § 10.8.7	HE-S 24 surge arresters	**CESI A8018577**	June 25, 2008	English	
Partial discharge test	IEC 60099-4 § 10.8.8	HE 36 surge arresters	**CESI AT-A0/042489**	December 22, 2000	English	see **Note 2**
Bending moment test	IEC 60099-4 § 10.8.13	HE-S 42 surge arresters	**TRIDELTA / SCÜS TR-E 12019BM**	November 15, 2012	English	
Weather ageing test	IEC 60099-4 § 10.8.14.2.1 (1000 h test)	HE 36 surge arrester	**CESI AT-A2/032924**	December 18, 2002	English	see **Note 2**
	IEC 60099-4 § 10.8.14.2.2 (5000 h test)	HE 24 surge arrester	**CESI AT-A3/007530**	March 27, 2003	English	see **Note 2**

Note 1 : Reference is made to the latest version of IEC 60099-4 standard, namely edition 2.2 published in May 2009

Note 2 : The HE-S arrester design is very similar to the HE and is in particular built with the same MO resistors, resulting in the same voltage stress per unit length but even lower voltage stress per unit thickness.
Therefore, the type tests carried out on HE samples for checking the MO resistor or/and insulation performance also cover the HE-S range.

ВЯРНО С ОРИГИНАЛА

CESI

TENUE DIELECTRIQUE
HE ENEL

[redacted]

REMPLACE RAPPORT
CESI AT-AO/042765

ВЯРНО С
ОРИГИНАЛА

207

client	ALSTOM Parafoudres S.A. - Bagneres de Bigorre Cedex (France)
equipment under test	housing of 10kA polymeric housed surge arresters
tests performed	dry lightning impulse voltage test; wet power frequency voltage test.
normative documents	IEC 60099-4 (1991-06)

receipt date of the sample	december 15, 2000	
test date	from december 19, 2000	to february 01, 2001

the test results relate only to the sample tested
this document shall not be reproduced except in full without the written approval of CESI and of the accreditation body, if any

n° 0030

no. of pages	12	no. of pages annexed	–

issue date	September 03, 2001
prepared	PeC/TEST - C. Del Giorgio
verified	PeC/TEST - A. Sironi
approved	PeC/TEST - V. Scarioni

Carlo Del Giorgio
Alberto Sironi

CESI
CENTRO ELETTROTECNICO SPERIMENTALE ITALIANO
Business Unit
Prove e Componenti
Il Responsabile del Laboratorio

ВЯРНО С
ОРИГИНАЛА

268

CESI
Centro Elettrotecnico
Sperimentale Italiano
Giacinto Motta SpA

Via R. Rubattino 54
20134 Milano - Italia
Telefono +39 022125.1
Fax +39 0221255440
www.cesi.it

Capitale sociale 8 550 000 Euro
interamente versato
Codice fiscale e numero
iscrizione CCIAA 00793580150

Registro Imprese di Milano
Sezione Ordinaria
N. R.E.A. 429222
P.I. IT00793580150

tests witnessed by: Mr. F. Malpiece - ALSTOM Parafudre S.A.

identification of the object: effected
The Manufacturer guarantees that the tested objects are manufactured according to the submitted drawings.
CESI checked that these drawings adequately represents in shape and dimensions the essential details and the parts of the tested objects.
These drawings identified by CESI and numbered **A0/041852 no.1 (12kV)**, **A0/041853 no.1 (24kV)**, **A0/041855 no.1 (36kV)** are annexed to this document.

The data necessary to permit repetition of the tests are contained in the document marked: AT–A0/041765

The measurement uncertainties of the test results reported in this document are the following:
- dielectric tests with impulse voltage : **peak voltage:** ± 3 % ; **time parameters:** ± 10 %
- dielectric tests with impulse current : **peak value:** ± 3 % ; **time parameters:** ± 10 %
- dielectric tests with alternating voltage : **voltage (rms):** ± 3 %
- dielectric tests with direct voltage : **voltage:** ± 3 %

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to a confidence level of about 95 %) and have to be considered as maximum values.

activity code: 29380X
keywords: 12015R 23801L 31020W 41040M 53001D 62501B

ВЯРНО С ОРИГИНАЛА

269

ВЯРНО С ОРИГИНАЛА

270

contents	page	test date
rated characteristics of the test voltage declared by the manufacturer	4	
test voltage values	5	
summary of test results	6	
dry lightning impulse voltage test	7	dec.19, 2000 - feb.01,
wet power frequency voltage test	8	dec.19, 2000 - feb.01,
circuit A002	9	
circuit A059	10	
panoramic view of the test samples	11	
panoramic view of the test arrangement	12	

reference document annexed

12kV sample - drawing no. W 8997 12 31 identified by CESI and numbered A0/041852 no.1
24kV sample - drawing no. W 8997 24 31 identified by CESI and numbered A0/041853 no.1
36kV sample - drawing no. W 8997 36 31 identified by CESI and numbered A0/041855 no.1

rated characteristics of the test voltage declared by the manufacturer

12kV sample

manufacturer	ALSTOM Parafudre S.A.
type	HE
drawing no.	W 8997 12 31
rated voltage (U_r)	12 kV
nominal discharge current (I_N)	10 kA
line discharge class	1
dry lightning impulse withstand voltage	95 kV_{pk}
wet power frequency withstand voltage	38 kV_{rms}

24kV sample

manufacturer	ALSTOM Parafudre S.A.
type	HE
drawing no.	W 8997 24 31
rated voltage (U_r)	24 kV
nominal discharge current (I_N)	10 kA
line discharge class	1
dry lightning impulse withstand voltage	125 kV_{pk}
wet power frequency withstand voltage	50 kV_{rms}

36kV sample

manufacturer	ALSTOM Parafudre S.A.
type	HE
drawing no.	W 8997 36 31
rated voltage (U_r)	36 kV
continuous operating voltage (U_c)	30 kV_{rms}
nominal discharge current (I_N)	10 kA
line discharge class	1
dry lightning impulse withstand voltage	170 kV_{pk}
wet power frequency withstand voltage	70 kV_{rms}

ВЯРНО С ОРИГИНАЛА

271

272

test voltage values

12kV sample

Lightning impulse voltage test (dry)	95 kV_{pk}
Power frequency voltage test (wet)	38 kV_{rms}

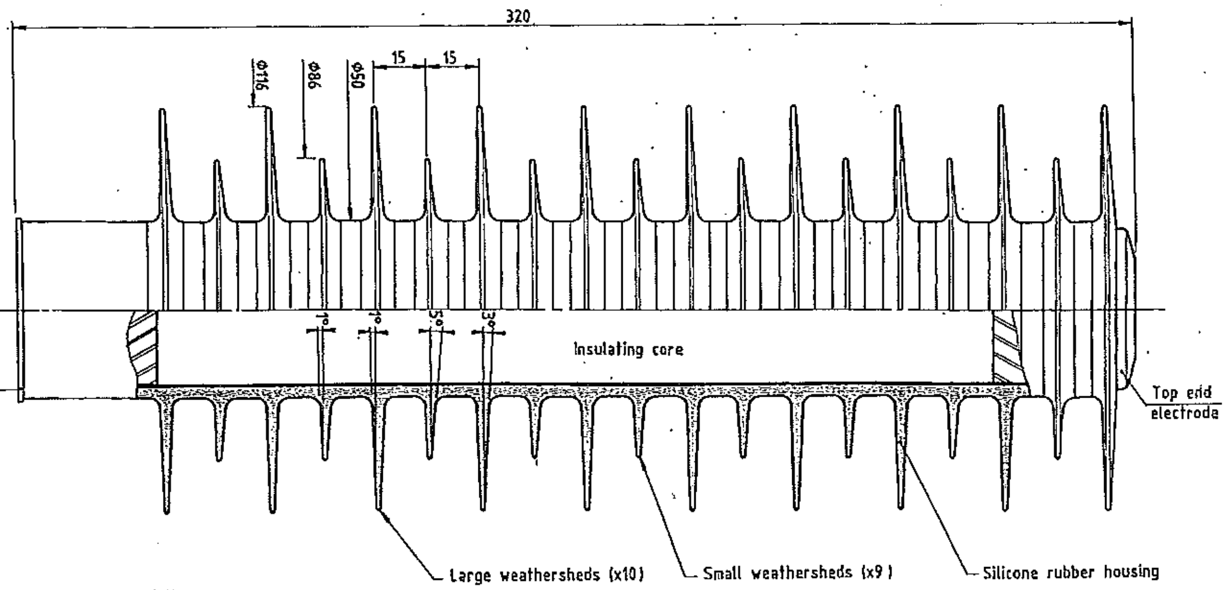
24kV sample

Lightning impulse voltage test (dry)	125 kV_{pk}
Power frequency voltage test (wet)	50 kV_{rms}

36kV sample

Lightning impulse voltage test (dry)	170 kV_{pk}
Power frequency voltage test (wet)	70 kV_{rms}

ВЯРНО С
ОРИГИНАЛА



CESI
PROTOCOLLO DATA
A 0/0 4 1 8 3 ; n0 0 1 1 9 DIC 2000
Firma ...

Nominal arc length : 355 mm

Nominal creepage distance : 1200 mm

Modification :		Dessinateur :	Date :	Vérification :
Tolérances générales :				
Matière :				
Traitement :				
	Echelle :	Dessinateur : HS	Date : 12/12/00	Vérification :
36 kV rated silicone rubber housing for VARISIL type HE surge arresters.			ALSTOM TRANSMISSION & DISTRIBUTION Parafoudres B.P. 256 65202 Bagnères-de-Bigorre	
A3	APF	W 8997 36 31	Folio : 1 / 1	Indice : 00

Accessibilité du plan : Libre ☐ Confidentiel ☒

Ce plan est propriété de ALSTOM Parafoudres S.A. ; il ne peut être ni reproduit ni communiqué sans autorisation préalable

ВЯРНО С ОРИГИНАЛА

273

summary of test result

dry lightning impulse voltage test

For each rated voltage level one housing of 10kA polymeric housed surge arresters was tested.
The test was performed at the specified lightning impulse voltage obtained applying the corrections for atmospheric conditions.
Fifteen impulses were applied at positive and negative polarity to each sample under test.
No external flashovers occurred and the housings have not been damaged by these tests
Therefore the test result is to be considered positive.

wet power frequency voltage test

For each rated voltage level one housing of 10kA polymeric housed surge arresters was tested.
The test samples withstood for one minute the wet power frequency withstand voltage claimed by the manufacturer.
Therefore the test result is to be considered positive.

ВЯРНО С
ОРИГИНАЛА

274

275

ВЯРНО С ОРИГИНАЛ

M00-A1420-G

dry lightning impulse voltage test

test object: housing of 10kA polymeric housed surge arresters

test circuit: A002

test housing	positive polarity						negative polarity						test date
	requested voltage	correction factor	applied voltage	applied impulses	flashover	test result	requested voltage	correction factor	applied voltage	applied impulses	flashover	test result	
	kV	K	kV	no.	no.		kV	K	kV	no.	no.		
12kV sample	95,0	0,978	92,9	15	0	withstand	95,0	0,978	92,9	15	0	withstand	December 19, 2000
24kV sample	125,0	0,978	122,3	15	0	withstand	125,0	0,978	122,3	15	0	withstand	December 19, 2000
36kV sample	170,0	0,986	167,6	15	0	withstand	170,0	0,986	170,0	15	0	withstand	February 01, 2001

note:

MOD.A1225/G

wet power frequency voltage test

test object: housing of 10kA polymeric housed surge arresters

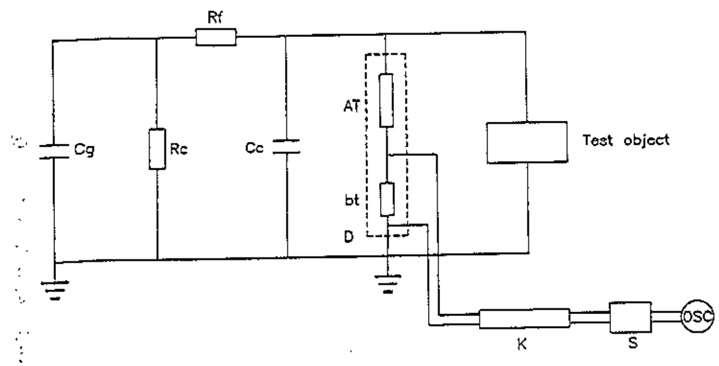
test circuit : A059

	precipitation conditions				
	precipitation rate mm / min			water temperature	water resistivity
	top	center	bottom	°C	Ω × m
vertical	--	1,5	--	15,0	100,0
horizontal	--	1,6	--		

test housing	voltage			test duration	test result	test date
	required (U)	correction factor	applied (U × K_t)			
	kV_{rms}	K_t	kV_{rms}	s		
12kV sample	38,0	1,006	38,2	60	withstand	December 19, 2000
24kV sample	50,0	1,006	50,3	60	withstand	December 19, 2000
36kV sample	70,0	1,000	70,0	60	withstand	February 01, 2001

Note:

circuit A002



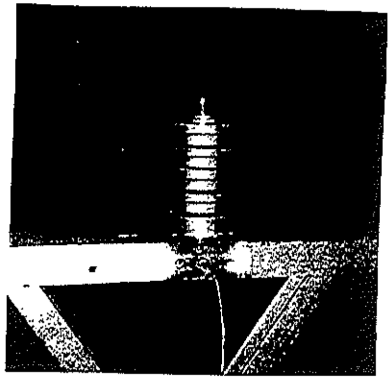
lightning impulse test circuit

Cg : Impulse generator capacitance
Rf : Front resistor
Rc : Tail resistor
Cc : Load capacitance
D : Divider type RC series
K : coaxial cable
S : attenuation and termination unit
Osc : Oscilloscope

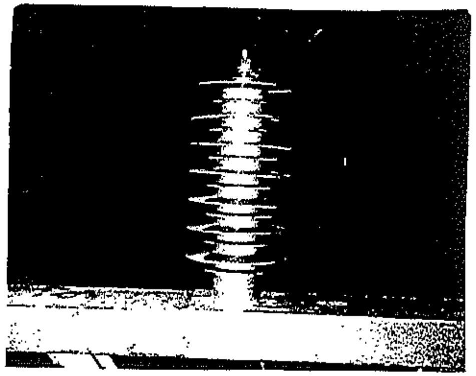
ВЯРНО С ОРИГИНАЛА

277

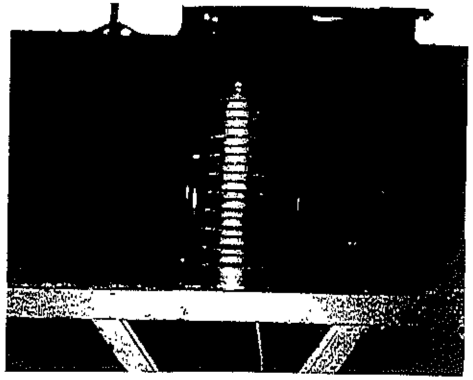
panoramic view of the test samples



12kV sample



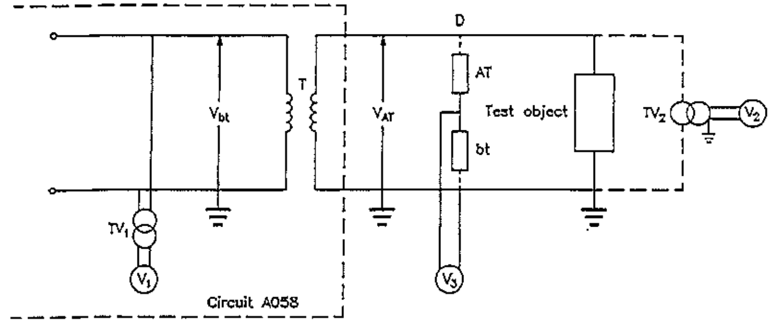
24kV sample



36kV sample

ВЯРНО С
ОРИГИНАЛА

circuit A059



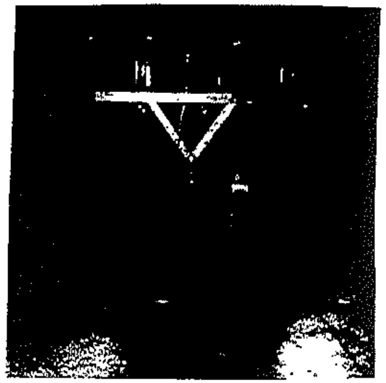
power frequency measuring circuit

TV_2: voltage transformer
V_2 : voltmeter
D : voltage divider type RC series
low voltage arm
V_3 : voltmeter
TV_1: voltage transformer
V_1 : voltmeter

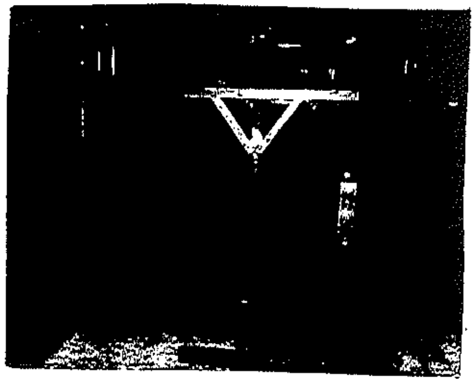
ВЯРНО С
ОРИГИНАЛА

279

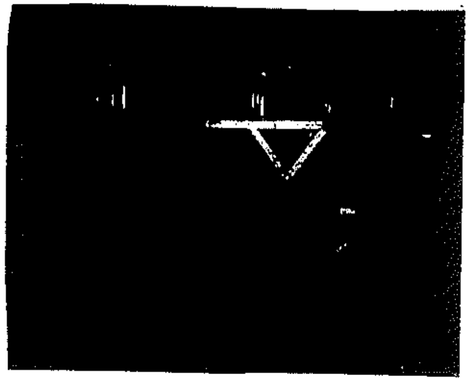
panoramic view of the test arrangement



12kV sample



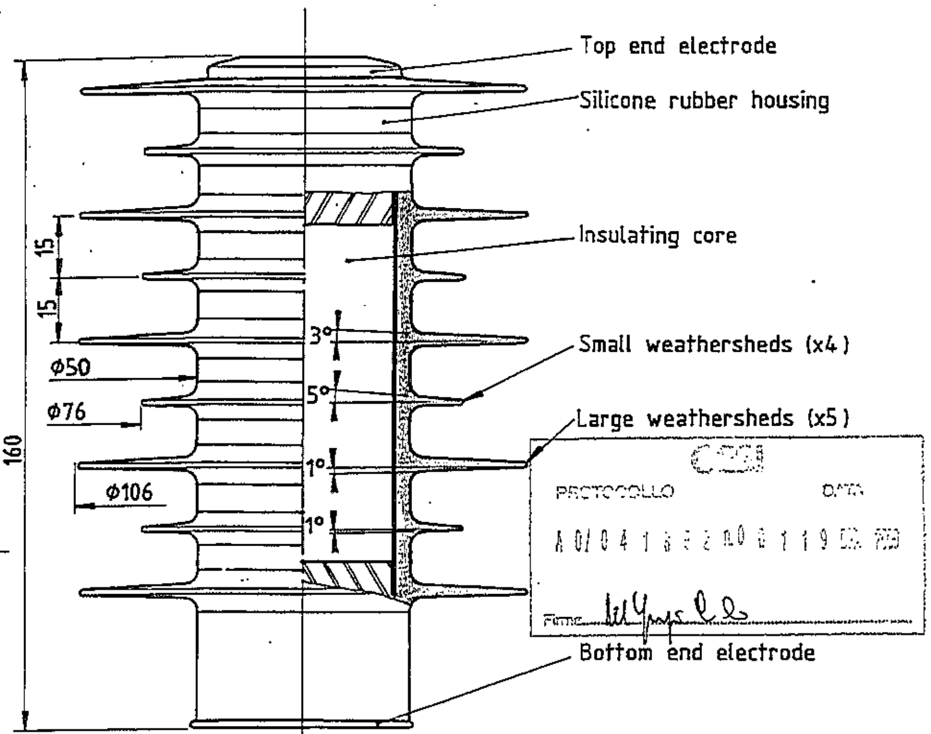
24kV sample



36kV sample

ВЯРНО С
ОРИГИНАЛА

280



Nominal arc length : 195 mm
Nominal creepage distance : 480 mm

Modification :	Dessinateur :	Date :	Vérification :
Tolérances générales :			
Matière :			
Traitement :			
Echelle :	Dessinateur : HS	Date : 12/12/00	Vérification :

Accessibilité du plan : Confidentiel ☐ Libre ☒

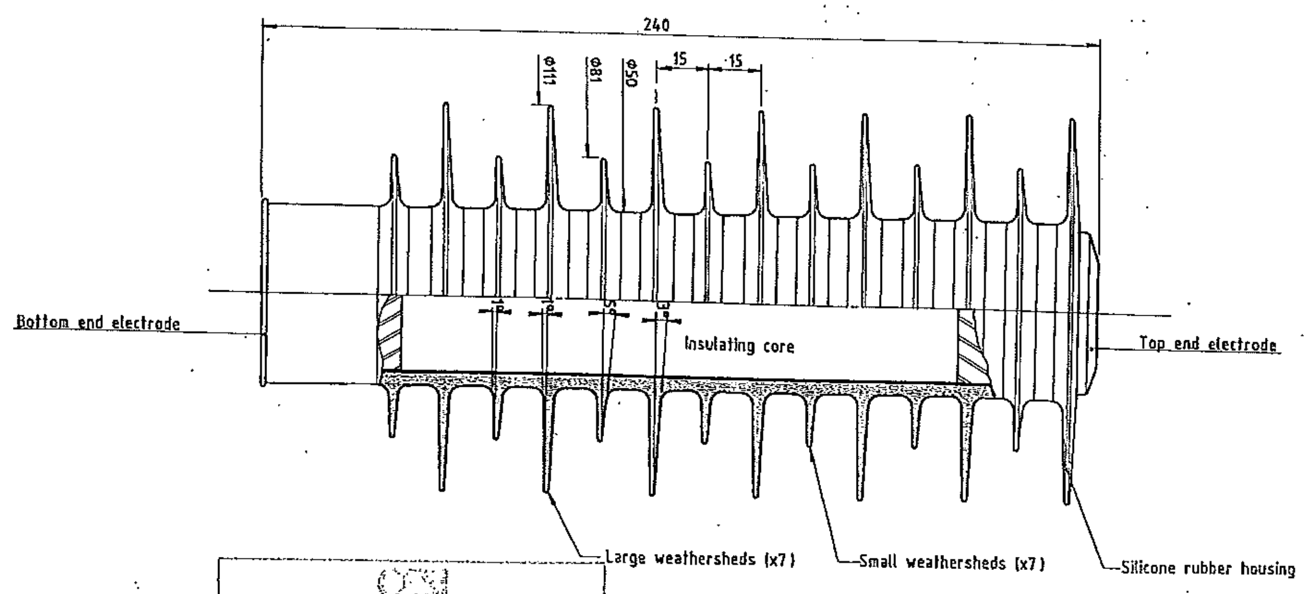
Ce plan est propriété de ALSTOM Parafoudres SA : il ne peut être ni reproduit ni communiqué sans autorisation préalable

12 kV rated silicone rubber housing for VARISIL type HE surge arresters.

ALSTOM
TRANSMISSION & DISTRIBUTION
Parafoudres
B.P. 256
65202 Bagnères-de-Bigorre

A4 | APF | W 8997 12 31 | Folio : 1 / 1 | Indice : 00

ВЯРНО С ОРИГИНАЛА



PROTOCOLLO DATA
A 0/04 1 3 3 3 n 0 0 1 1 9 DIC 2000
Firma

Nominal arc length : 270 mm

Nominal creepage distance : 800 mm

Modification :	Dessinateur :	Date :	Vérification :
Tolérances générales :			
Matière :			
Traitement :			
Echelle :	Dessinateur : HS	Date : 12/12/00	Vérification :

Accessibilité du plan : Confidentiel ☐ Libre ☒

Ce plan est propriété de ALSTOM Parafoudres SA ; il ne peut être ni reproduit ni communiqué sans autorisation préalable

24 kV rated silicone rubber housing for VARISIL type HE surge arresters.

ALSTOM
TRANSMISSION & DISTRIBUTION
Parafoudres
B.P. 256
65202 Bagnères-de-Bigorre

A3 | APF | W 8997 24 31 | Folio : 1 / 1 | Indice : 00

ВЯРНО С
ОРИГИНАЛА

232

CESI

TENUE ELECTRIQUE
HE ENEL

~~[illegible] POUR~~
~~ENVELOPPE 18 kV~~
~~&~~
~~SUPPORT S3~~

ВЯРНО С
ОРИГИНАЛА

283

client	ALSTOM Parafoudres S.A. - Bagneres de Bigorre Cedex (France)
equipment under test	polymer housed surge arrester housing
tests performed	lightning impulse voltage test; power frequency voltage test - wet.
normative documents	ENEL technical specifications DY 557 (July 1999, draft), DY 1018 (May 1999, draft); IEC 60099-4 (1991-06)

receipt date of the sample	May 29, 2001	
test date	from May 30, 2001	to May 30, 2001

the test results relate only to the sample tested
this document shall not be reproduced except in full without the written approval of CESI and of the accreditation body, if any

no. of pages 12 no. of pages annexed --

issue date	September 5, 2001	
prepared	PeC/TEST - C. Del Giorgio	Carlo Del Giorgio
verified	PeC/TEST - A. Sironi	Alb. S
approved	PeC/TEST - V. Scarioni	

CESI
CENTRO ELETTROTECNICO SPERIMENTALE ITALIANO
Business Unit
Prove e Componenti
Il Responsabile del Laboratorio

ВЯРНО С ОРИГИНАЛА

234

tests witnessed by: Mr. F. Malpiece - ALSTOM Parafuodres S.A.

identification of the object: effected
The Manufacturer guarantees that the tested object is manufactured according to the submitted drawings.
CESI checked that these drawings adequately represent in shape and dimensions the essential details and the parts of the tested object.
These drawings identified by CESI and numbered **A1/021094 no.1 and no.4** are annexed to this document.

The data necessary to permit repetition of the tests are contained in the document marked: AT–A1/016942

The measurement uncertainties of the test results reported in this document are the following:
- dielectric tests with impulse voltage : **peak voltage: ± 3 % ; time parameters: ± 10 %**
- dielectric tests with impulse current : **peak value: ± 3 % ; time parameters: ± 10 %**
- dielectric tests with alternating voltage : **voltage (rms): ± 3 %**
- dielectric tests with direct voltage : **voltage: ± 3 %**

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to a confidence level of about 95 %) and have to be considered as maximum values.

activity code: 31126P
keywords: 12015R 23801L 31020W 41040M 53001D 62501B

MOD.A10011G-R01

ВЯРНО С ОРИГИНАЛА

285

286

ВЯРНО С
ОРИГИНАЛА

MOD.A1002/3

contents	page	test date
rated characteristics of the test voltage declared by the manufacturer	4	
test voltage values	5	
summary of test result	6	
dry lightning impulse withstand voltage test	7	May 30, 2001
wet power frequency withstand voltage test	8	May 30, 2001
circuit A002	9	
circuit A059	10	
panoramic view of the test samples	11	
panoramic view of the test arrangement	12	

reference document annexed

- drawings identified by CESI and numbered **A1/021094 no.1 and no.4**

rated characteristics of the test voltage declared by the manufacturer

manufacturer	**ALSTOM Parafudre S.A.**
ALSTOM designation	VARISIL HE 18 sd/E
ENEL type	DY 557/4
code	B 8997 07 18
drawing no.	W 8997 07 18/I
rated voltage (U_r)	18 kV
continuous operating voltage (U_c)	15 kV
nominal discharge current (I_N)	10 kA
line discharge class	1
minimum creepage distance of arrester housing	650 mm
bracket type	S3/E
drawing no.	B 8997 09 41/I

ВЯРНО С ОРИГИНАЛА

287

MOD.A1176/G

test voltage values

arrester housing

Lightning impulse voltage test (dry)

$U_{pk} = 1,3xU_{LIPL} = 1,3x65 = 84,5\ kV_{pk}$

U_{LIPL} : lightning impulse protection level (according to ENEL technical specifications) = 65 kV_{pk}

Power frequency voltage test (wet)

$U_{pk} = 0,88xU_{LIPL} = 0,88x65 = 57,2\ kV_{pk}$

$U_{rms} = U_{pk}/\sqrt{2} = 40,44\ kV_{rms}$

U_{LIPL} : lightning impulse protection level (according to ENEL technical specifications) = 65 kV_{pk}

bracket

Lightning impulse voltage test (dry)

$U_{test} = 73\ kV_{pk}$

Power frequency voltage test (wet)

$U_{test} = 40\ kV_{rms}$

ВЯРНО С ОРИГИНАЛА

288

summary of test result

arrester housing

dry lightning impulse voltage test
For each rated voltage level one housing of 10kA polymeric housed surge arresters was tested.
The test was performed at the specified lightning impulse voltage obtained applying the corrections for atmospheric conditions.
Fifteen impulses were applied at positive and negative polarity to each sample under test.
No external flashovers occurred and the housings have not been damaged by these tests
Therefore the test result is to be considered positive.

wet power frequency voltage test
For each rated voltage level one housing of 10kA polymeric housed surge arresters was tested.
The test samples withstood for one minute the wet power frequency withstand voltage claimed by the manufacturer.
Therefore the test result is to be considered positive.

bracket

dry lightning impulse voltage test
For each rated voltage level one bracket of surge arresters was tested.
The test was performed at the specified lightning impulse voltage obtained applying the corrections for atmospheric conditions.
Fifteen impulses were applied at positive and negative polarity to each sample under test.
No external flashovers occurred and the housings have not been damaged by these tests
Therefore the test result is to be considered positive.

wet power frequency voltage test
For each rated voltage level one bracket of surge arresters was tested.
The test samples withstood for one minute the wet power frequency withstand voltage claimed by the manufacturer.
Therefore the test result is to be considered positive.

ВЯРНО С ОРИГИНАЛА

MOD.A1178G

290

dry lightning impulse withstand voltage test

test circuit: A002

test object: polymer housed surge arrester housing

test object	positive polarity						negative polarity						test date
	requested voltage	correction factor	applied voltage	applied impulses	flashover	test result	requested voltage	correction factor	applied voltage	applied impulses	flashover	test result	
no.	kV_{peak}	K	kV_{peak}	no.	no.		kV_{peak}	K	kV_{peak}	no.	no.		
1	84,5	0,989	84,5	15	0	withstand	84,5	0,989	84,5	15	0	withstand	May 30, 2001

note:

test object: bracket

test object	positive polarity						negative polarity						test date
	requested voltage	correction factor	applied voltage	applied impulses	flashover	test result	requested voltage	correction factor	applied voltage	applied impulses	flashover	test result	
no.	kV_{peak}	K	kV_{peak}	no.	no.		kV_{peak}	K	kV_{peak}	no.	no.		
1	73,0	0,978	71,4	15	0	withstand	73,0	0,978	71,4	15	0	withstand	May 30, 2001

note:

ВЯРНО С ОРИГИНАЛА

691

wet power frequency withstand voltage test

test circuit: A059

	precipitation conditions				
	precipitation rate mm / min			water temperature	water resistivity
	top	center	bottom	°C	Ω × m
vertical	--	1,8	--	22,6	95,0
horizontal	--	1,8	--		

test circuit : polymer housed surge arrester housing

test object	voltage			test duration	test result	test date
	required (U)	correction factor	applied (U × K_t)			
no.	kV_{rms}	K_t	kV_{rms}	s		
1	57,2	0,992	56,7	60	withstand	May 30, 2001

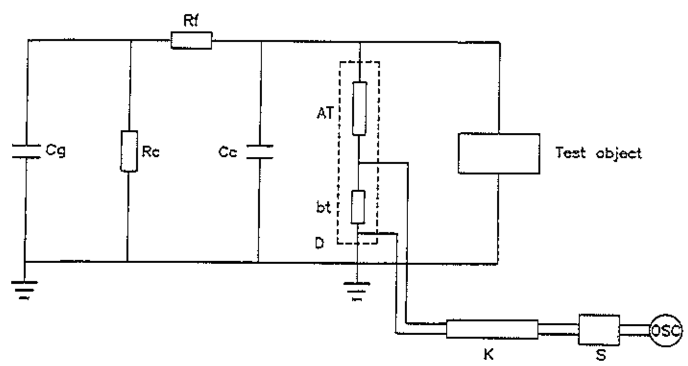
Note:

test circuit : bracket

test object	voltage			test duration	test result	test date
	required (U)	correction factor	applied (U × K_t)			
no.	kV_{rms}	K_t	kV_{rms}	s		
1	40,0	0,990	39,6	60	withstand	May 30, 2001

Note:

circuit A002



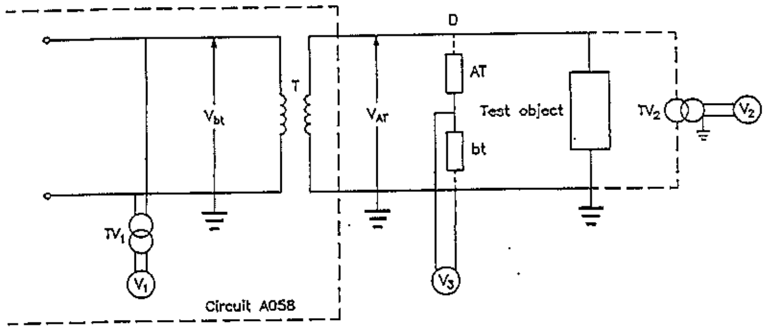
lightning impulse test circuit

Cg : Impulse generator capacitance
Rf : Front resistor
Rc : Tail resistor
Cc : Load capacitance
D : Divider type RC series
K : coaxial cable
S : attenuation and termination unit
Osc : Oscilloscope

ВЯРНО С ОРИГИНАЛА

292

circuit A059



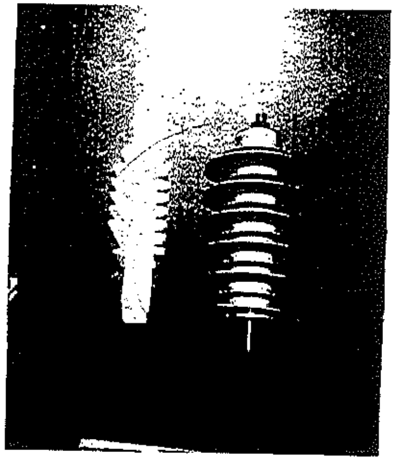
power frequency measuring circuit

TV_2: voltage transformer
V_2 : voltmeter
D : voltage divider type RC series
low voltage arm
V_3 : voltmeter
TV_1: voltage transformer
V_1 : voltmeter

ВЯРНО С
ОРИГИНАЛ

293

panoramic view of the test sample



294

CESI

ВЯРНО С
ОРИГИНАЛ

T-A0/041526

client	Alstom Parafudres S.A. - Bagnères de Bigorre (France)	
equipment under test	Metal-oxide surge arrester type VARISIL HE	
tests performed	Residual voltage test	
normative documents	Client's request based on IEC 60099-4 (1998)	
receipt date of the sample	December 15, 2000	
test date	from December 18, 2000	to December 19, 2000

no. of pages	14	no. of pages annexed	27	
issue date	January 25, 2001			
prepared	PeC/TEST -	R. Malgesini	A. M.	
verified	PeC/TEST -	A. Sironi	Allo. S.	
approved	PeC/TEST -	V. Scarioni		

CESI
CENTRO ELETTROTECNICO SPERIMENTALE ITALIANO
Business Unit
Prove e Componenti
Il Responsabile del Laboratorio

ВЯРНО С ОРИГИНАЛА

296

tests witnessed by:

identification of the object: The manufacturer guarantees that the tested object is manufactured according to the submitted drawing.
CESI checked that drawing adequately represents in shape and dimension the essential detail and the parts of the tested object.
The drawing identified by CESI and numbered A1/002574 is annexed to this document.

The measurement uncertainties of the test results reported in this document are the following:
- dielectric tests with impulse voltage : **peak voltage:** ± 3 % ; **time parameters:** ± 10 %
- dielectric tests with impulse current : **peak value:** ± 3 % ; **time parameters:** ± 10 %
- dielectric tests with alternating voltage : **voltage (rms):** ± 3 %

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to a confidence level of about 95 %) and have to be considered as maximum values.

laboratory information

CESI testing team: L. Podavitte
I. Guacci

test laboratory: P177 surge arrester laboratory

activity code: 29380X
keywords: 12015R, 23810H, 31020W, 46030U, 53001D

MOD.A1001IG-R01

ВЯРНО С ОРИГИНАЛА

297

298

M00A1002/G

contents	page	test date
Test object characteristics	4	
Reference standard	6	
Test carried out	6	
Test object identification	6	
Test procedure	7	
Lightning impulse residual voltage test	8	December 18 - 19, 2000
Switching impulse residual voltage test	10	December 19, 2000
Steep current impulse residual voltage test	11	December 19, 2000
Technical data of the test circuit	12	
Page annexed: oscillograms no. 27		
Reference document annexed: Drawing of test sample CESI no. A1/002574 (1 page)		

ВЯРНО С ОРИГИНАЛА

Test object characteristics

type: Metal-oxide surge arrester type VARISIL HE

electrical characteristics (claimed by the client)

manufacturer's name	Alstom Parafudros S.A. - Bagneres de Bigorre - France
nominal discharge current - I_N [kA]	10,0
rated voltage - U_r [kV]	6,0
continuous operating voltage - U_c [kV]	5,0
minimum reference voltage - U_{refmin} [kV]	5,8
reference current - $I_{ref.}$ [mA]	1,0
rated frequency - [Hz]	50 - 60
year of manufacture	2000

geometrical characteristics (measured on the test sample)

total height [mm]	268
number of sheds	9
shed diameter [mm]	max 106 - min 76
shed spacing [mm]	max 30 - min 15
core diameter [mm]	50

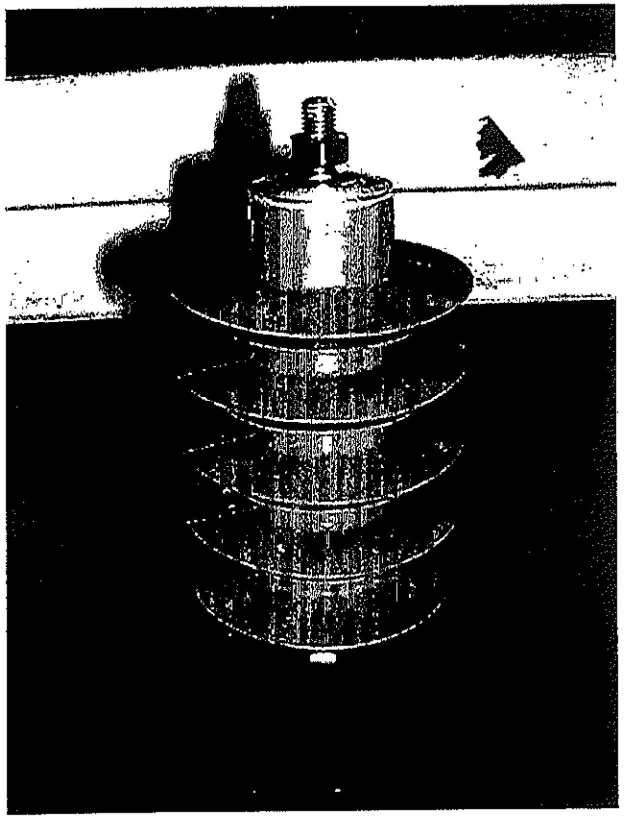
other characteristics

housing material	silicone rubber
housing color	grey

ВЯРНО С ОРИГИНАЛ

299

Photograph of metal-oxide surge arrester.



ВЯРНО С ОРИГИНАЛА

300

Reference Standard

Client request's based on IEC 60099-4 (1998) Clause 7.3
" Metal-oxide surge arrester without gaps for a.c. system"

Test carried out

test carried out	number of sample tested
Lightning impulse residual voltage test	3
Switching impulse residual voltage test	
Steep current impulse residual voltage test	

Test object identification

test object names	identification of test sample (given by the client)
metal-oxide surge arrester	1 - 2 - 3

ВЯРНО С ОРИГИНАЛА

MOD.A1176IC

331

302

Test procedure

- The lightning impulse residual voltage with current waveshape having front time equal to 8 μs and time to half value equal to 20 μs at the following values has been measured:

  I_N = 10,0 kA
  0.5 I_N = 5 kA
  2 I_N = 20,0 kA
  4 I_N = 40,0 kA

- The switching impulse residual voltage with current waveshape having front time greater than 30 μs and time to half value roughly twice of front time at the following values has been measured:

  125 A
  500 A
  1000 A

- The steep current residual voltage at I_N with current waveshape having front time equal to 1 μs and time to half value not longer than 20 μs at the following values has been measured:

  I_N = 10,0 kA
  0.5 I_N = 5 kA

ВЯРНО С ОРИГИНАЛА

Lightning impulse residual voltage test. IEC 60099-4 Standard

test object: Metal-oxide surge arrester
test circuit: A014

date: December 18 - 19, 2000

sample	requested current	charging voltage	oscillogram	current waveshape	discharge current	residual voltage	lightning impulse protection level
no.		kV	no.	μs	kA	kV	kV
1	0,5 × I_N	20,1	4	8,4/19,0	4,96	14,04	see relevant curve in the following page
	I_N	28,0	1	8,4/18,4	10,1	15,09	
	2,0 × I_N	42,8	7	8,2/19,0	20,0	16,55	
	4,0 × I_N	56,1	10	8,1/18,0	39,7	18,73	
2	0,5 × I_N	20,2	5	8,4/19,0	5,00	14,04	
	I_N	28,0	2	8,4/18,4	10,0	15,09	
	2,0 × I_N	42,7	8	8,2/19,0	19,9	16,47	
	4,0 × I_N	56,2	11	8,1/18,0	39,7	18,73	
3	0,5 × I_N	20,2	6	8,4/19,0	5,08	14,06	
	I_N	27,9	3	8,4/18,4	10,0	15,01	
	2,0 × I_N	43,0	9	8,2/19,0	20,0	16,55	
	4,0 × I_N	56,3	12	8,1/18,0	39,8	18,80	

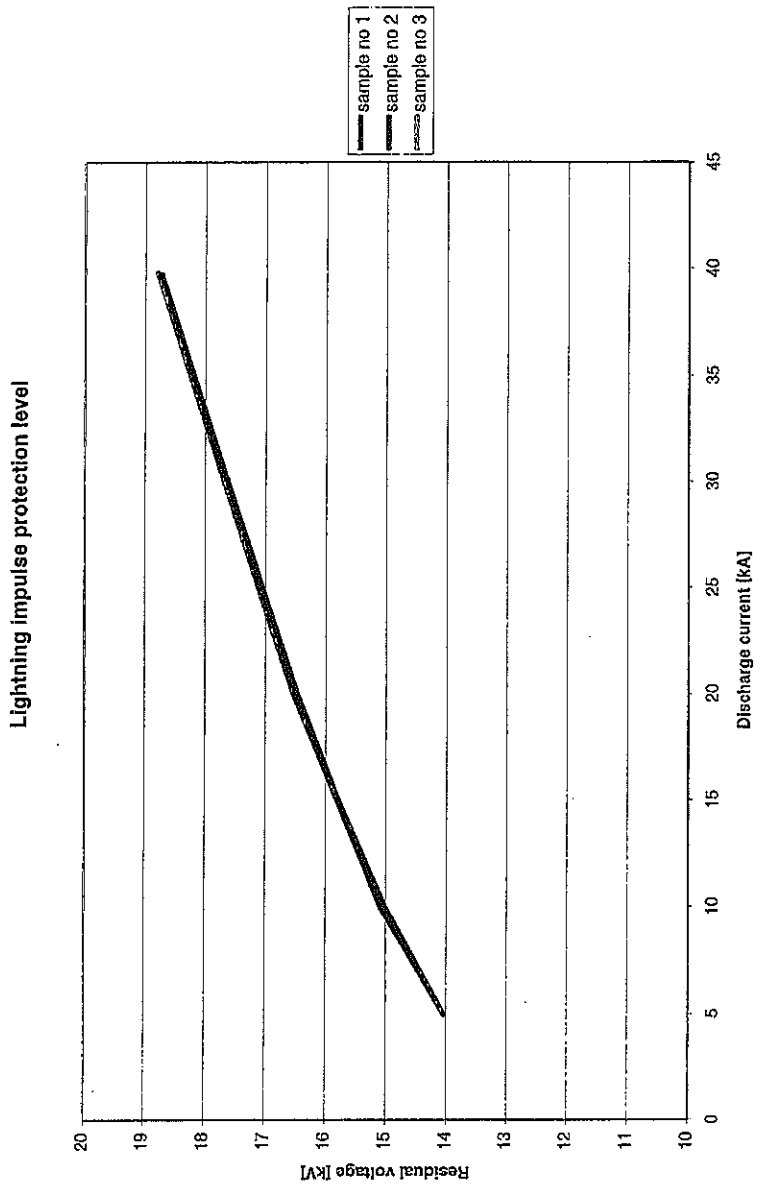
		oscilloscope settings		
		sampling division	input	attenuation
		μs	V_{div}	
current	0,5 I_N	5	0,5	20:5
	I_N		0,5	50:5
	2 I_N		1,0	50:5
	4 I_N		1,0	100:5
voltage	0,5 I_N		1,0	20:5
	I_N		1,0	20:5
	2 I_N		1,0	20:5
	4 I_N		1,0	20:5

ВЯРНО С ОРИГИНАЛА

303

MOD.A1144IG

C 48



ВЯРНО С ОРИГИНАЛА

304

MOD.A1170IG

Switching impulse residual voltage test. IEC 60099-4 Standard

test object: Metal-oxide surge arrester
test circuit: A014B

date: December 19, 2000

sample	requested current	charging voltage	oscillogram	current waveshape	discharge current	residual voltage
no.	A	kV	no.	μs	A	kV
1	125	11,6	13	30,0/83,0	125,0	11,26
	500	13,9	16	34,0/79,0	496,0	11,85
	1000	16,8	19	35,0/78,0	1010	12,35
2	125	11,5	14	30,0/83,0	122,0	11,22
	500	14,0	17	34,0/79,0	500,0	11,95
	1000	16,8	20	35,0/78,0	1015	12,36
3	125	11,5	15	30,0/83,0	129,0	11,22
	500	13,9	18	34,0/79,0	495,0	11,87
	1000	16,8	21	35,0/78,0	1020	12,27

	oscilloscope settings		
	sampling division	input	attenuation
	μs	V_{div}	
current (125A)	20	0,5	5:5
current (500A)		0,5	20:5
current (1000A)		0,5	50:5
voltage (125A)	20	0,8	20:5
voltage (500A)		0,8	20:5
voltage (1000A)		0,8	20:5

MOD.A114SIG

ВЯРНО С ОРИГИНАЛА

Steep current impulse residual voltage test. IEC 60099-4 Standard

test object: Metal-oxide surge arrester
test circuit: A014A

date: December 19, 2000

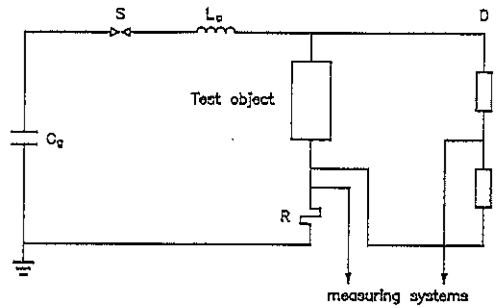
sample	charging voltage	oscillogram	current waveshape	discharge current	residual voltage
no.	kV	no.	µs	kA	kV
1	24,0	22	1,10/2,35	5,00	14,83
	34,4	25		9,96	16,14
2	24,1	23		5,04	14,83
	34,4	26		9,96	16,14
3	24,1	24		5,06	14,73
	34,5	27		10,0	16,14

	oscilloscope settings		
	sampling division	input	attenuation
	µs	V_{div}	
current	1,0	10 - 20	x 10
voltage		5	/

ВЯРНО С ОРИГИНАЛА

306

circuit A014



impulse generator

plant P177
no. of stages 1
C_g 4,98 (6,64 x 40 kA) μF
L_c 8 (5 x 40 kA) μH
S spark gap

current shunt (R) CESI no. 6042 ; R = 0,002Ω ; 100 kA
electro optical system CESI no. 11517/518 ; attenuation 20:5 - 10:5
oscilloscope CESI no. 11873
type Tektronix TDS 540

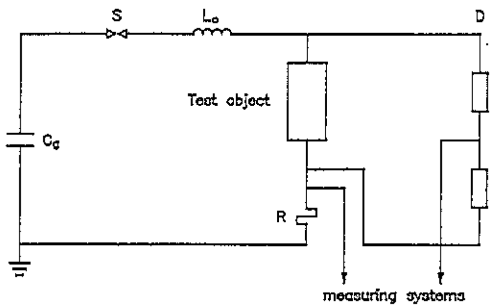
voltage divider (D) CESI no.11120 ; k = 1013
electro optical system CESI no.11519/520 ; attenuation 50:5
oscilloscope CESI no. 11873
type Tektronix TDS 540

MOD.A11430

ВЯРНО С ОРИГИНАЛА

307

circuit A014B



impulse generator

plant P177
no. of stages 1
C_g 6,64 μF
L_o 100 μH
S spark gap

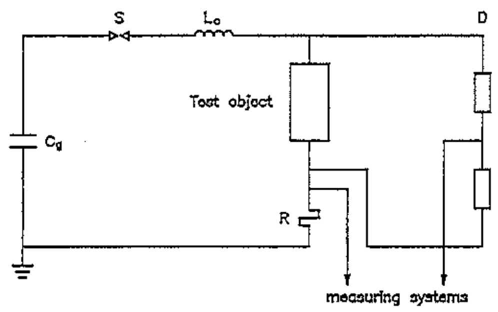
current shunt (R) CESI no. 6039 ; R = 0.020 Ω ; 10 kA
electro optical system CESI no.11517/518 ;
oscilloscope CESI no. 11873
type Tektronix TDS 540

voltage divider (D) CESI no. 11120 ; k = 1009
electro optical system CESI no.11519/520 ; attenuation
oscilloscope CESI no. 11873
type Tektronix TDS 540

ВЯРНО С ОРИГИНАЛА

308

circuit A014A



impulse generator

plant P177
no. of stages 1
C_g 0,25 μF
L_o 1 μH
S spark gap

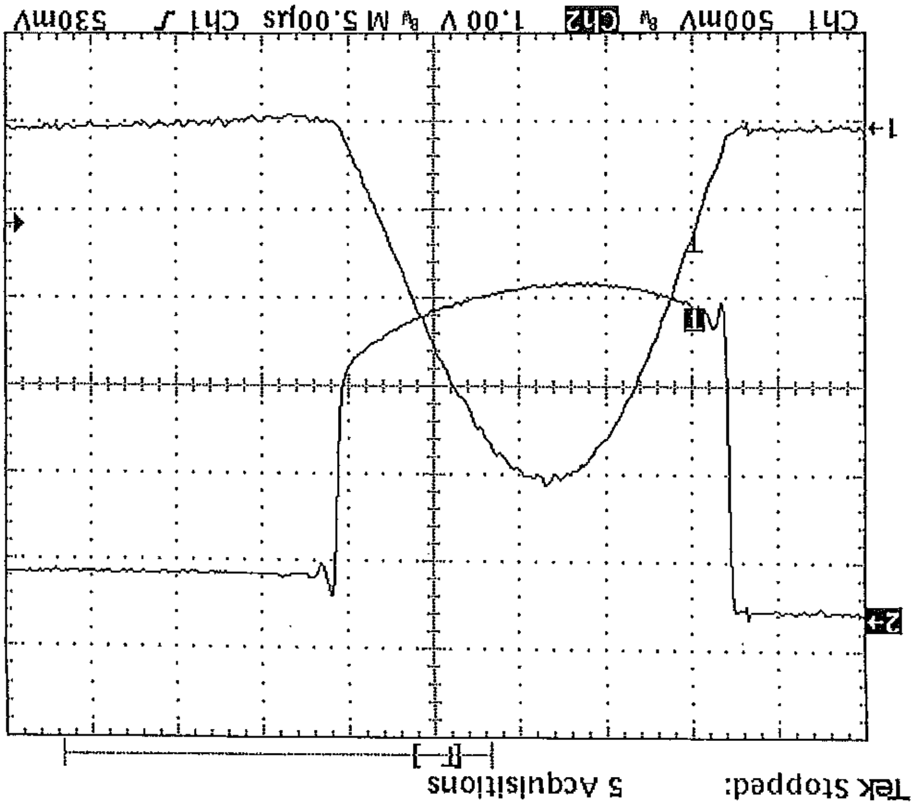
current TA (R) type Pearson CESI no.8250 ; 0,01 V x A
oscilloscope CESI no. 11873
type Tektronix TDS 540

voltage divider (D) CESI no.11120 ; k = 1009
oscilloscope CESI no. 11873
type Tektronix TDS 540

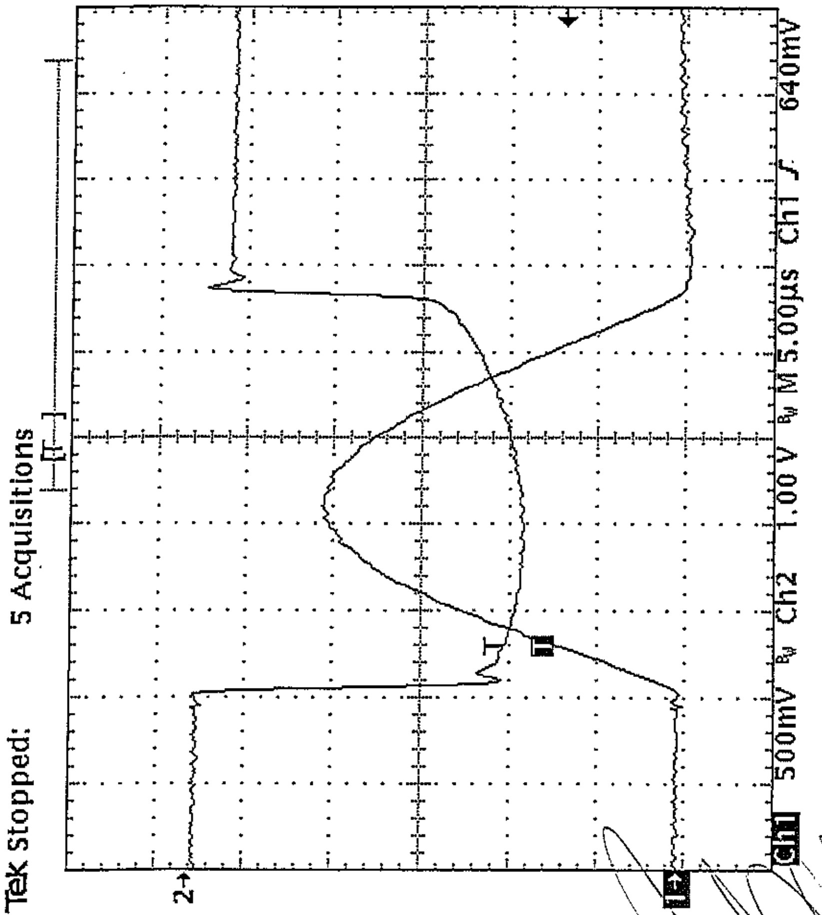
ВЯРНО С ОРИГИНАЛА

309

ВЯРНО С
ОРИГИНАЛА



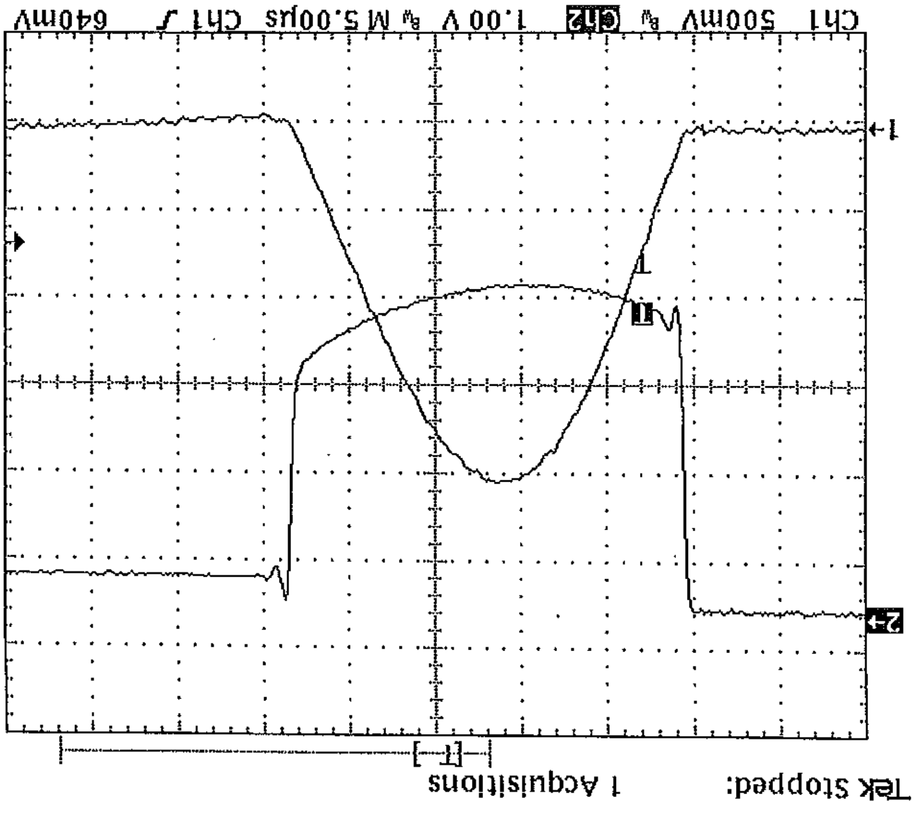
CESI TEST A0/041526 oscillogramma n. 1



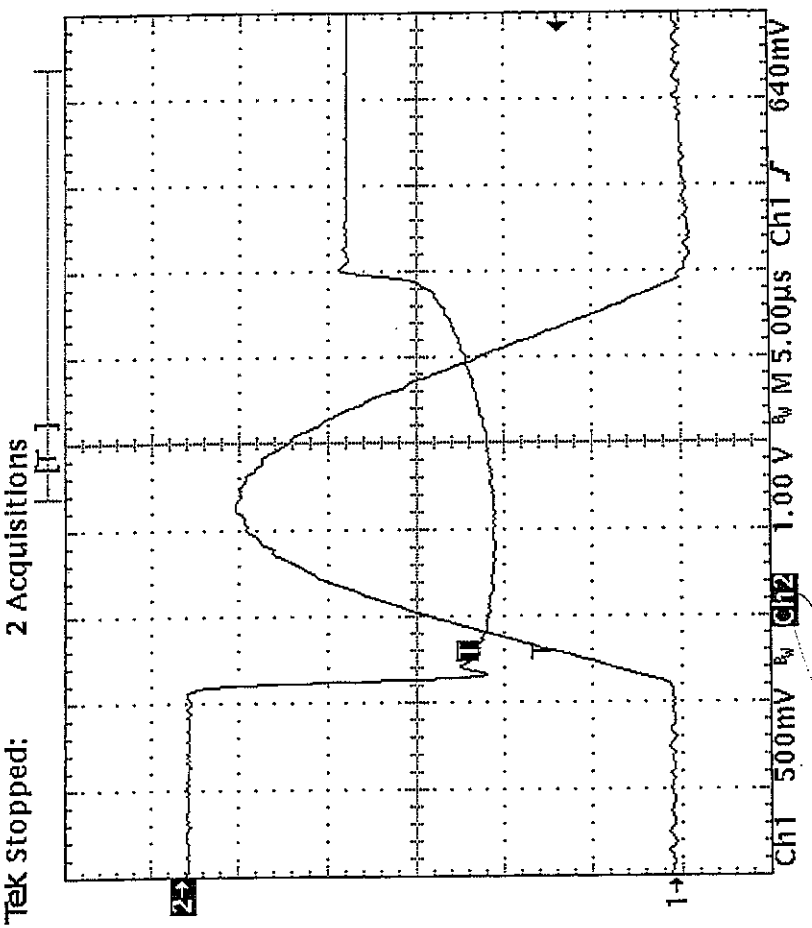
CESI TEST A0/041526 oscillogramma n. 2

ВЯРНО С ОРИГИНАЛА

ВЯРНО С ОРИГИНАЛА



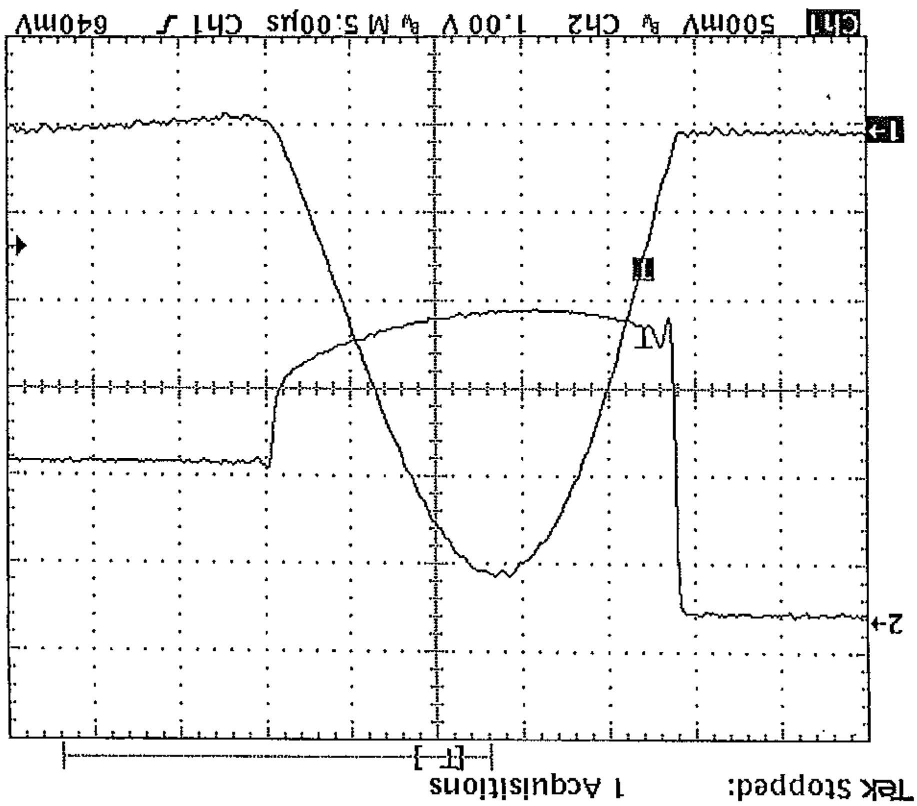
CESI TEST A0/041526 oscillogramma n. 3



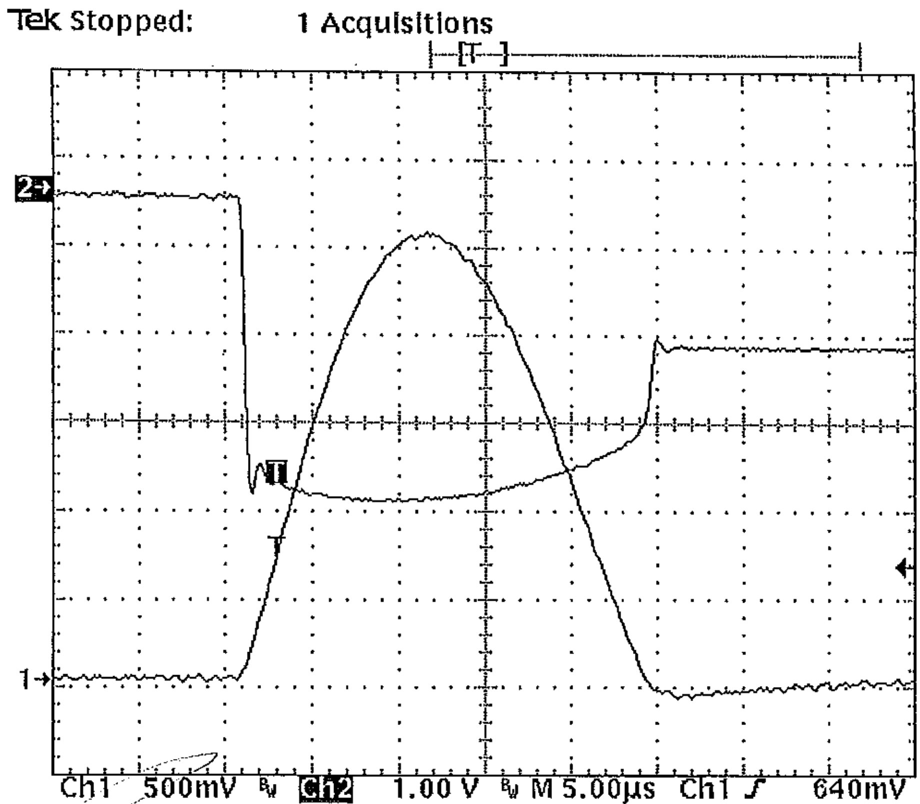
CESI TEST A0/041526 oscillogramma n. 4

ВЯРНО С ОРИГИНАЛА

ВЯРНО С ОРИГИНАЛА



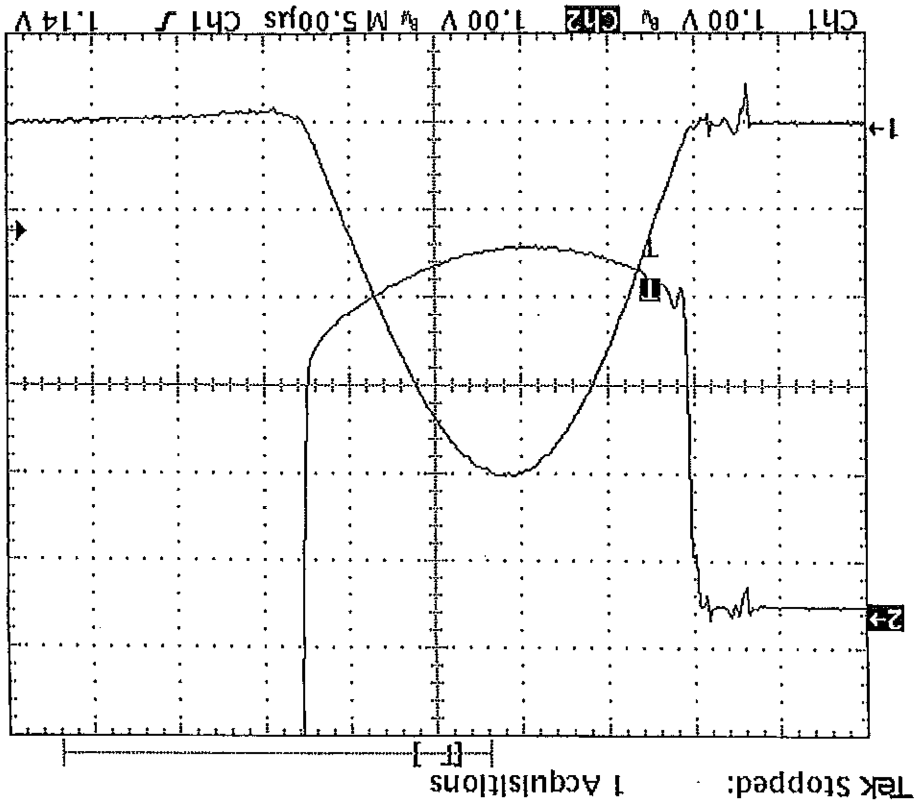
CESI TEST A0/041526 oscillogramma n. 5



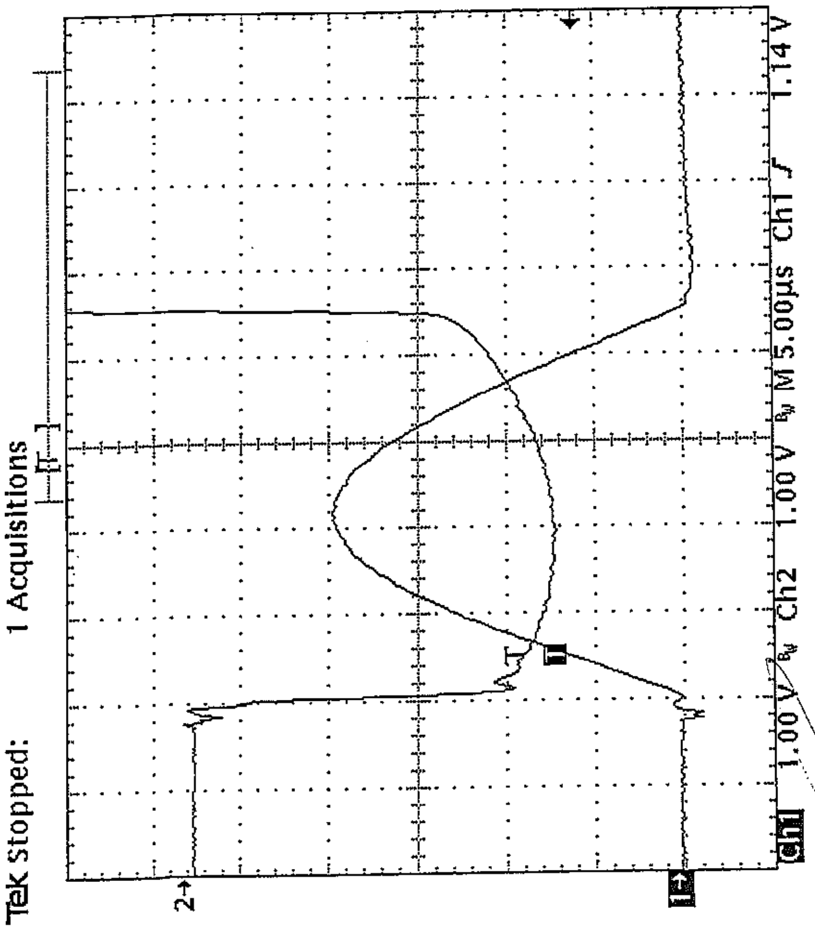
CESI TEST A0/041526 oscillogramma n. 6

ВЯРНО С ОРИГИНАЛА

ВЯРНО С
ОРИГИНАЛА



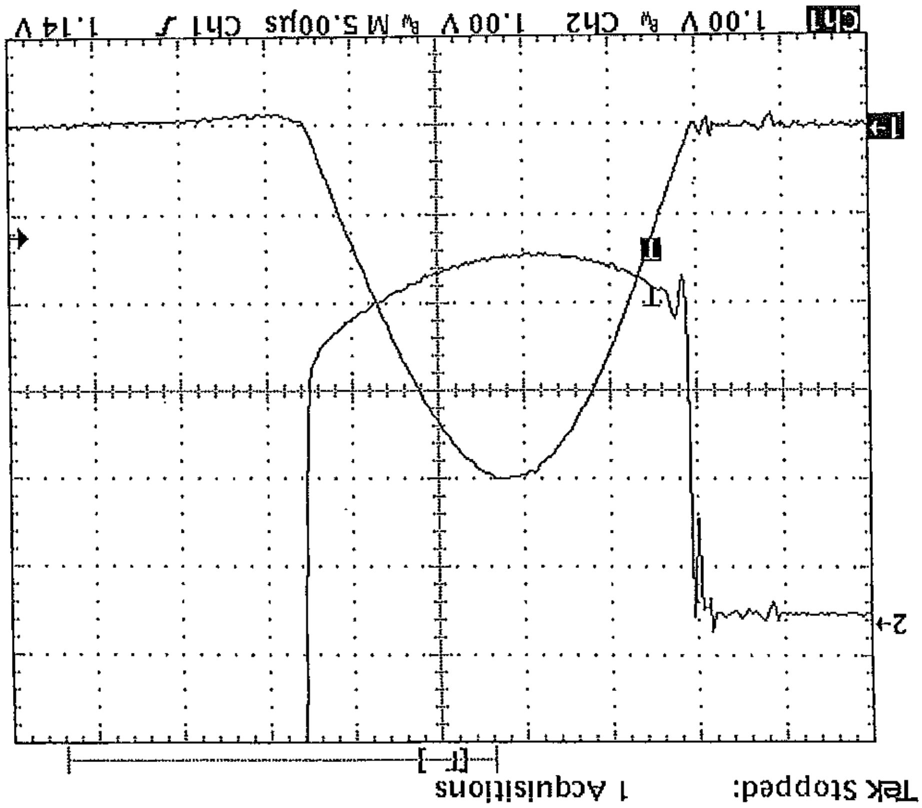
CESI TEST A0/041526 oscillogramma n. 7



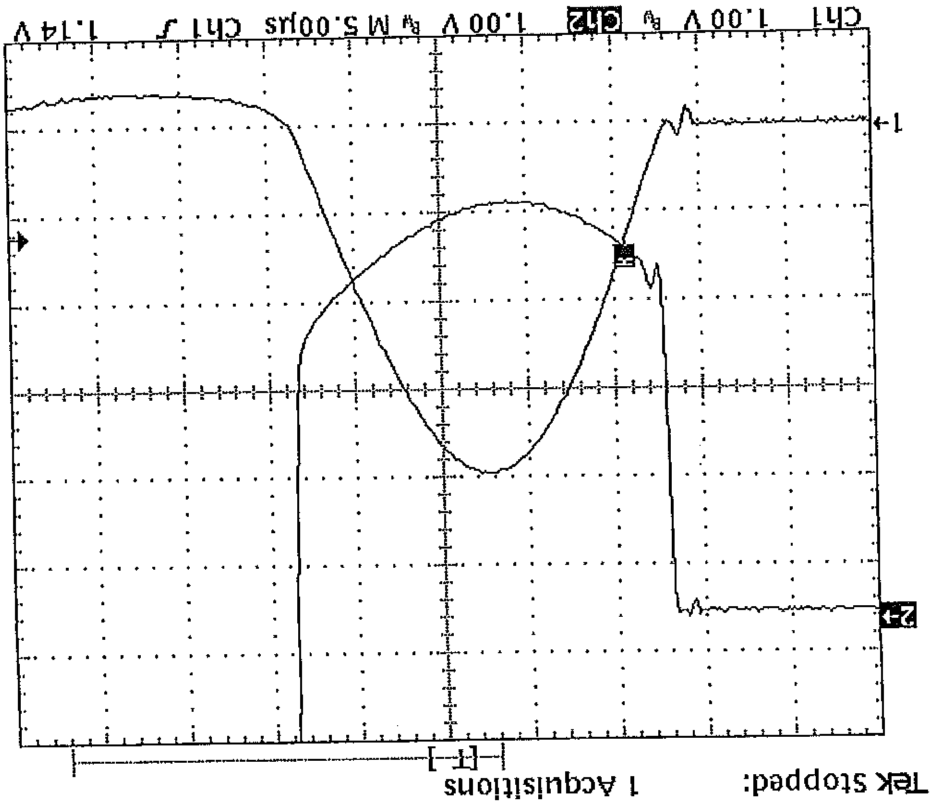
CESI TEST A0/041526 oscillogramma n. 8

ВЯРНО С ОРИГИНАЛА

ВЯРНО С ОРИГИНАЛА

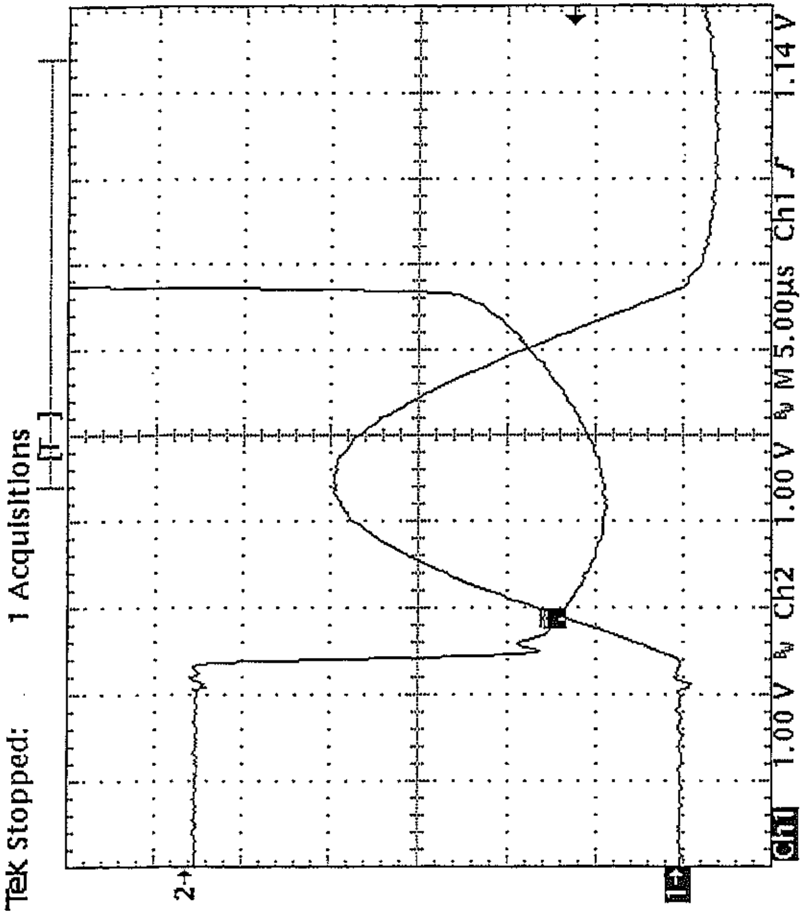


CESI TEST A0/041526 oscillogramma n. 9

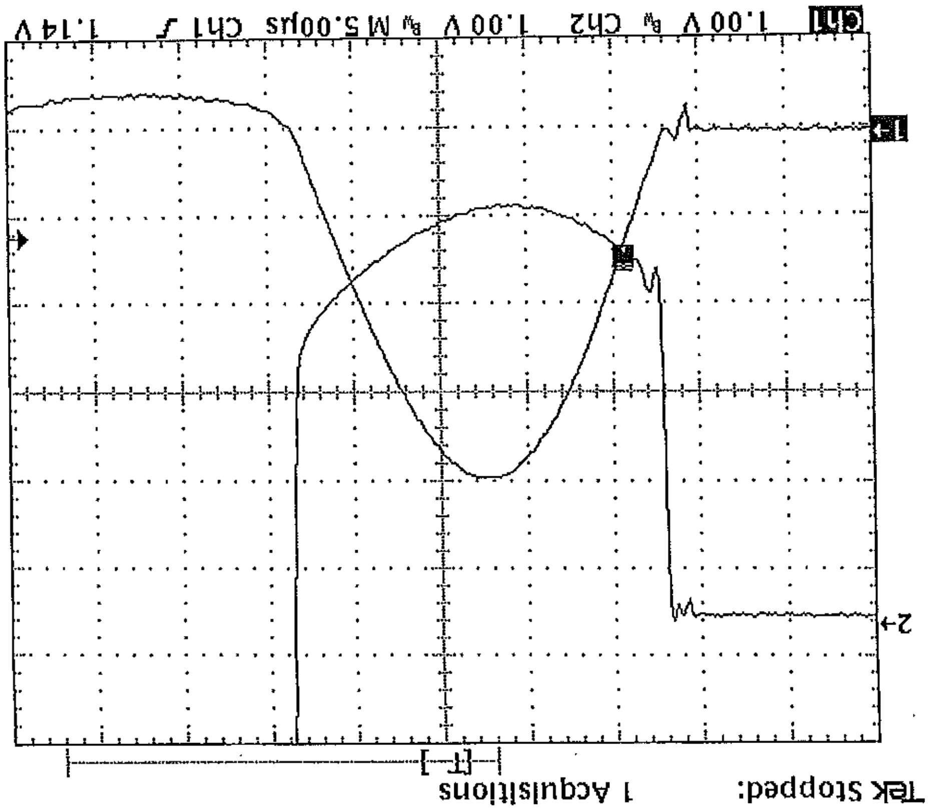


CESI TEST A0/041526 oscillogramma n. 10

ВЕРНО С ОРИГИНАЛА

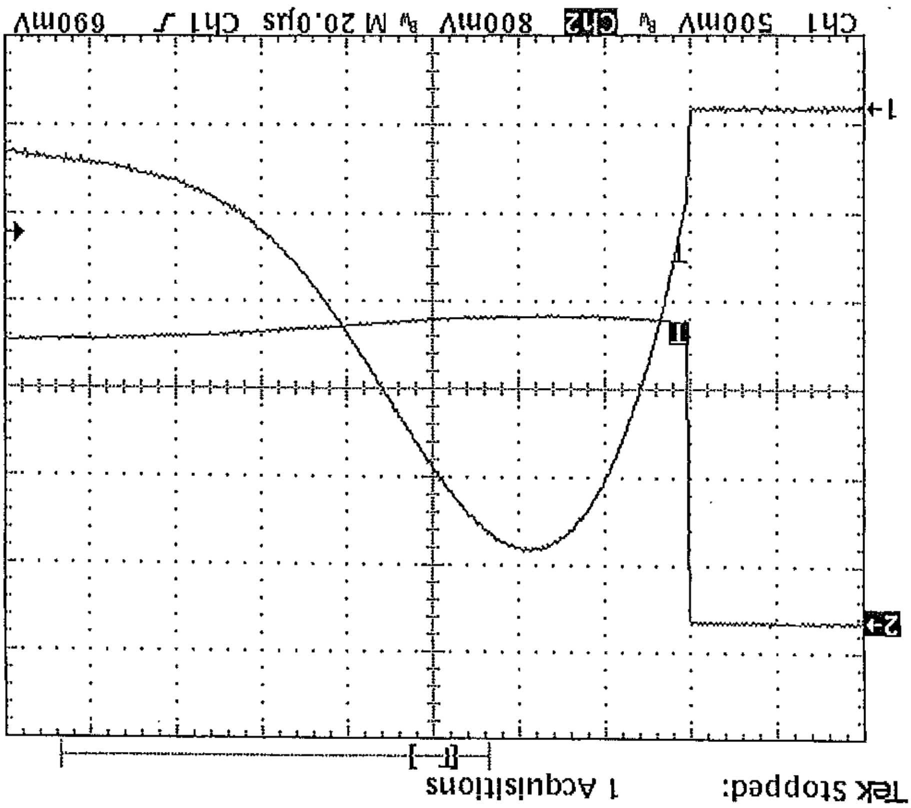


CESI TEST A0/041526 oscillogramma n. 11

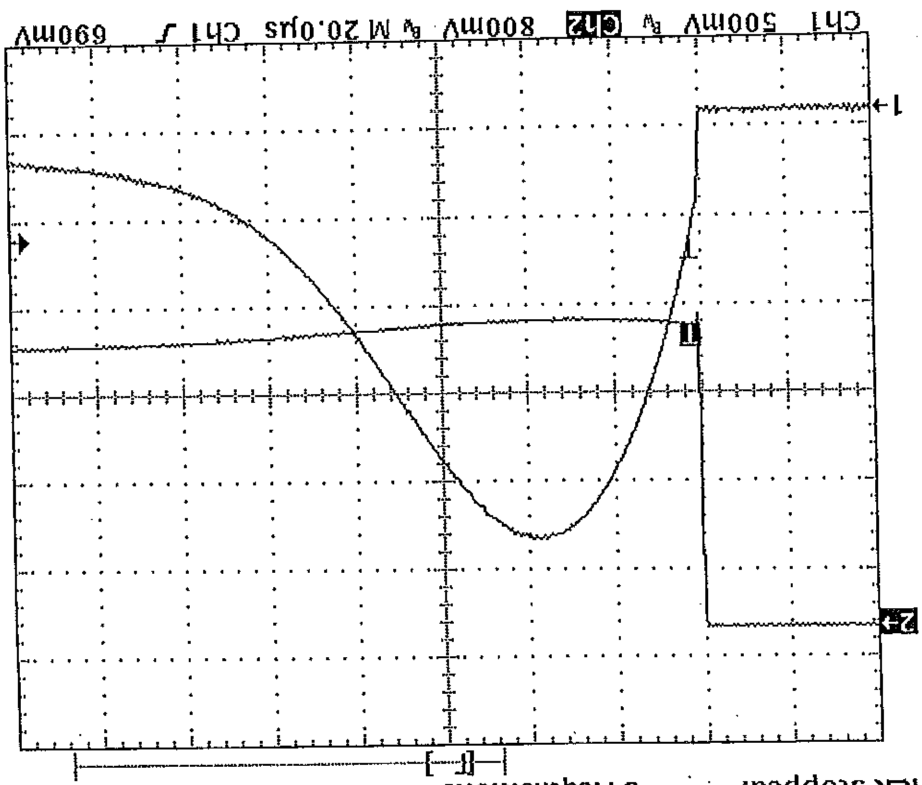


CESI TEST A0/041526 oscillogramma n. 12

ВЯРНО С ОРИГИНАЛА

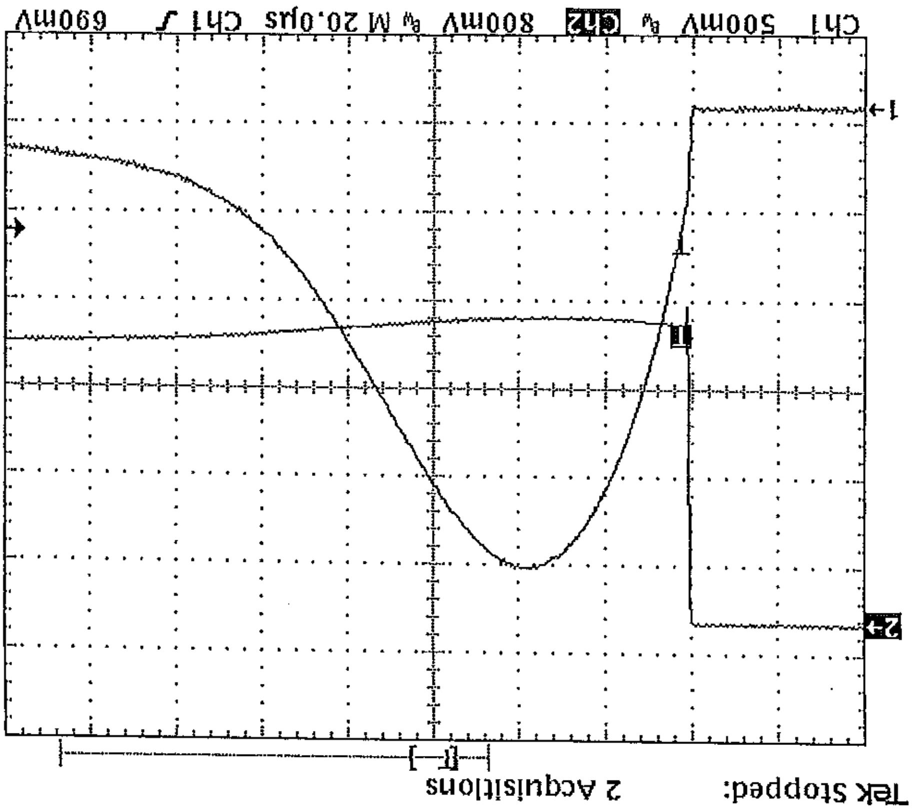


CESI TEST A0/041526 oscillogramma n. 13

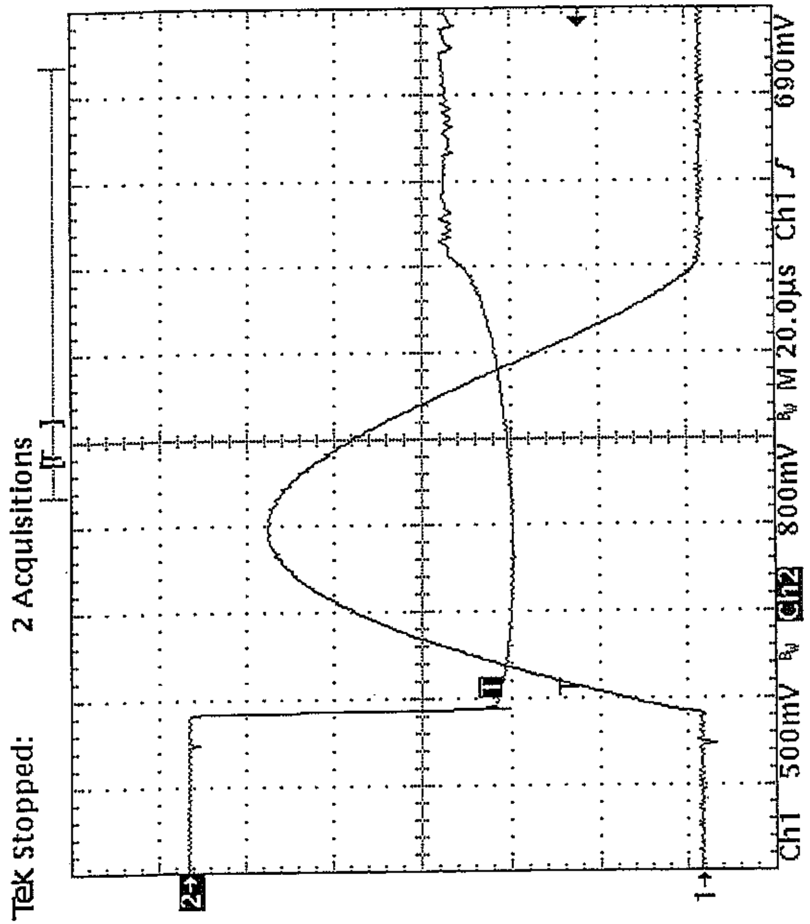


CESI TEST A0/041526 oscillogramma n. 14

ВЯРНО С ОРИГИНАЛА



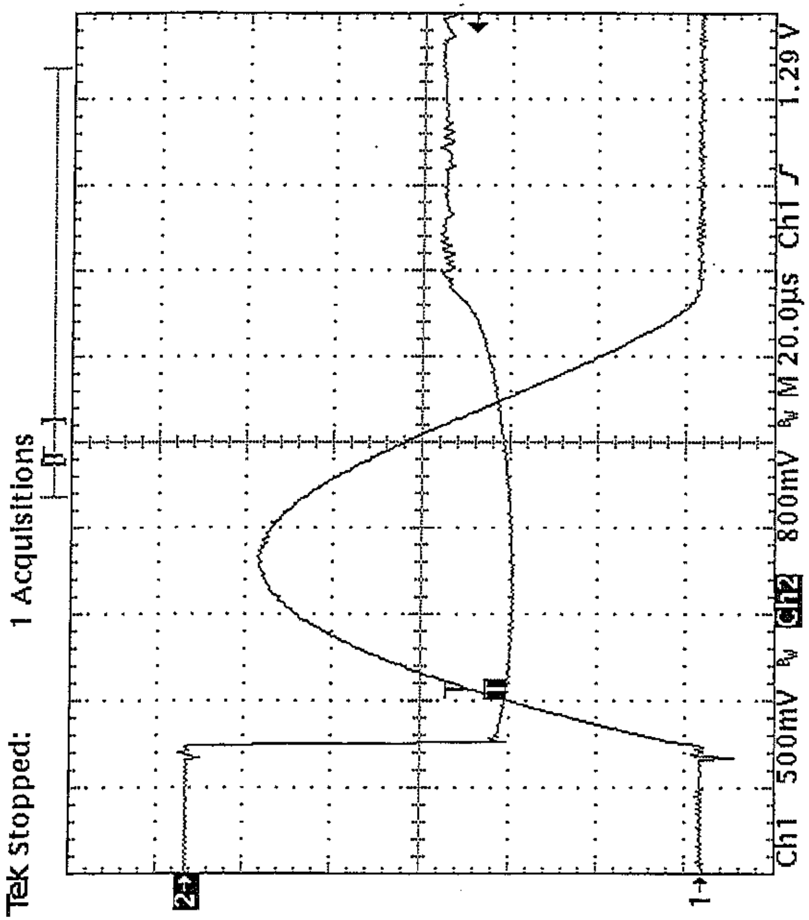
CESI TEST A0/041526 oscillogramma n. 15



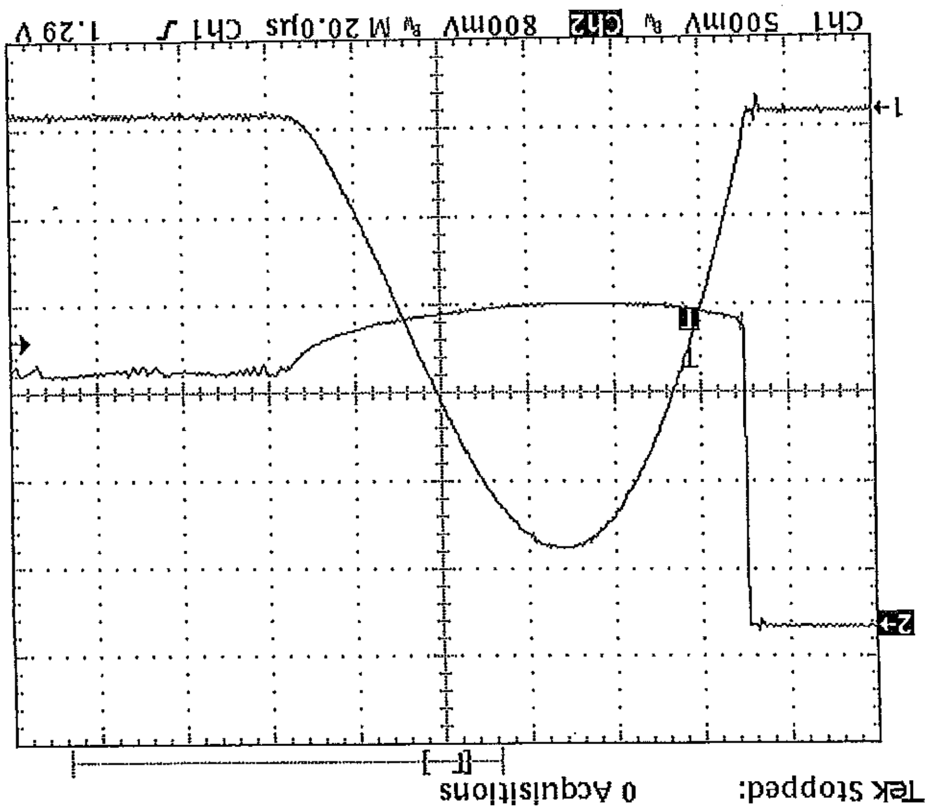
CESI TEST A0/041526 oscillogramma n. 16

ВЯРНО С ОРИГИНАЛА

325

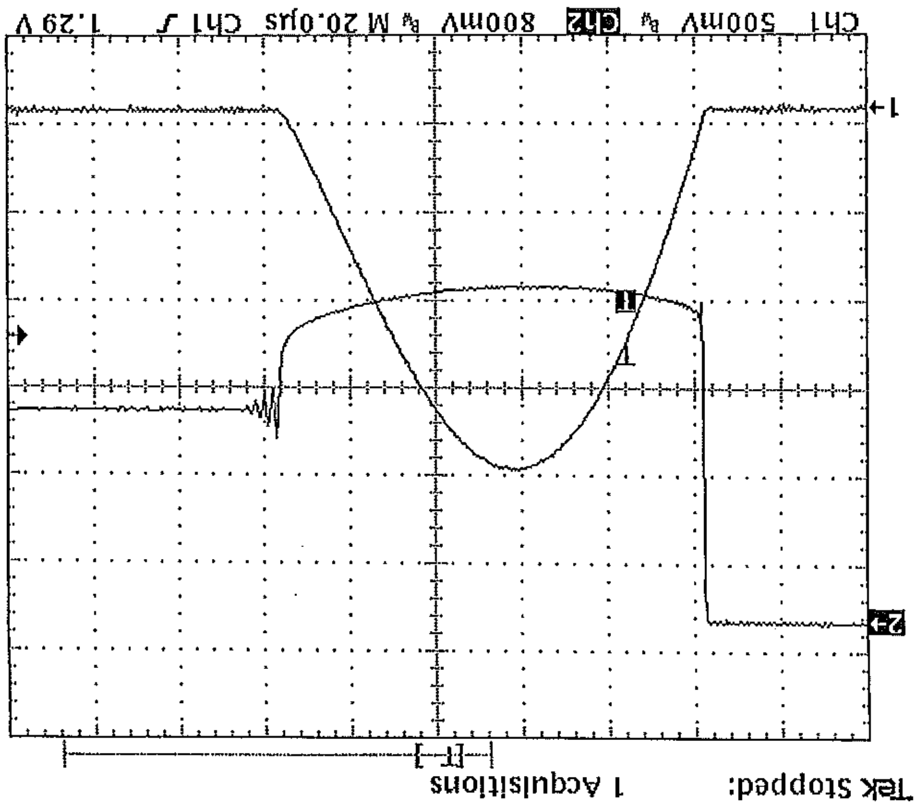


CESI TEST A0/041526 oscillogramma n. 17

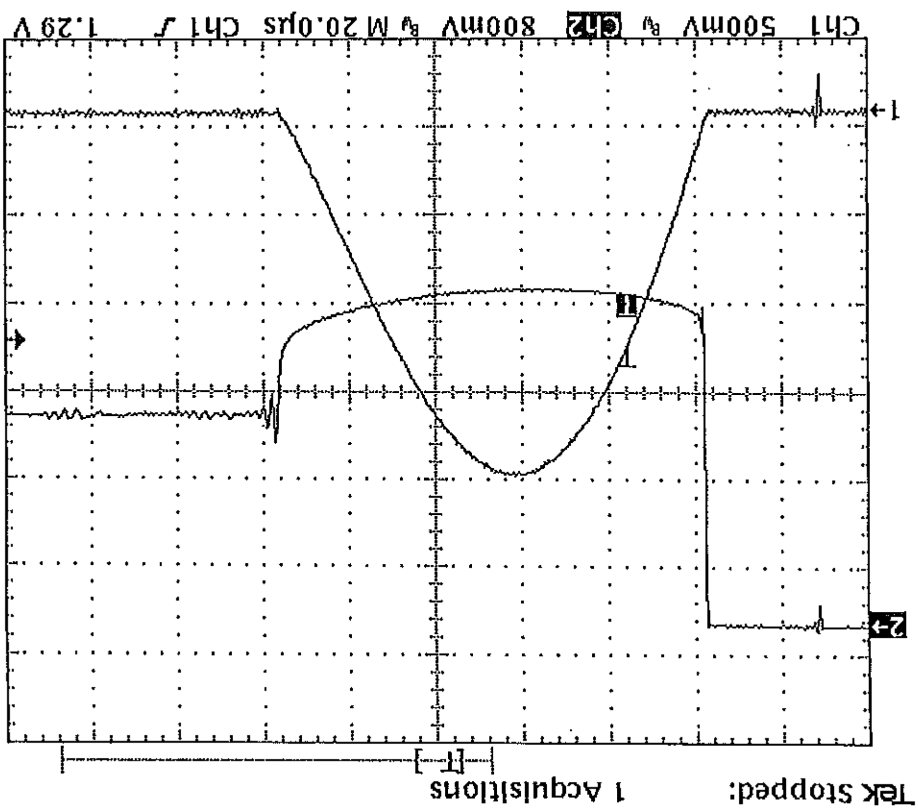


CESI TEST A0/041526 oscillogramma n. 18

ВЯРНО С
ОРИГИНА



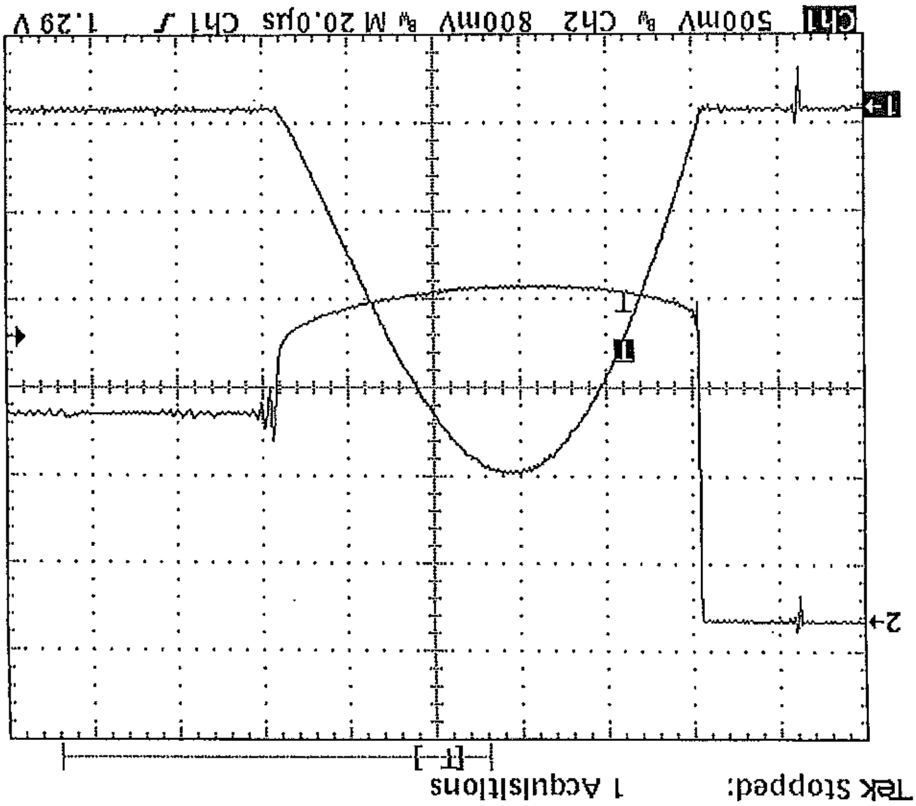
CESI TEST A0/041526 oscillogramma n. 19



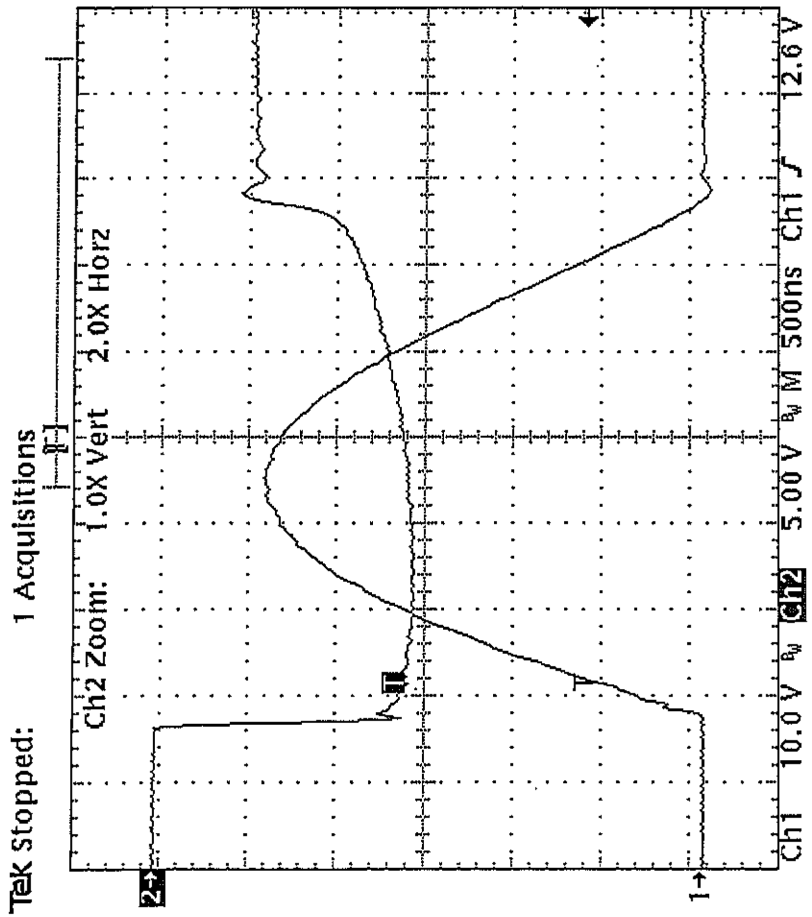
CESI TEST A0/041526 oscillogramma n. 20

ВЯРНО С ОРИГИНАЛА

ВЯРНО С ОРИГИНАЛА



CESI TEST A0/041526 oscillogramma n. 21

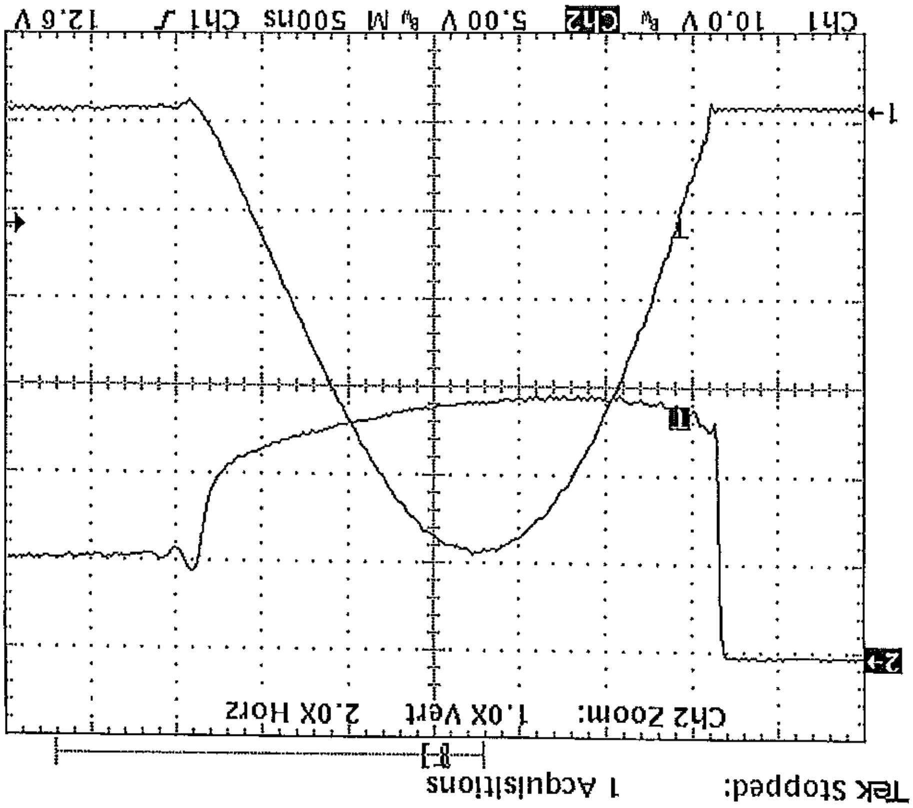


CESI TEST A0/041526 oscillogramma n. 22

ВЯРНО С ОРИГИНАЛА

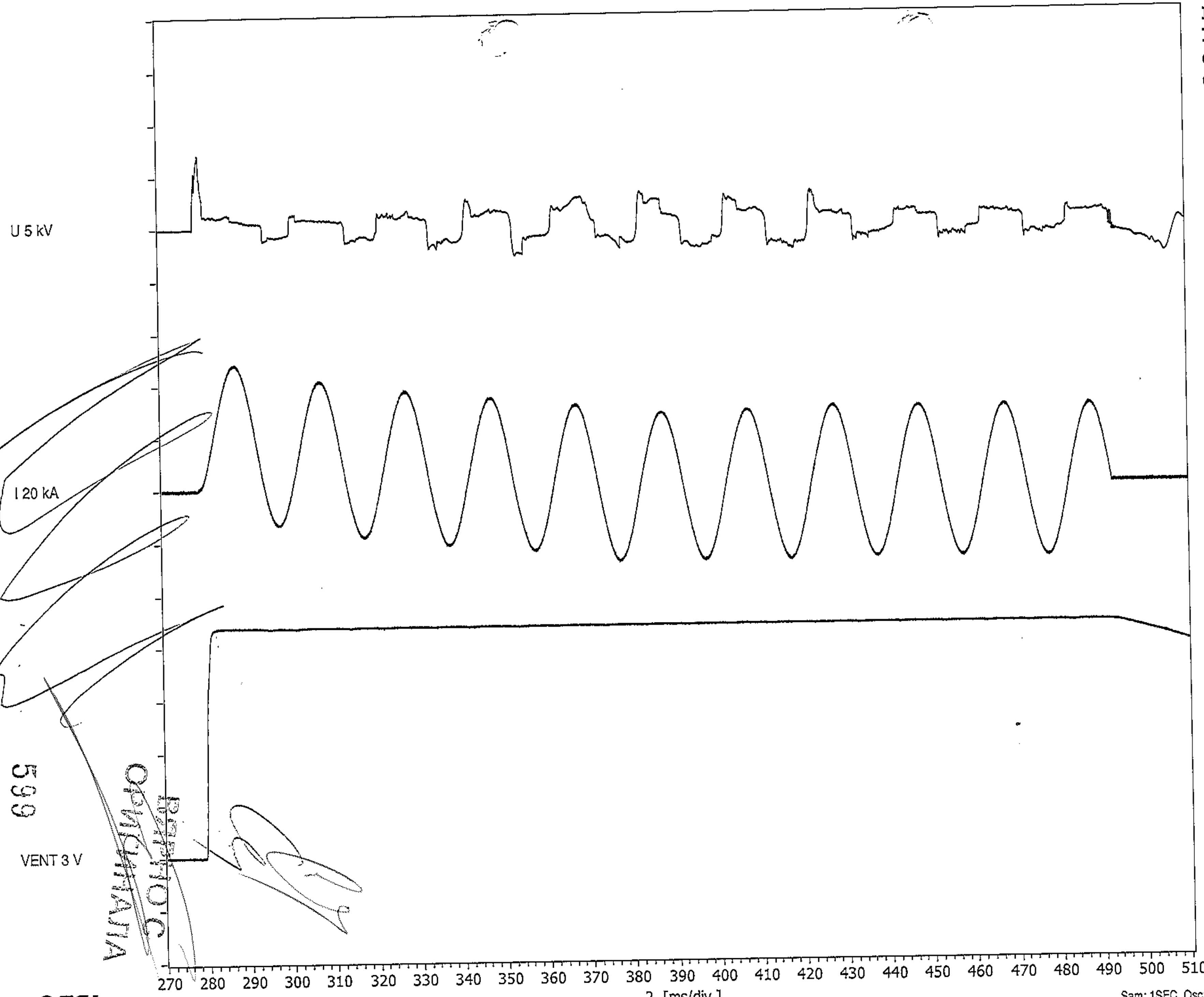
331

ВЯРНО С
ОРИГИНАЛА



CESI TEST A0/041526 oscillogramma n. 23

I= 20,5 kA
Ip= 48,6 kA
dT= 214 ms
dT= 1,53 ms

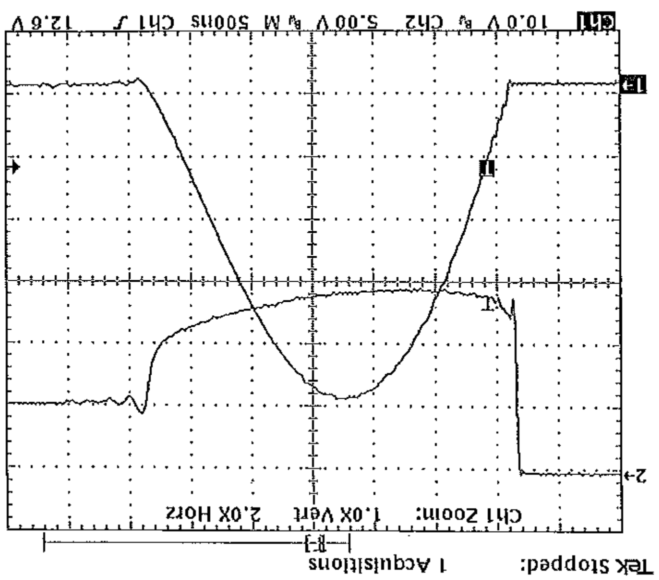


Sam: 1SEC, Osc: BD3F, Cal: BD3F

CESI P140 A8014192/0030

599

ВЕРНО С ОРИГИНАЛА

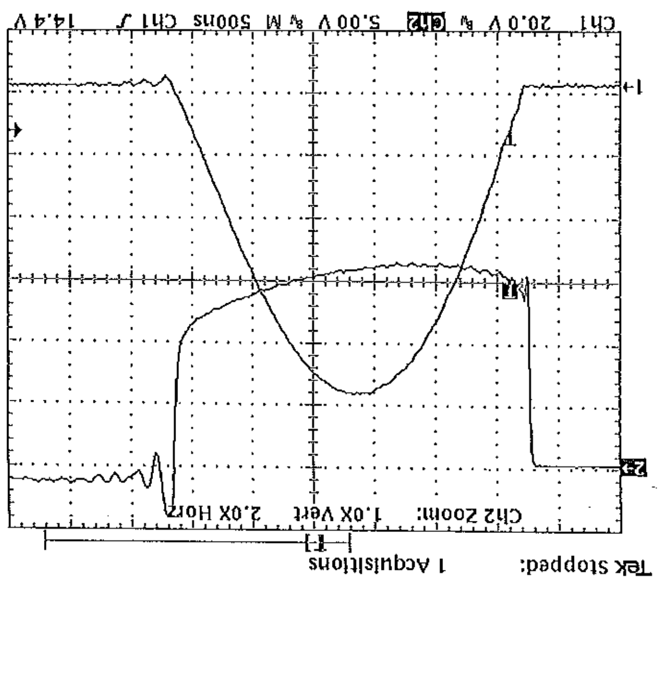


CESI TEST A0/041526 oscillogramma n. 24

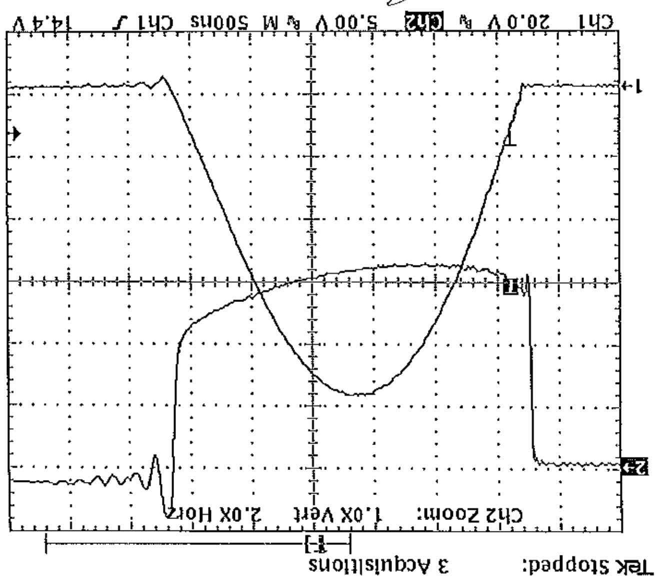
ВЯРНО С
ОРИГИНАЛА

333

ВЯРНО С
ОРИГИНАЛА



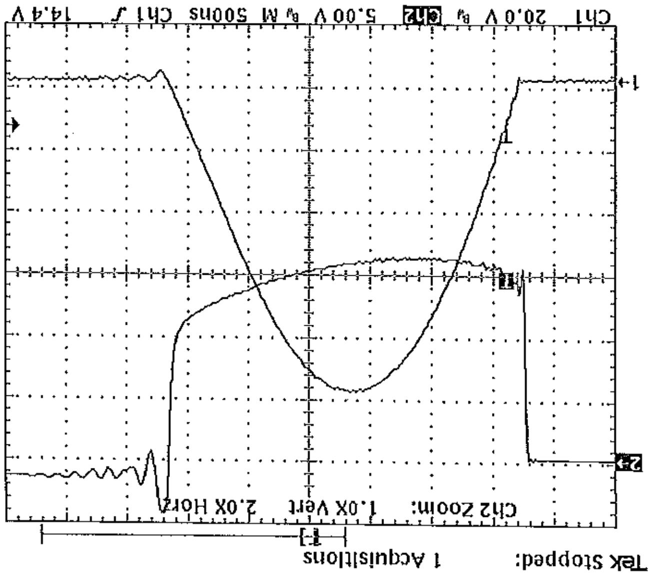
CESI TEST A0/041526 oscillogramma n. 25



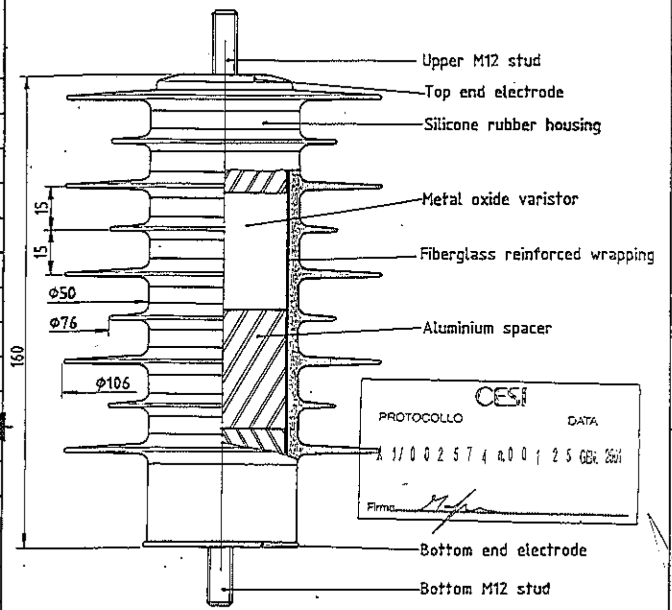
CESI TEST A0/041526 oscillogramma n. 26

ВЯРНО С
ОРИГИНАЛА

335



CESI TEST A0/041526 oscillogramma n. 27



Modification :	Dessinateur :	Date :	Vérification :
Tolérances générales :			
Matière :			
Traitement :			
Echelle :	Dessinateur : HS	Date : 12/12/00	Vérification :

VARISIL type HE
6 kV electrical section

ALSTOM
TRANSMISSION & DISTRIBUTION
Parafoudres
B.P. 256
65202 Bagnères-de-Bigorre

A4 APF W 8997 01 06

Folio : 1 / 1
Indice : 00

Accessibilité du plan :
Confidentiel
Libre

Ce plan est propriété de ALSTOM Parafoudres SA ; il ne peut être ni reproduit ni communiqué sans autorisation préalable.

ВЯРНО С
ОРИГИНАЛА

Client	AREVA Parafoudres S.A. - Bagneres de Bigorre (France)
Tested equipment	Polymer housed metal-oxide surge arrester type VARISIL HB fitted with type SnD2 disconnector
Tests carried out	Long duration current impulse withstand tests
Standards/Specifications	IEC 60099-4 (2004-05)
Test date	from September 26, 2005 September 28, 2005

No. of pages	21	**No. of pages annexed**	24
Issue date	September 28, 2005		
Prepared	BU PeC - M. Gregori		
Verified	BU PeC - R. Malgesini		
Approved	BU PeC - M. de Nigris		

ВЯРНО С ОРИГИНАЛА

CESI CENTRO ELETTROTECNICO SPERIMENTALE ITALIANO Business Unit Prove e Componenti Il Responsabile del Laboratorio

CESI Centro Elettrotecnico Sperimentale Italiano Giacinto Motta spa
Via R. Rubattino 54 20134 Milano - Italia Telefono +39 022125.1 Fax +39 0221255440 http://www.cesi.it
Capitale sociale 8 550 000 Euro interamente versato Codice fiscale e numero iscrizione CCIAA 00793580150
Registro Imprese di Milano Sezione Ordinaria N. R.E.A. 429222 P.I. IT00793580150

Tests witnessed by: -

ВЯРНО С ОРИГИНАЛА

Mr F. Malpiece - AREVA Parafoudres S.A.

Identification of the object: Not Requested

The data necessary to permit repetition of the tests are contained in the document marked: ---

- dielectric tests with impulse voltage	: **peak voltage: ± 3 %; time parameters: ± 10 %**
- dielectric tests with impulse current	: **peak value: ± 3 %; time parameters: ± 10 %**
- dielectric tests with alternating voltage	: **voltage (rms): ± 3 %**
dielectric tests with direct voltage	: **voltage: ± 3 %**

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to confidence level of about 95%) and have to be considered as maximum values

Laboratory information

Receipt date of the sample	September 26, 2005
Test location	CESI – Via Rubattino 54 – Milan
CESI testing team	Mr L. Podavitte – Mr I. Guacci
Test laboratory	P177
Activity code	42926J

339

A1002IG

content	page a	test date
Test object characteristics	4	
Photograph of the test sample	5	
Reference standard	6	
Test carried out	6	
Test object identification	6	
Test procedure	7	
Summary of the test result	8	
Power frequency voltage characteristics	9	September 26, 2005
Lightning impulse residual voltage measurement before the test	10	September 26, 2005
Switching impulse residual voltage test	11	September 26, 2005
Voltage correction factor and energy calculations	12	September 26, 2005
Long duration current impulse withstand test	13-15	September 27, 2005
Long duration current impulse withstand test (additional shot)	16	September 27, 2005
Lightning impulse residual voltage measurement after the test	17	September 28, 2005
Technical data of the test circuit	18-21	

Pages annexed:
oscillograms n. 24 pages

ВЯРНО С ОРИГИНАЛА

ВЯРНО С ОРИГИНАЛА

Test object characteristics

type: Polymer housed metal-oxide surge arrester

electrical characteristics (assigned by the client)

Manufacturer's name	AREVA Parafoudres S.A. - Bagneres de Bigorre (France)
Nominal discharge current - I_N [kA]	10
Rated voltage – U_r [kV]	Uref x 1,035
Continuous operating voltage - U_c [kV]	Uref x 0,880
Reference current - I_{ref} [mA]	1,0
Line discharge class	1
Rated frequency - [Hz]	50 - 60

geometrical characteristics (measured on the test sample)

Height [mm]	245
Number of sheds	n. 4 large – n. 3 small
Shed diameter [mm]	103 large - 73 small
Core diameter [mm]	48

other characteristics

Housing material	Silicone
Housing color	Grey

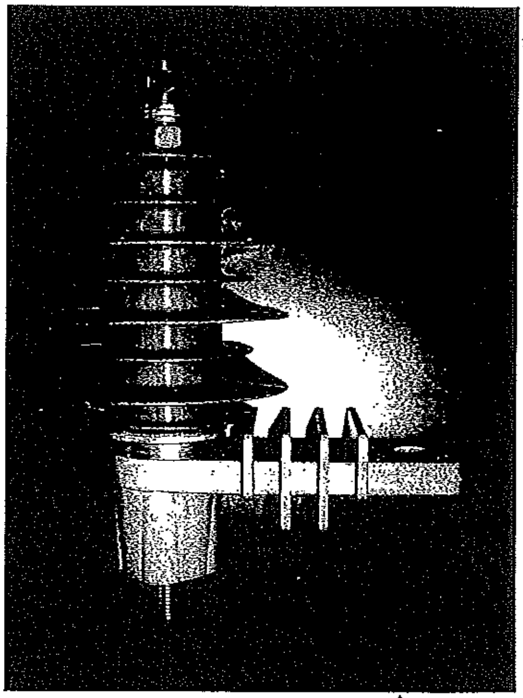


Photo no. 1

ВЯРНО С
ОРИГИНАЛА

312

Reference Standard

IEC 60099-4 (2004-05) Clause 10.8.4
"Metal-oxide surge arrester without gaps for a.c. system"

Test carried out	Number of sample tested
Long duration current impulse withstand test	3

Test object identification

Test object name	Identification of test sample (given by Cesi)
polymer housed metal-oxide surge arresters	LD1-LD2-LD3

ВЯРНО С ОРИГИНАЛА

Test procedure

- The power frequency voltage at reference current (I_{ref} = 1mA) has been measured
- The lightning impulse residual voltage at I_N = 10 kA has been measured
- The switching impulse residual voltage with current waveshape having front time greater then to 30 µs but less than 100 µs and time to half value roughly twice has been measured according to table 4 of the reference standard at following current level:

  I = 125 A

- Eighteen long duration current impulses with the specified calculated energy (see pag.12) on a virtual duration of
- 2000 µs have been applied in six groups of three operations.
  Intervals between operations of the same groups have been about 60 seconds; between different groups the samples have been let to cool down to near ambient temperature
- After the eighteenth impulse the test samples have been cool down to ambient temperature and a nineteenth impulse has been applied
- The measurement of the lightning impulse residual voltage at I_N has been repeated

ВЯРНО С ОРИГИНАЛА

311

Visual inspection and summary test results

Variation of lightning impulse residual voltage at I_N

Sample	before test		after test		variation
	discharge current	residual voltage	discharge current	residual voltage	
	kA	kV	kA	kV	%
LD1	10,15	16,12	10,05	15,99	- 0,81
LD2	10,20	15,89	10,05	16,00	0,69
LD3	10,20	15,92	10,00	15,84	- 0,50

The visual inspection of the metal-oxide surge arrester after the test has revealed no sign of physical damage. The variation of lightning impulse residual voltage before and after the test was less than 5% (maximum allowed variation according to reference standard is 5%).
The oscillographic record of the 19th impulse doesn't reveal any sign of internal discharge.
The disconnectors did not operate
All acceptance criteria according to the reference standard are satisfied and therefore the result is to be considered positive.

ВЯРНО С
ОРИГИНАЛА

Power frequency voltage-current characteristics. IEC 60099-4 Standard

Test circuit: A0019

Date: September 26, 2005

Sample No. LD1						
Oscillogram	Voltage	current	Current	current	power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	μA
1	6,08	1,00	0,98	0,59	2,06	---

Sample No. LD2						
Oscillogram	Voltage	current	Current	current	Power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	μA
2	6,01	1,02	0,98	0,58	2,03	---

Sample No. LD3						
Oscillogram	Voltage	current	Current	current	Power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	μA
3	6,04	1,01	0,97	0,580	2,00	---

ВЯРНО С ОРИГИНАЛА

3188

Long duration current impulse withstand test. IEC 60099-4 Standard

Lightning impulse residual voltage measurement before the test

Test circuit: A0120

Date: September 26,2005

Sample	Requested Current	Charging Voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage
No.		kV	No.	µs	kA	kV
LD1	I_N	29,8	4	8,6/18,6	10,15	16,12
LD2		29,7	5		10,20,	15,89
LD3		29,7	6		10,20	15,92

	Oscilloscope settings		
	Sampling division	Input	attenuation
	µs	V_{div}	
Current	5	0,5	50:5
Voltage	5	0,5	50:5

Notes:

ВЯРНО С
ОРИГИНАЛА

Switching impulse residual voltage test. IEC 60099-4 Standard

Test circuit: A0122

Date: September 26, 2005

Sample	Requested Current	Charging voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage	Switching impulse protection level
No.	A	kV	No.	µs	A	kV	kV
LD1	125	14,0	7	31/68	130	12,26	12,26
LD2	125	13,9	8		128	12,13	
LD3	125	13,9	9		130	12,07	

Oscilloscope settings			
	sampling division	input	attenuation
	µs	V_{div}	
Current	20	0,5	5:5
Voltage	20	0,5	50:5

Notes:

ВЯРНО С ОРИГИНАЛА

С3/8

Long duration current impulse withstand test. IEC 60099-4 Standard

Voltage correction factor and energy calculations

Date: September 26, 2005

Sample	U_{ref} [1]	kU_r [2]	kU_c [3]	U_r' [4]	U_c' [5]
No.	kV			kV	kV
LD1	6,08	1,035	0,880	6,29	5,35
LD2	6,01			6,22	5,29
LD3	6,04			6,25	5,32

[1] U_{ref} : measured reference voltage
[2] kU_r : maximum guarantees factor for calculation of Ur
[3] kU_c : maximum guarantees factor for calculation of Uc
[4] U_r' : corrected rated voltage [4] = [1] × [2]
[5] U_c' : corrected continuous operating voltage [5] = [1] × [53

Sample	Ur'	U_L	V_{res}	T	Z	W	W'
No.	kV		kV	μs	Ω	kJ	kJ/kV
LD1	6,29	20,13	12,07	2000	30,82	6,31	1,003
LD2	6,22	19,90			30,48	6,21	0,998
LD3	6,25	20,00			30,63	6,25	1,000

V_{res} : switching impulse residual voltage
U_L, T, Z : see table 5 of IEC 60099-4 Standard
W : $= V_{res} \times (U_L - V_{res}) \times (T / Z)$

ВЯРНО С ОРИГИНАЛА

Long duration current impulse withstand test. IEC 60099-4 Standard

Test circuit: A017

Date: September 27, 2005

Sample	Impulse	Charging voltage V_c	Oscillogram	Peak current I	Residual voltage V_r	Energy E
No.	No.	kV	No.	A	kV	kJ
LD1	1	13,6		249	11,22	6,41
	2	13,7		260	11,15	6,69
	3	13,7	10	256	11,22	6,66
	4	13,6		260	11,16	6,62
	5	13,6		254	11,12	6,55
	6	13,6		255	11,12	6,60
	7	13,6		260	11,15	6,81
	8	13,6		255	11,20	6,61
	9	13,6	13	250	11,20	6,48
	10	13,6		253	11,20	6,60
	11	13,6		250	11,15	6,53
	12	13,6		254	11,20	6,58
	13	13,5		240	11,10	6,48
	14	13,5		245	11,20	6,40
	15	13,5		240	11,20	6,37
	16	13,5		245	11,20	6,49
	17	13,5		244	11,25	6,45
	18	13,5	16	250	11,25	6,50

Notes:

Measured waveshape	
virtual duration	virtual total duration
µs	µs
2080	2560

Oscilloscope settings			
	sampling division	Input	Attenuation
	µs	V_{div}	
Current	50	1,0	10:5
Voltage	50	0,5	50:5

ВЯРНО С ОРИГИНАЛА 330

Continued

Вярно с оригинала

Continued

Date: September 27, 2005

Sample	Impulse	Charging voltage V_c	Oscillogram	Peak current I	Residual voltage V_r	Energy E
No.	No.	kV	No.	A	kV	KJ
LD2	1	13,6		258	11,12	6,60
	2	13,7		263	11,00	6,70
	3	13,6	11	257	11,05	6,61
	4	13,6		264	11,00	6,77
	5	13,6		263	11,00	6,78
	6	13,6		265	11,00	6,77
	7	13,6		265	11,00	6,80
	8	13,6		264	11,10	6,75
	9	13,6	14	265	11,05	6,78
	10	13,6		264	11,05	6,80
	11	13,6		266	11,05	6,77
	12	13,6		264	11,00	6,75
	13	13,5		258	11,05	6,60
	14	13,5		258	11,04	6,62
	15	13,5		260	11,05	6,62
	16	13,5		258	11,00	6,60
	17	13,5		260	11,00	6,62
	18	13,5	17	260	11,05	6,63

Notes:

Measured waveshape	
virtual duration	virtual total duration
μs	μs
2080	2560

	Oscilloscope settings		
	sampling division	input	Attenuation
	μs	V_{div}	
Current	50	1,0	10:5
Voltage	50	0,5	50:5

Continued

Continued

Date: September 27, 2005

Sample	Impulse	Charging voltage V_c	Oscillogram	Peak current I	Residual voltage V_r	Energy E
No.	No.	kV	No.	A	kV	kJ
LD3	1	13,6		269	11,12	6,80
	2	13,6		262	11,12	6,74
	3	13,6	12	260	11,15	6,70
	4	13,6		263	11,10	6,76
	5	13,6		264	11,10	6,80
	6	13,6		263	11,10	6,78
	7	13,6		264	11,10	6,79
	8	13,6		263	11,10	6,77
	9	13,6	15	264	11,10	6,80
	10	13,6		260	11,10	6,85
	11	13,6		258	11,10	6,62
	12	13,5		250	11,00	6,37
	13	13,6		263	11,00	6,92
	14	13,5		258	11,10	6,63
	15	13,5		257	11,10	6,66
	16	13,5		258	11,10	6,68
	17	13,5		257	11,15	6,63
	18	13,5	18	259	11,10	6,67

Notes:

Measured waveshape	
Virtual duration	virtual total duration
µs	µs
2080	2560

Oscilloscope settings			
	sampling division	input	Attenuation
	µs	V_{div}	
Current	50	1,0	10:5
Voltage	50	0,5	50:5

ВЯРНО С ОРИГИНАЛА

352

Continued

Long duration current impulse withstand test. IEC 60099-4 Standard

(check the integrity of the internal parts with an additional shot at ambient temperature)

Test circuit: A017

Date: September 27, 2005

Sample	Impulse	Charging voltage V_c	Oscillogram	Peak current I	Residual voltage V_r	Energy E
No.	No.	kV	No.	A	kV	kJ
LD1	19	13,6	19	250	11,20	6,50
LD2	19	13,6	20	260	11,00	6,70
LD3	19	13,6	21	260	11,10	6,73

Notes:

Measured waveshape	
virtual duration	virtual total duration
µs	µs
2080	2560

Oscilloscope settings			
	sampling division	input	Attenuation
	µs	V_{div}	
Current	50	1,0	10:5
Voltage	50	0,5	50:5

ВЯРНО С ОРИГИНАЛА

continued

Long duration current impulse withstand test. IEC 60099-4 Standard

Lightning impulse residual voltage measurement after the test

Test circuit: A0120

Date: September 28, 2005

Sample	Requested Current	Charging voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage
No.		kV	No.	μs	kA	kV
LD1	I_N	29,8	22	8,6/18,6	10,05	15,99
LD2		29,7	23		10,05	16,00
LD3		29,7	24		10,00	15,84

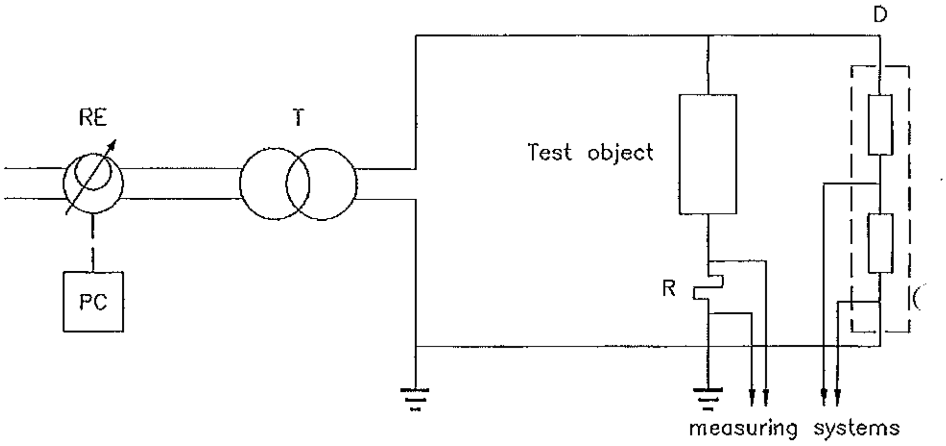
	Oscilloscope settings		
	sampling division	input	attenuation
	μs	V_{div}	
Current	5	0,5	50:5
Voltage	5	0,5	50:5

Notes:

ВЯРНО С ОРИГИНАЛА

354

Circuit A0019



Power frequency supply

RE - programmable supply type LARCET A.C. Power Source 5000 P.S.; CESI no. 23702-32191
PC - personal computer
T - voltage transformer type SPECIALTRASFO; power 30 kVA; voltage 200 V/15-30 kV

Current measuring system

R - Current shunt CESI No.31120; R= 941,4 Ω
- Electro optical system CESI No.11517/518; attenuation 5:5
OSC - Oscilloscope type SONY TEKTRONIX RTD 710A; CESI No.9090

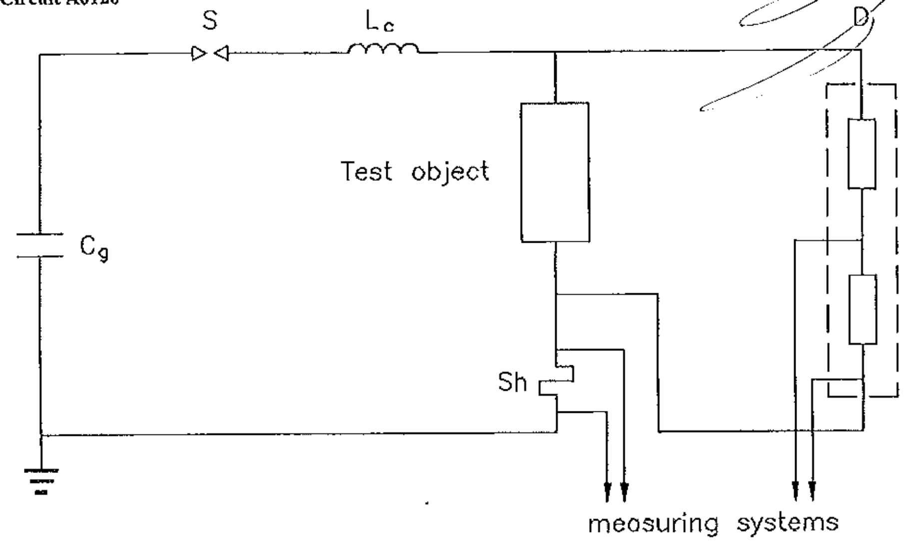
Voltage measuring system

D - Voltage divider SAGI; CESI No.11120
- Electro optical system CESI No.11521/522; attenuation 50:5
OSC - Oscilloscope type SONY TEKTRONIX RTD 710A; CESI No.9090

ВЯРНО С ОРИГИНАЛА

355

Circuit A0120



Impulse generator

No. of stages	1
Cg	4,98 μF
Lc	10 μH
S	- Spark-gap

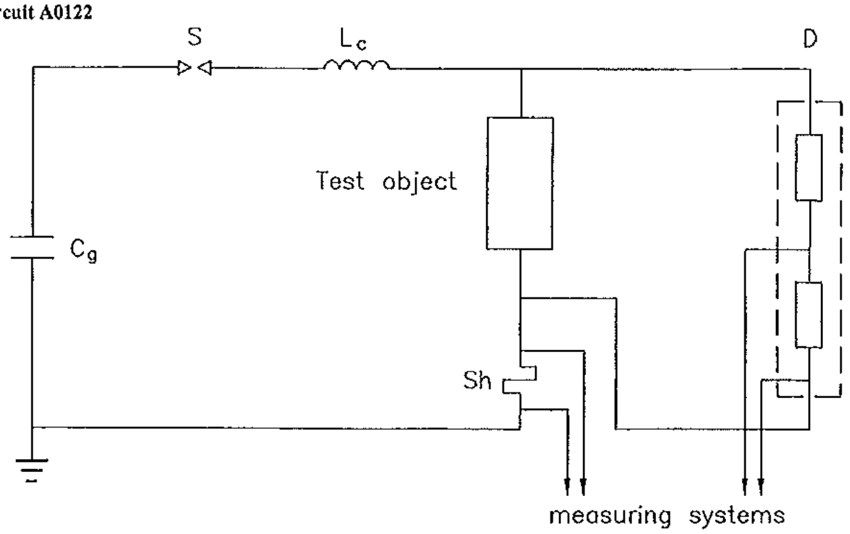
Voltage measuring system.

D	- Voltage divider SAGI; CESI No.13027
	- Electro optical system CESI No.11521/522;
OSC	- Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.2)

Current measuring system

Sh	- Current shunt CESI No.6042; R= 2 mΩ; peak current= 250 kA
	- Electro optical system CESI No.11517/518;
OSC	- Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.1)

Circuit A0122



Impulse generator

No. of stages 1
Cg 3,32 μF
Lc 100 μH

S - Spark-gap

Voltage measuring system.

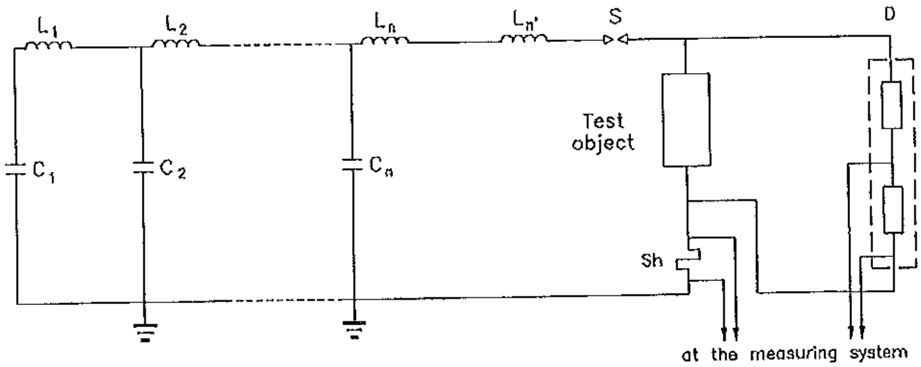
D	- Voltage divider SAGI; CESI No.11120
	- Electro optical system CESI No 11521/522
OSC	- Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.2)

Current measuring system

Sh	- Current shunt CESI No.6037; R= 20 mΩ; peak current= 250 kA
	- Electro optical system CESI No 11517/519
OSC	- Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.1)

ВЯРНО С ОРИГИНАЛА

Circuit A0017



Impulse generator

$C_1 \dots C_{13}$ - capacitors 0,83 μF
$L_1 \dots L_{13}$ - inductors 7 mH
L_{14} - inductor 14 mH

S : - spark gap

Voltage measuring system.

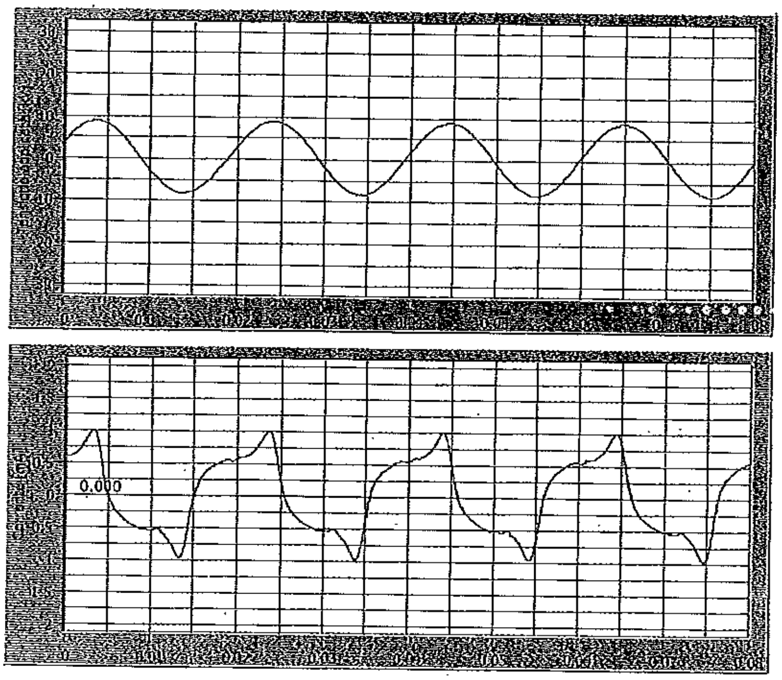
D - Voltage divider SAGI; CESI No.11120
- Electro optical system CESI No
OSC - Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.2)

Current measuring system

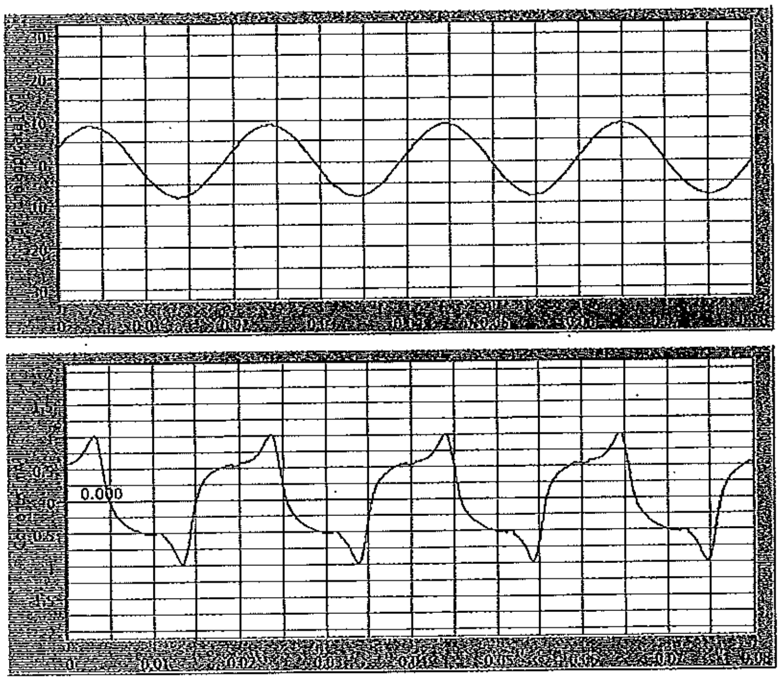
Sh - Current shunt CESI No.6042; R= 2 m Ω
- Electro optical system CESI No 11521/11522.
OSC - Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.1)

ВЯРНО С ОРИГИНАЛА

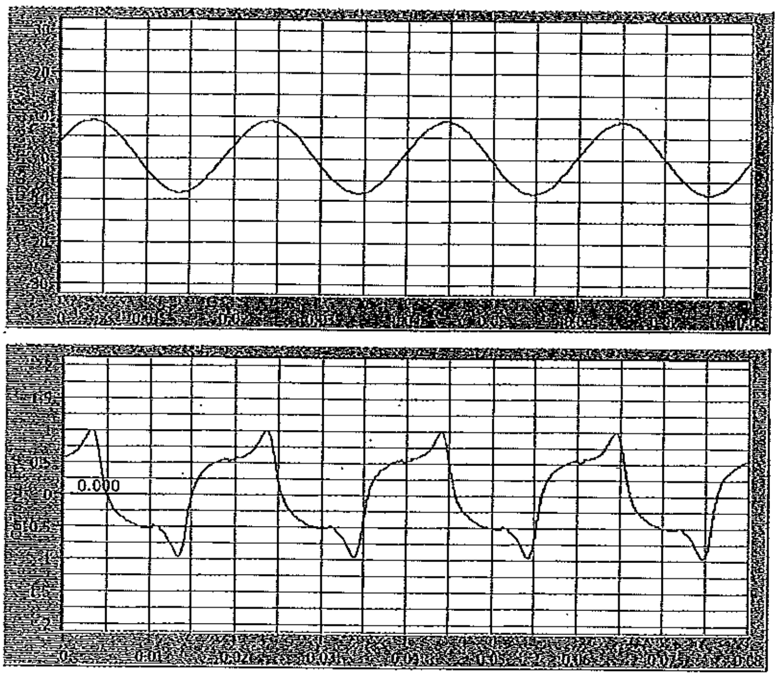
353



CESI - Pec A5046538 oscillogram n. 1

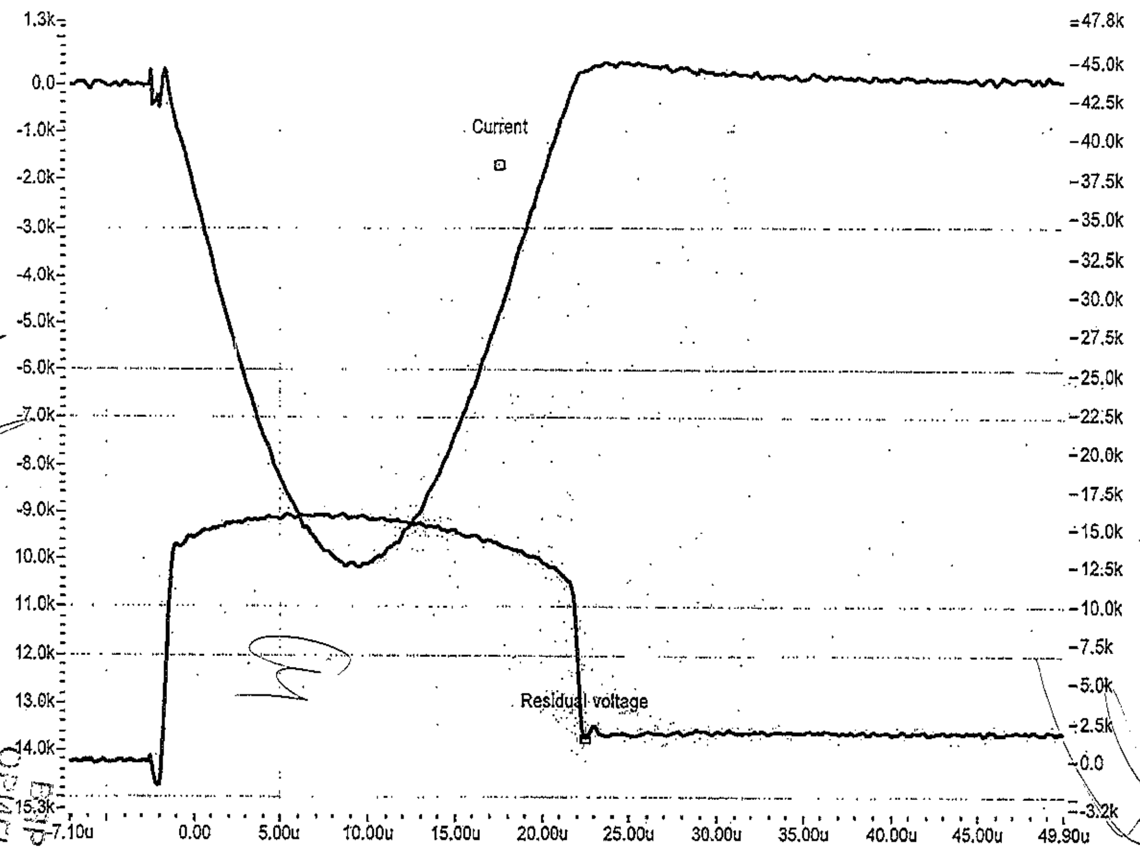


CESI - Pec A5046538 oscillogram n. 2



CESI - Pec A5046538 oscillogram n. 3

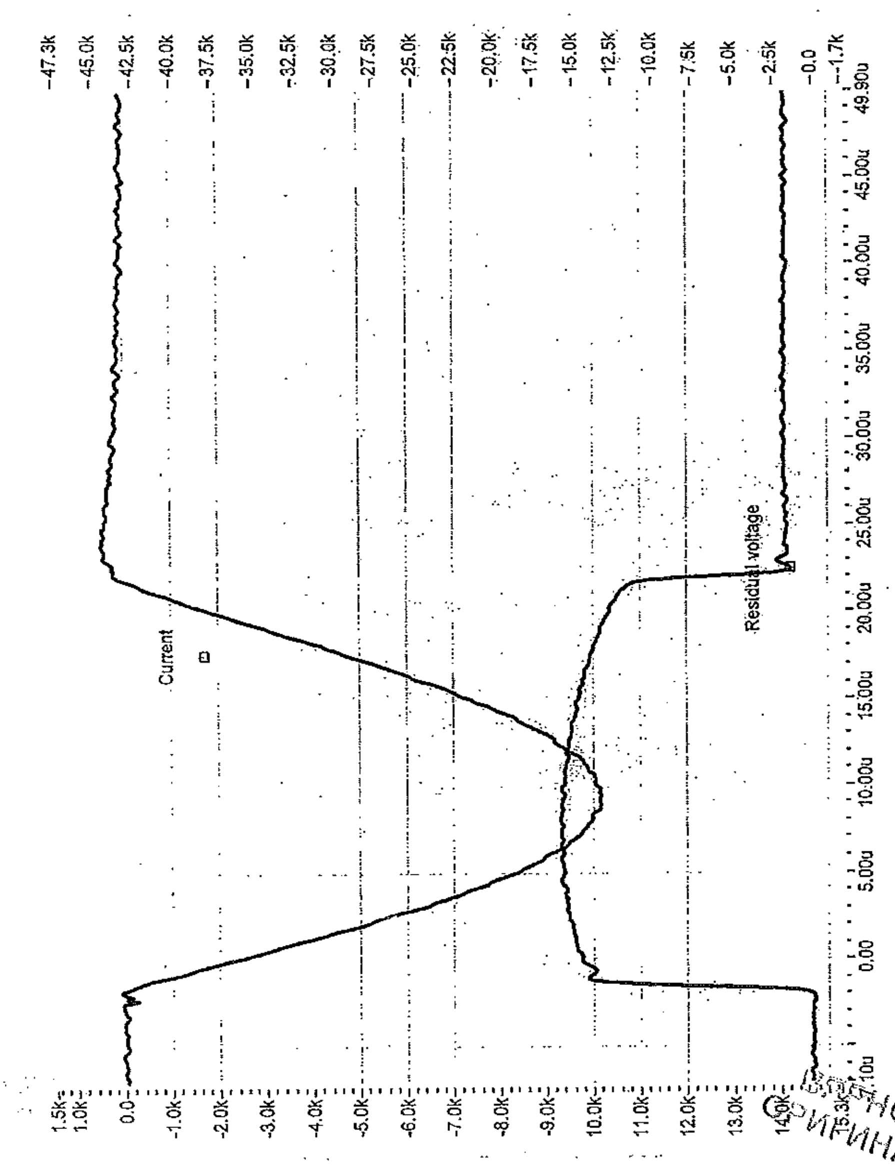
ВЯРНО С ОРИГИНАЛА



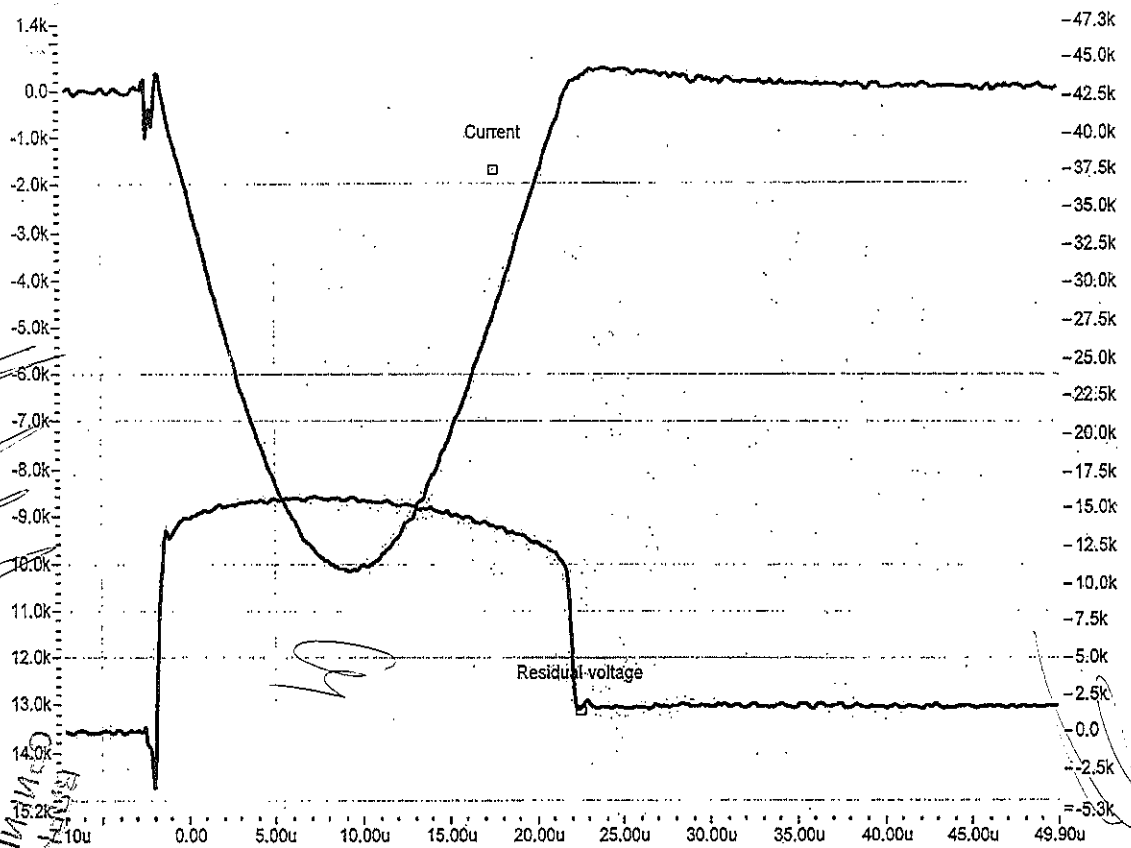
CESI PeC A5046538 Oscillogram n. 4

ВЯРНО С ОРИГИНАЛА

362



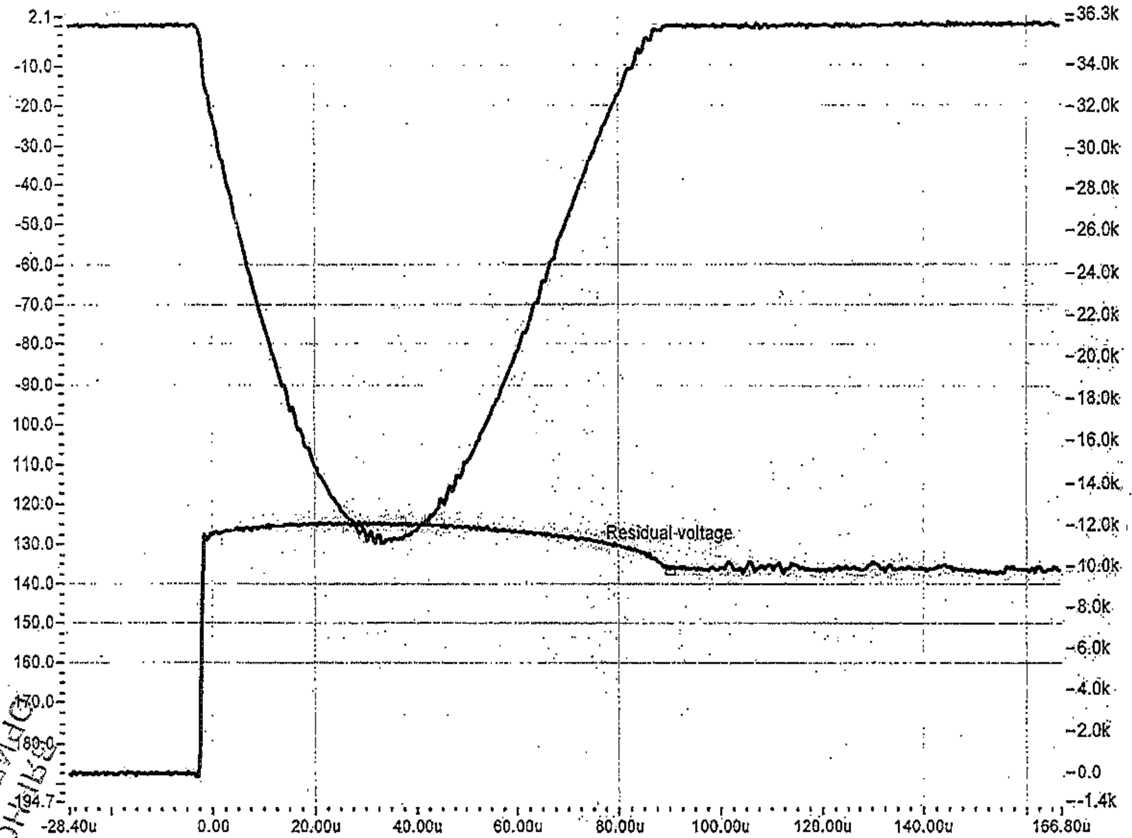
CESI PeC A5046538 Oscillogram n. 5



CESI PeC A5046538 Oscillogram n. 8

ВЯРНО С ОРИГИНАЛА

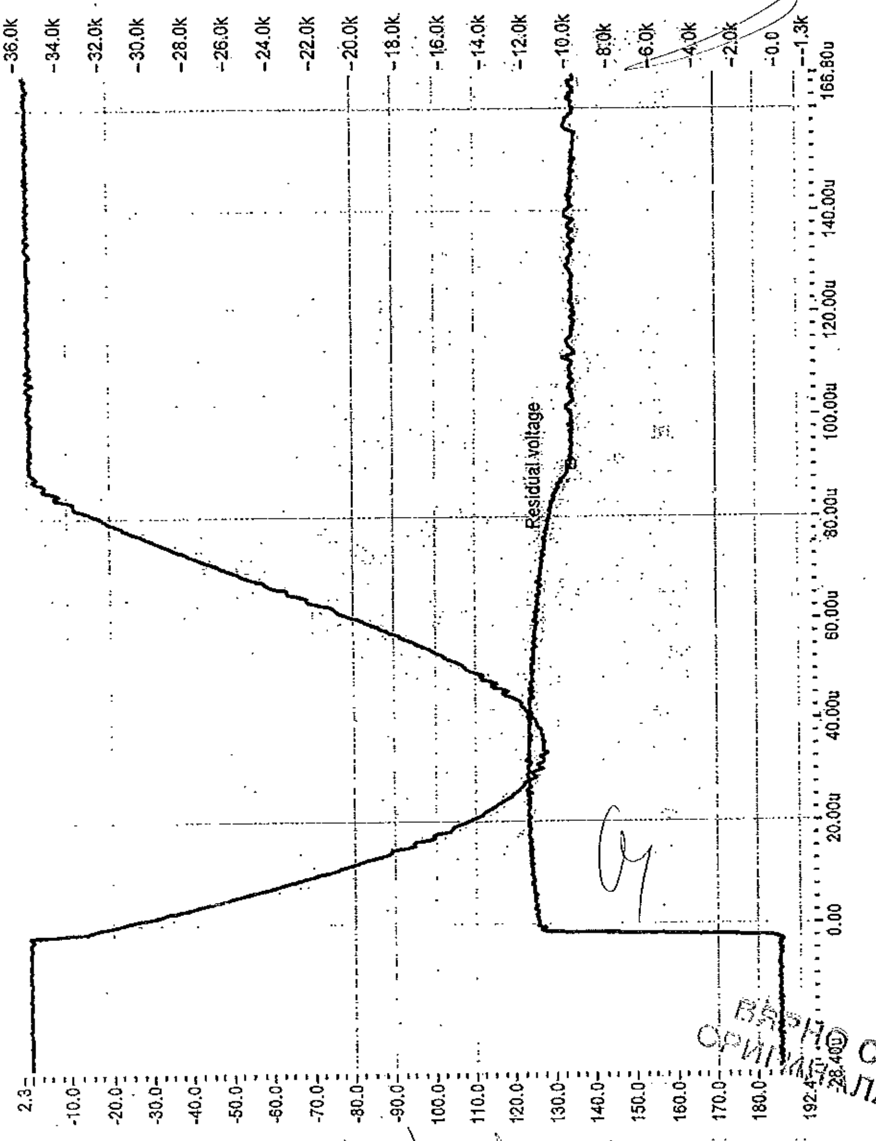
364



CESI PeC A5046538 Oscillogram n. 7

365

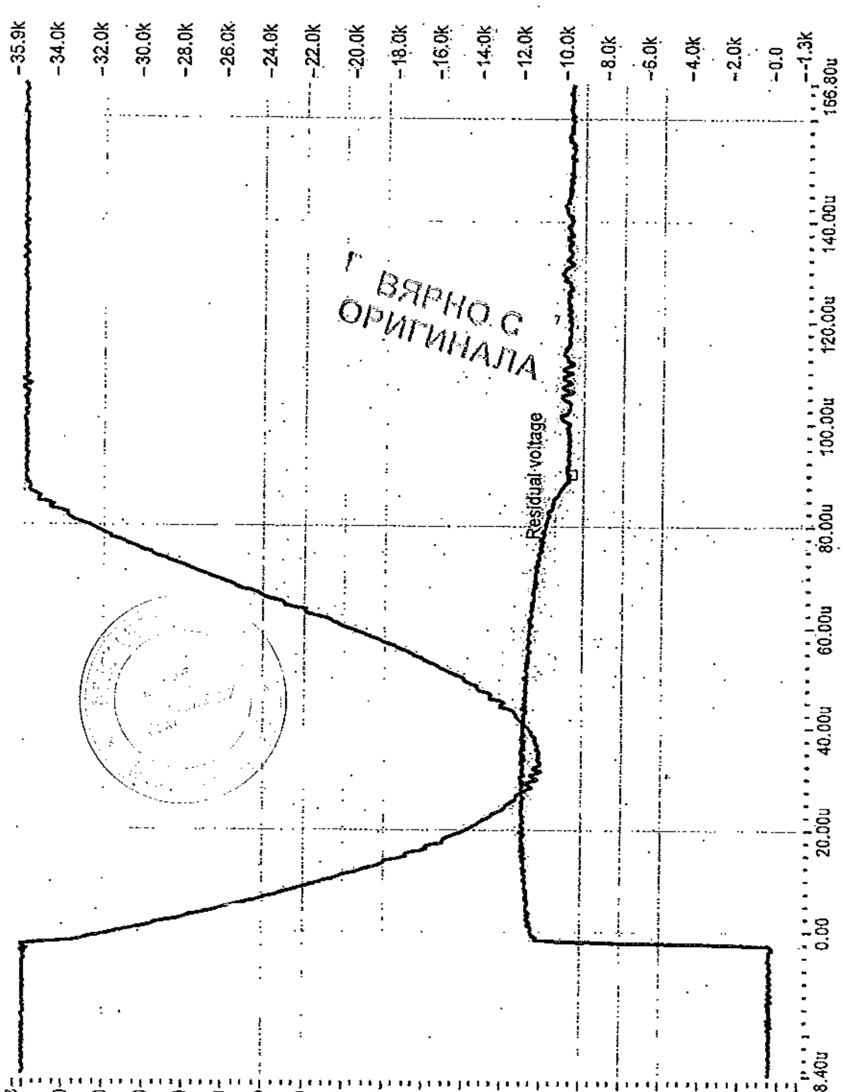
ВЯРНО С ОРИГИНАЛА



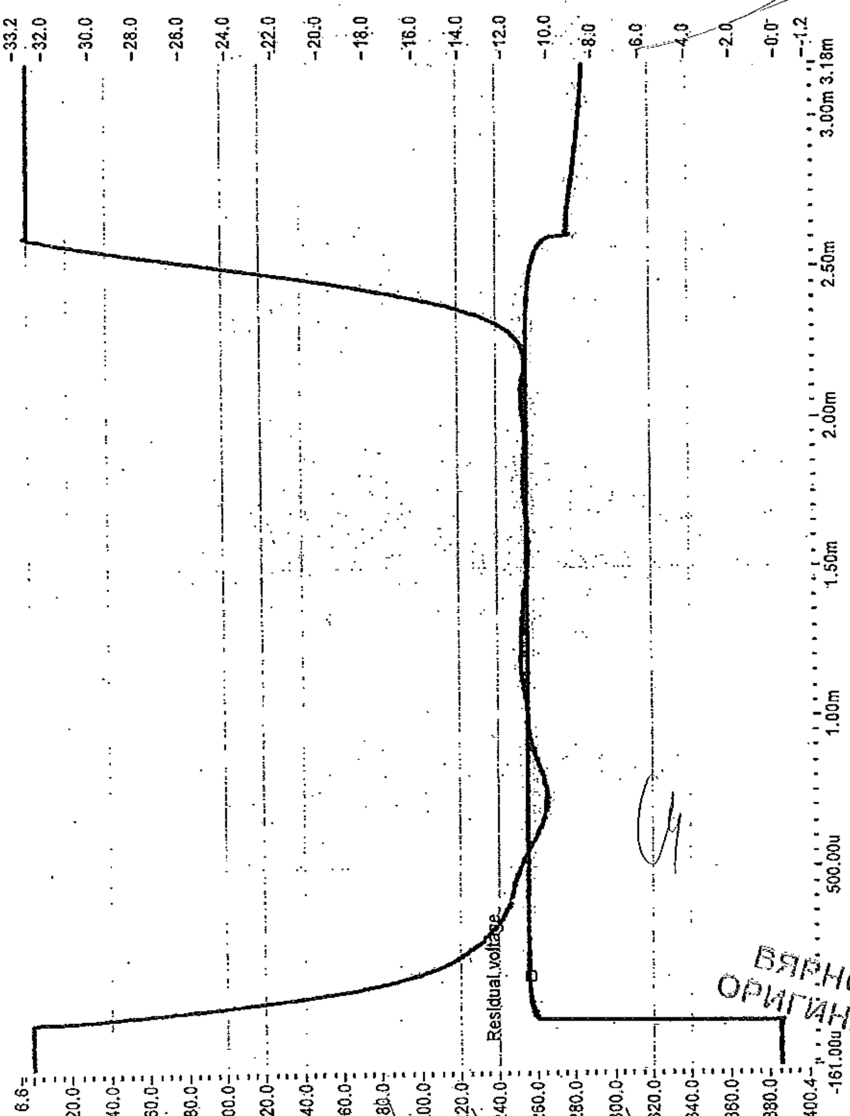
CESI PeC A5046538 Oscillogram n. 8

ВЕРНО С ОРИГИНАЛА

300



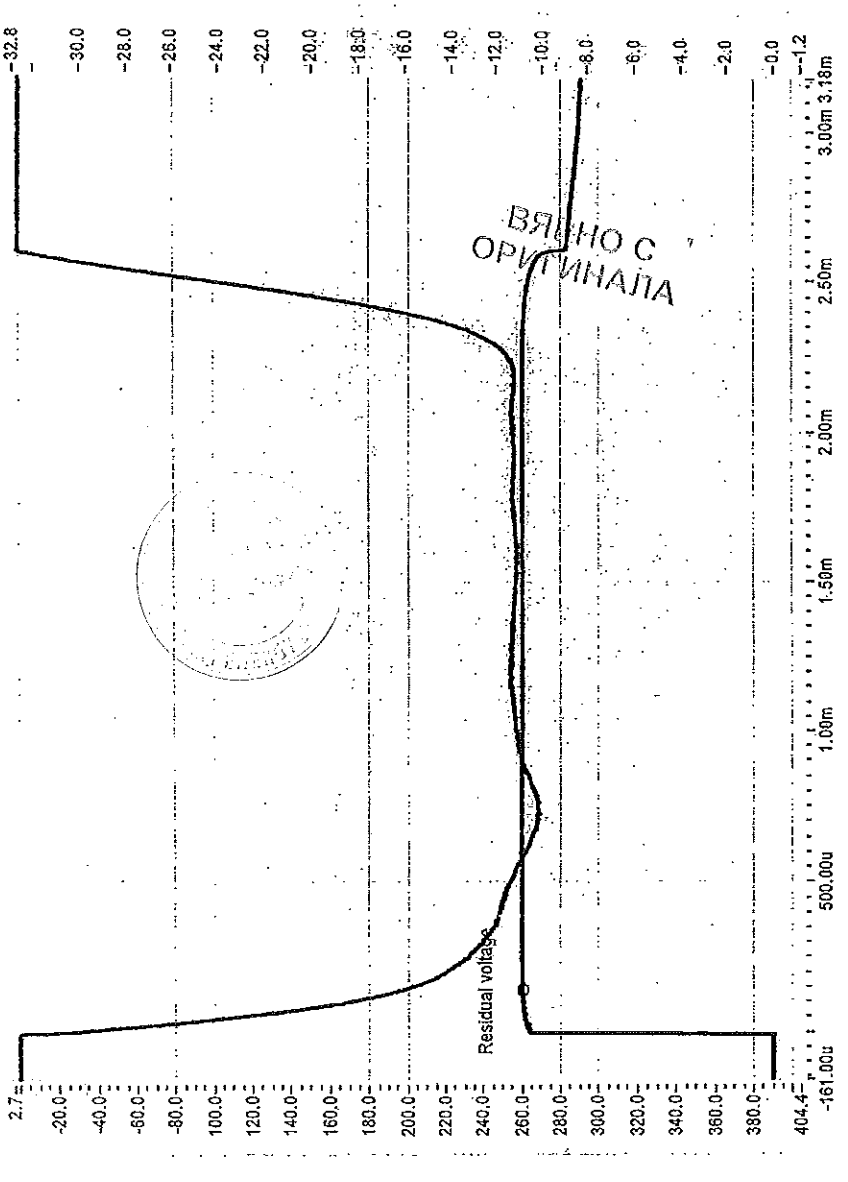
CESI PeC A5046538 Oscillogram n. 9



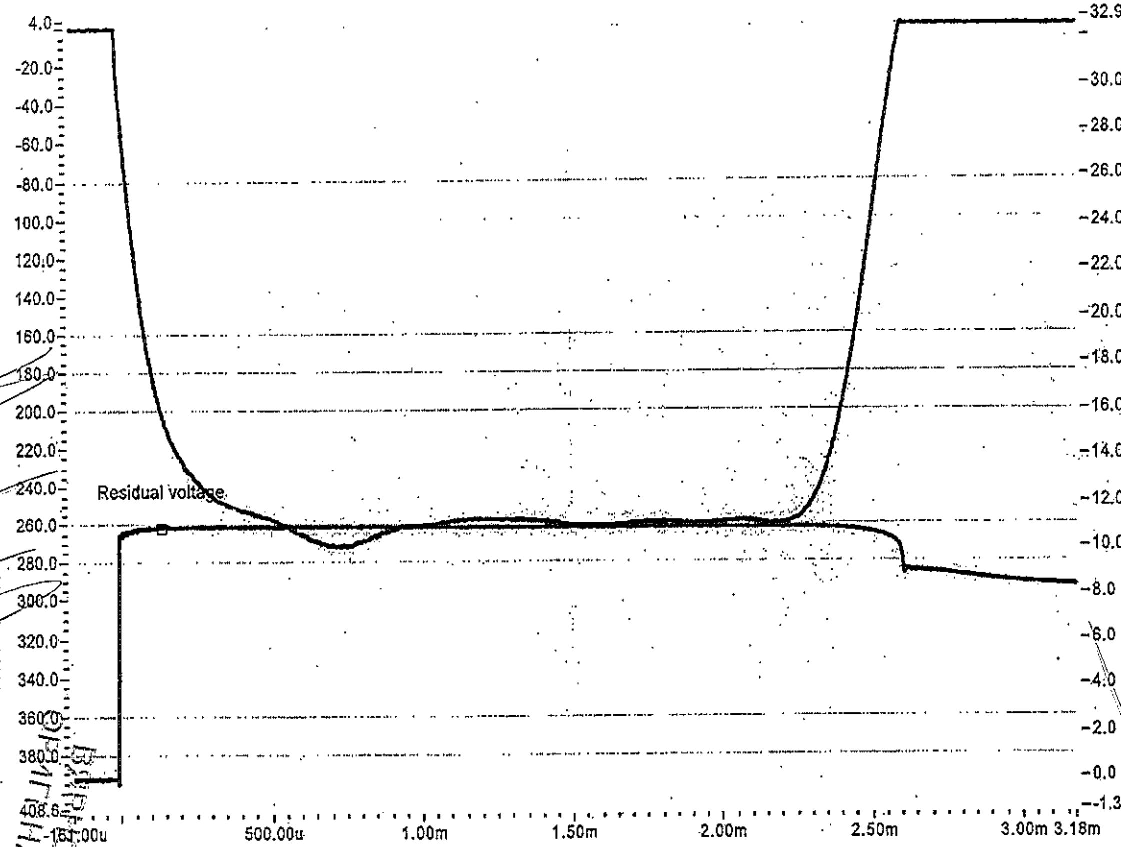
ВЯРНО С ОРИГИНАЛА

CESI PeC A5046538 Oscillogram n. 10

383

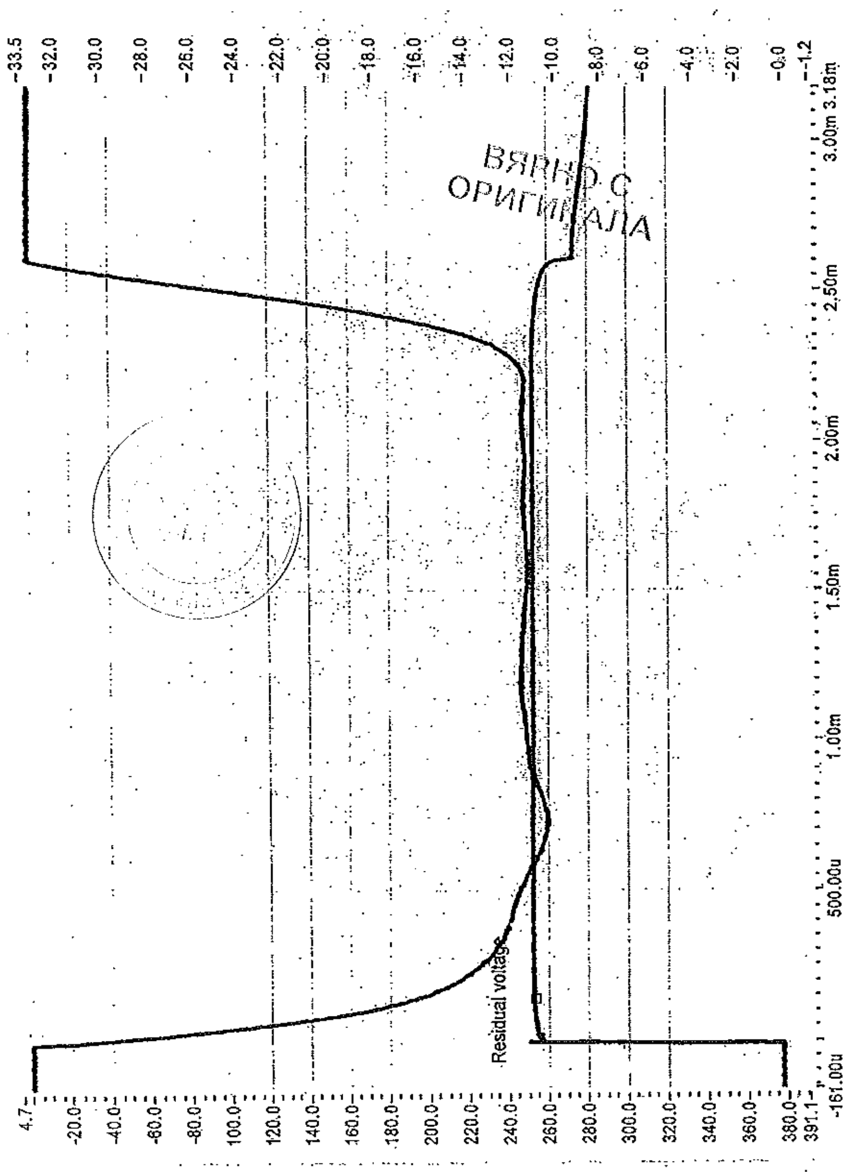


CESI PeC A5046538 Oscillogram n. 11



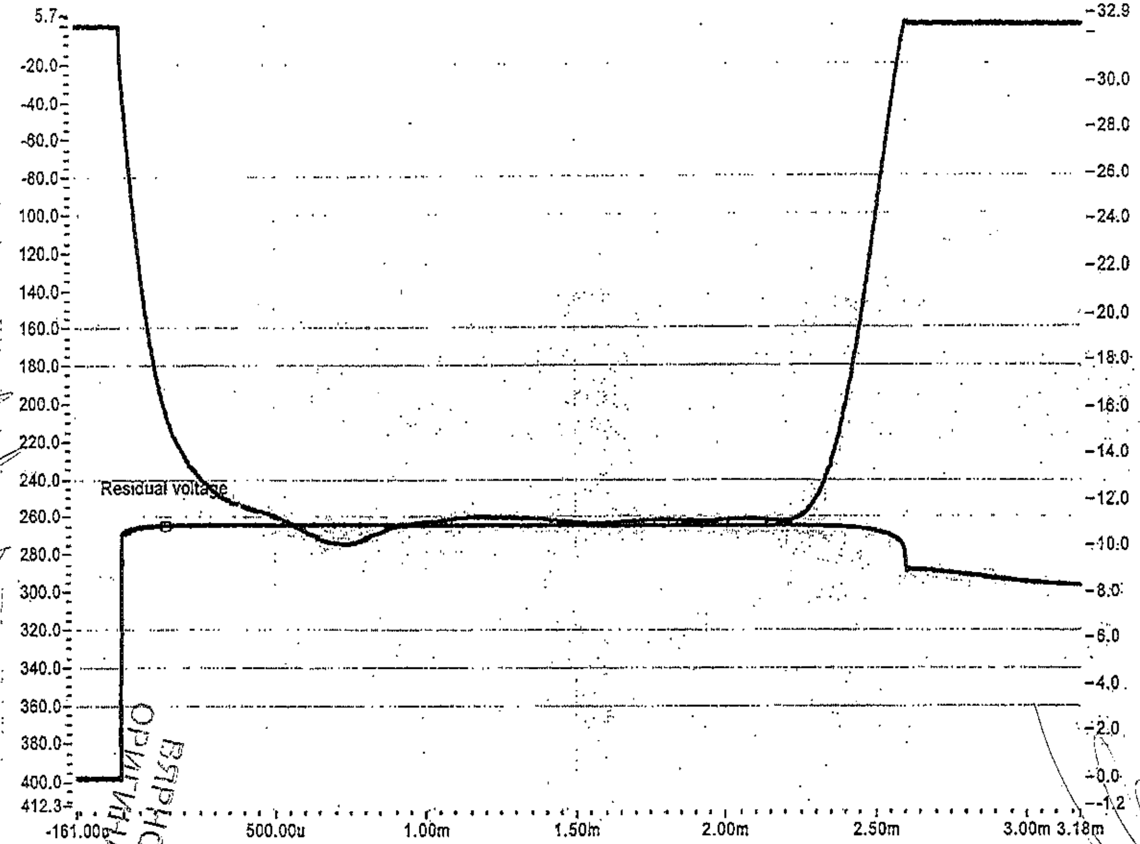
CESI PeC A5046538 Oscillogram n. 12

ВЯРНО С ОРИГИНАЛА

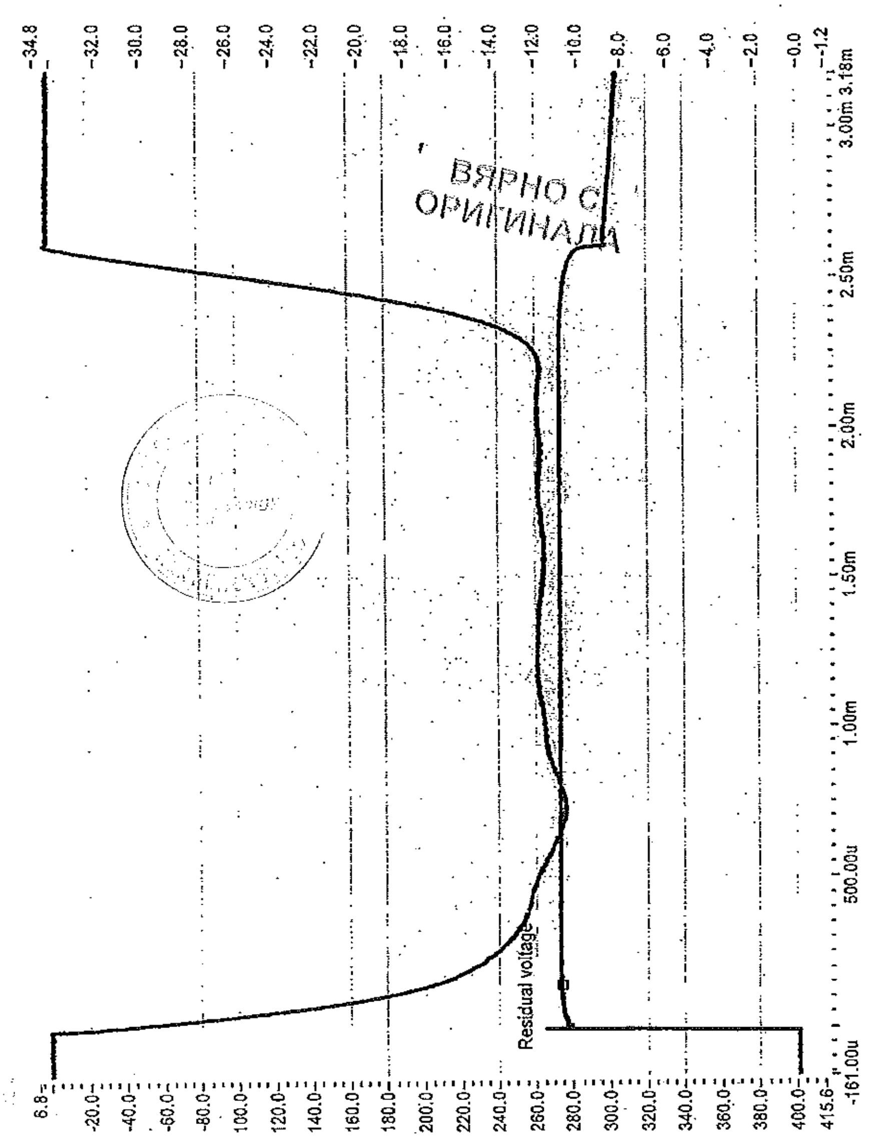


CESI PeC A5046538 Oscillogram n. 13

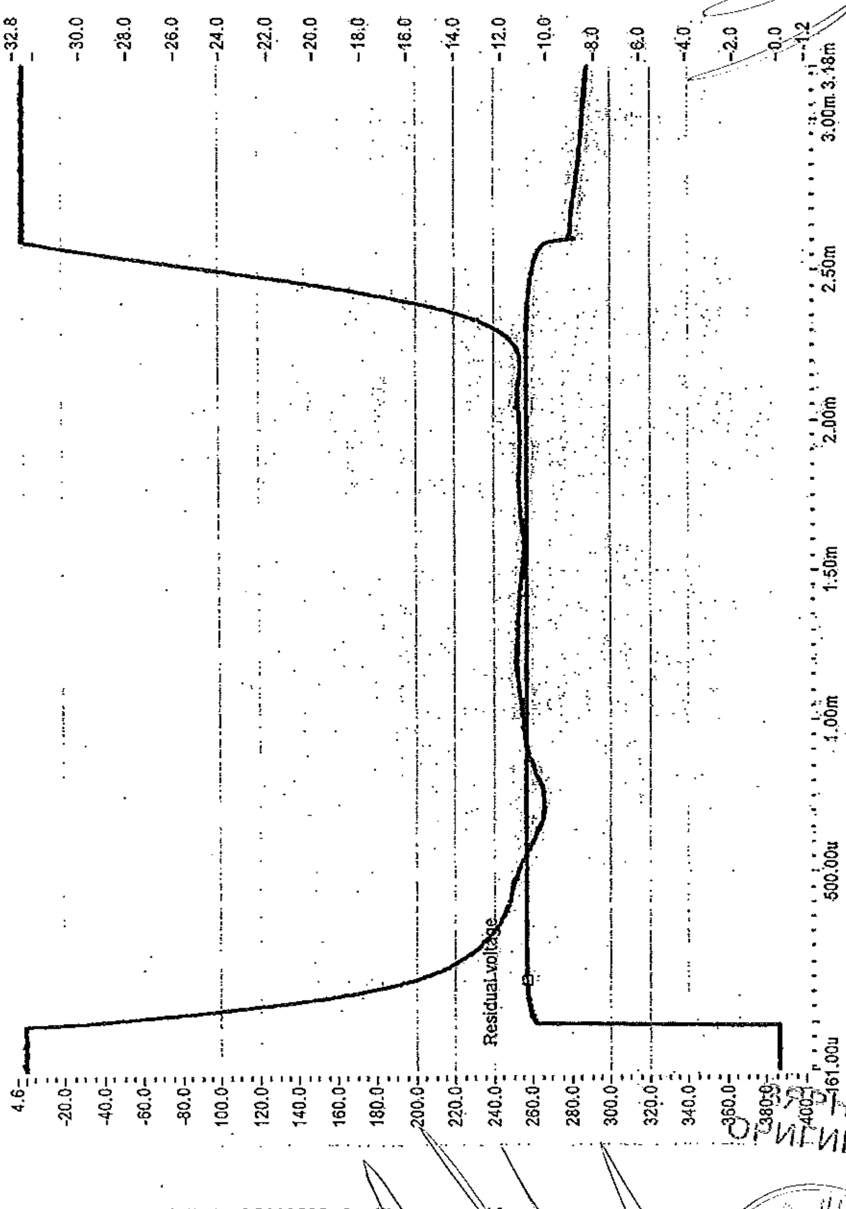
CESI PeC A5046538 Oscillogram n. 14



ВЯРНО С ОРИГИНАЛА



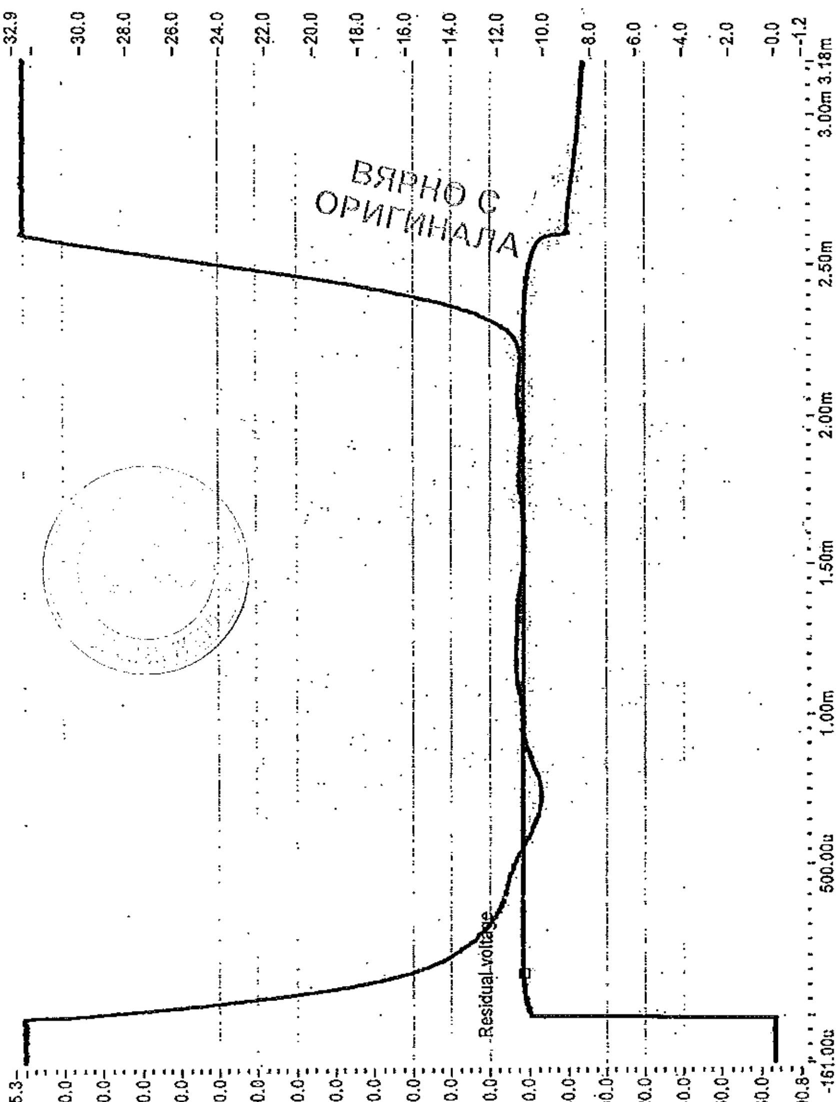
CESI PeC A5046538 Oscillogram n. 15



CESI PeC A5046538 Oscillogram n. 16

ВЯРНО С ОРИГИНАЛА

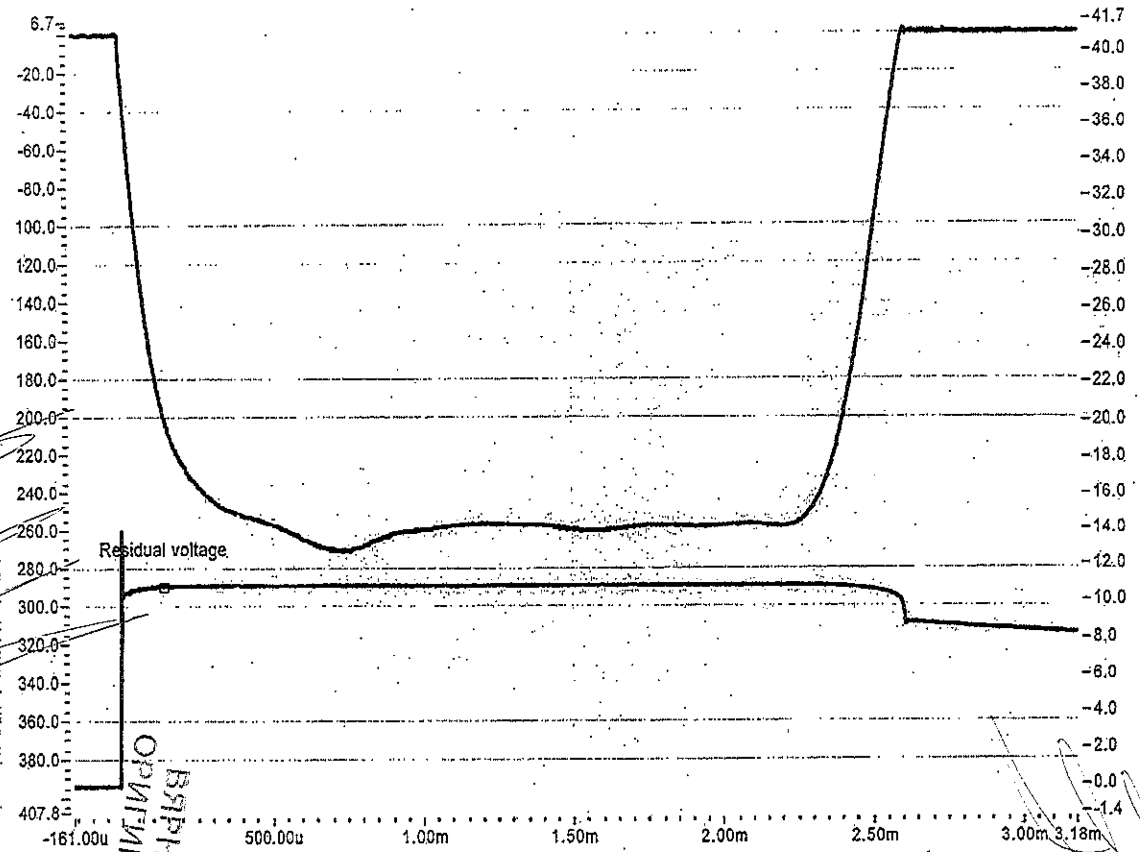
374



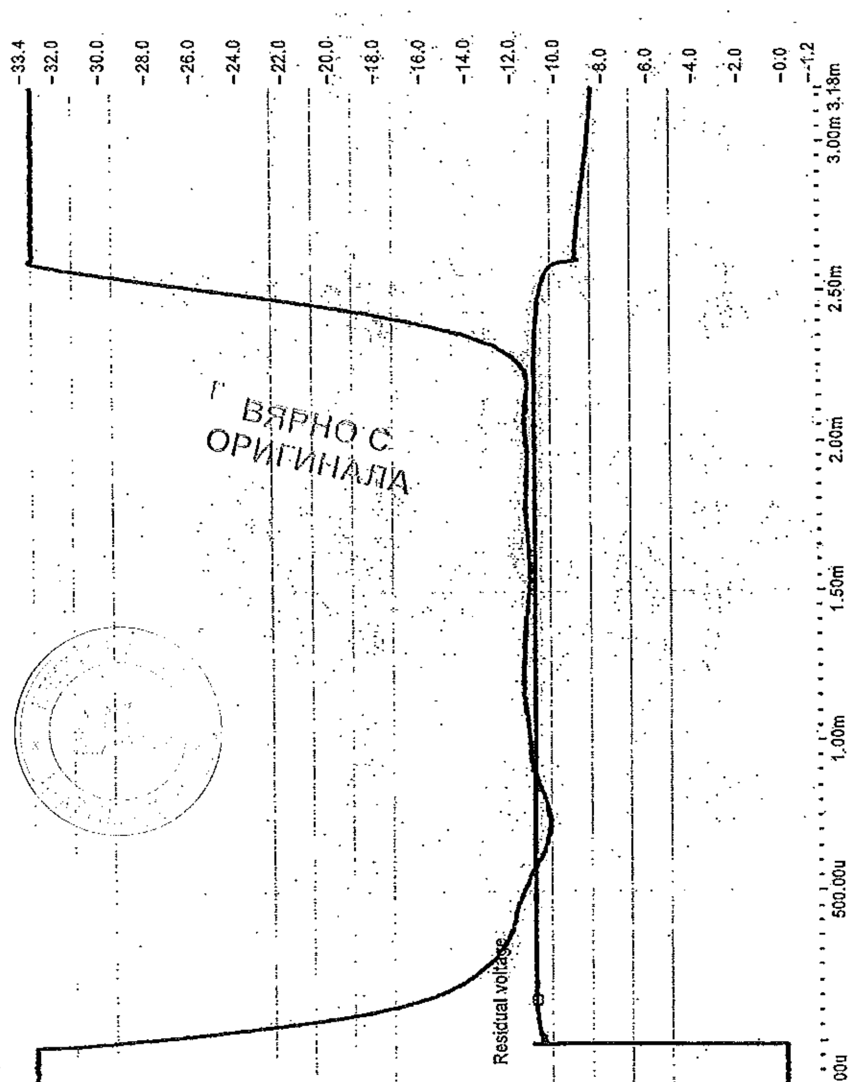
CESI PeC A5046538 Oscillogram n. 17

375

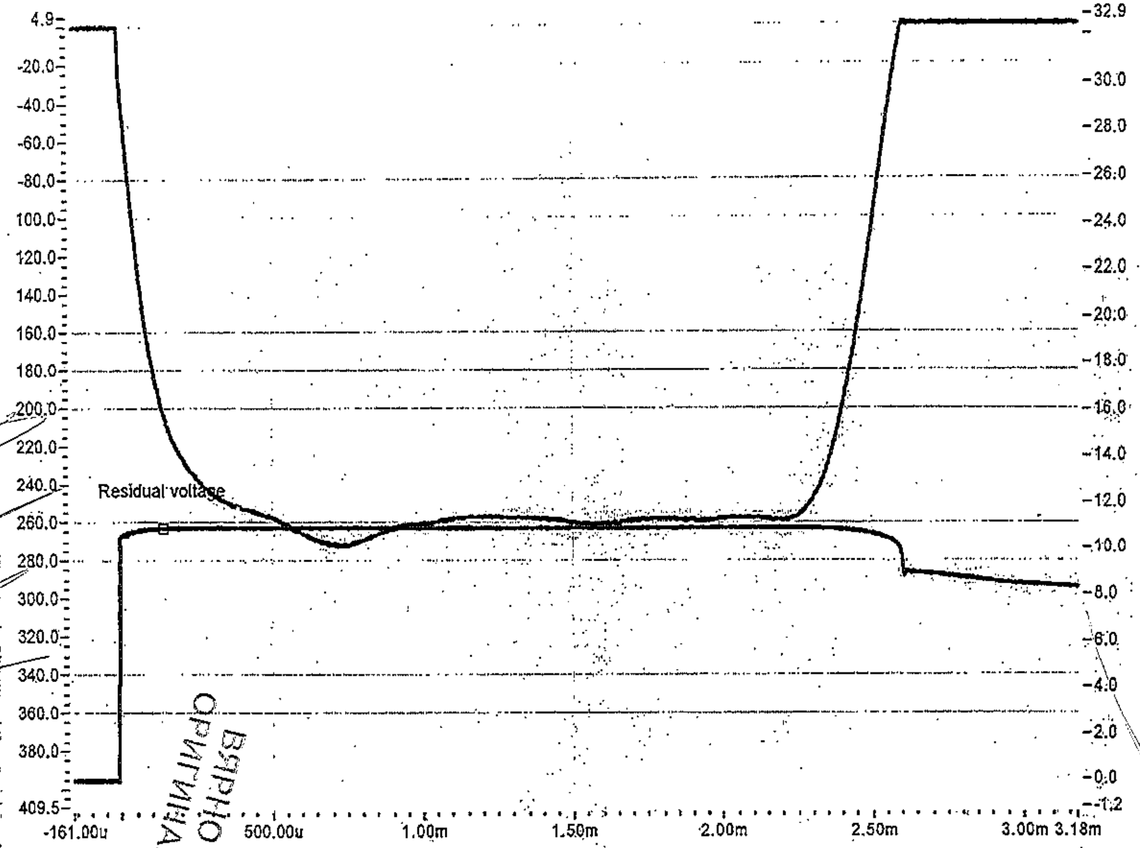
CESI PeC A5046538 Oscillogram n. 18



ВЯРНО С ОРИГИНАЛА



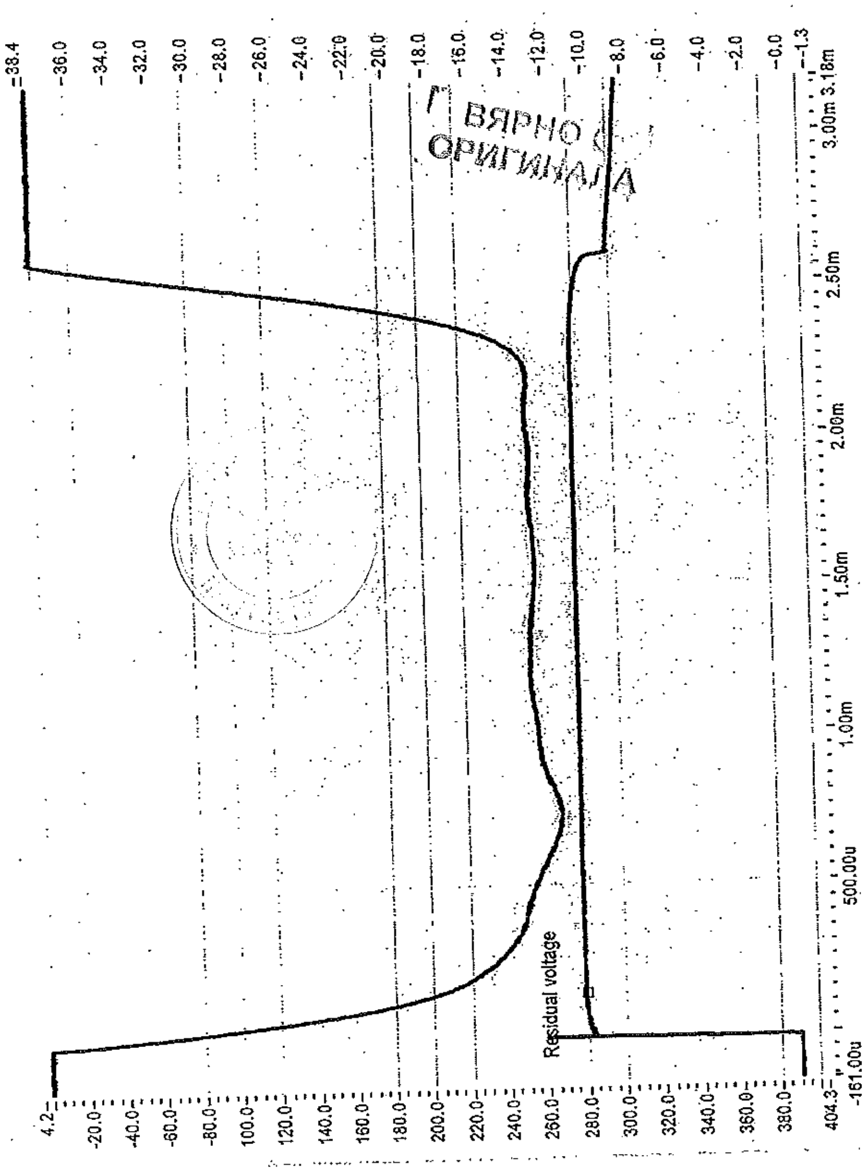
CESI PeC A5046538 Oscillogram n. 19



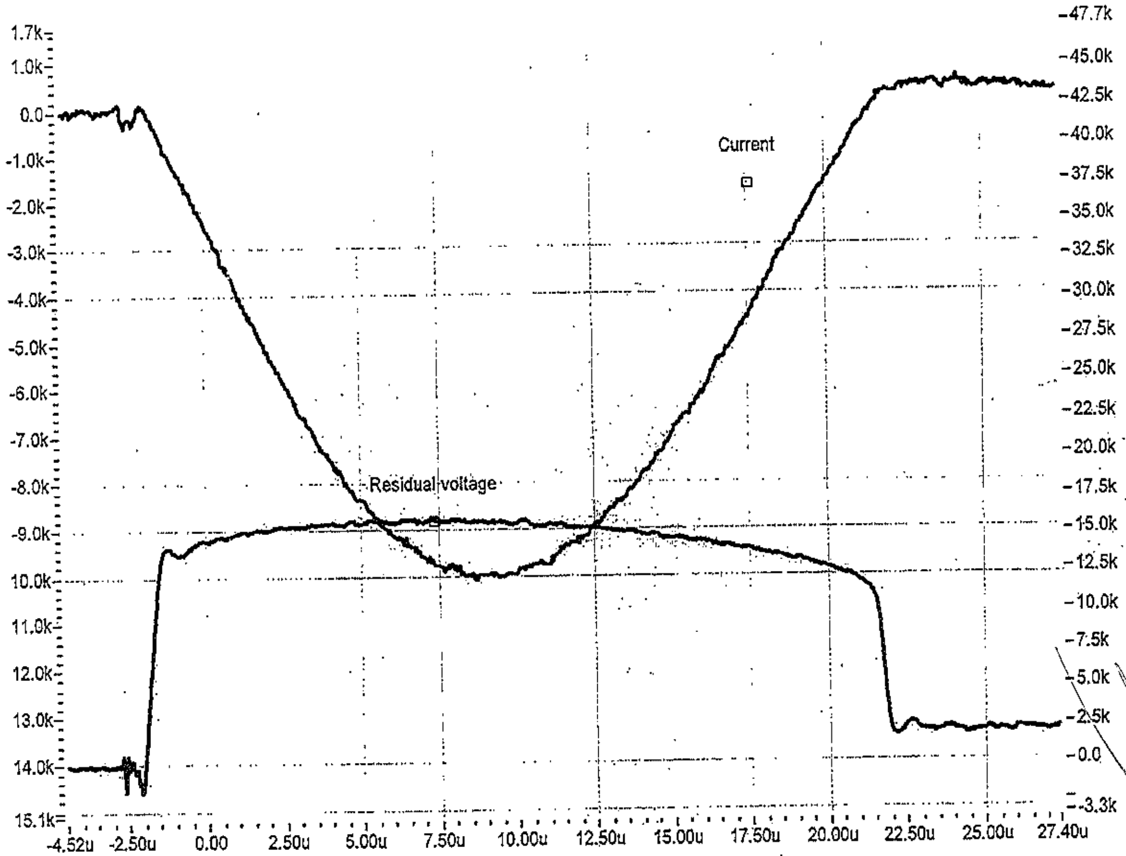
CESI PeC A5046538 Oscillogram n. 20

ВЯРНО С ОРИГИНАЛА

373

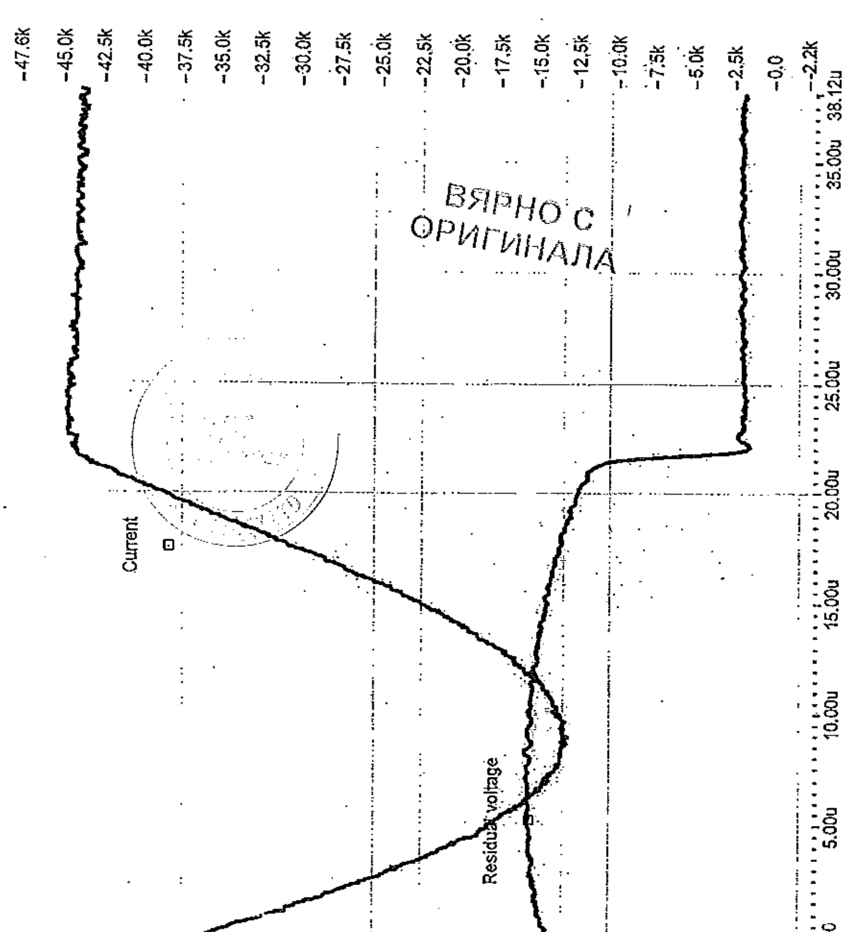


CESI PeC A5046538 Oscillogram n. 21



CESI PeC A5046538 Oscillogram n. 22

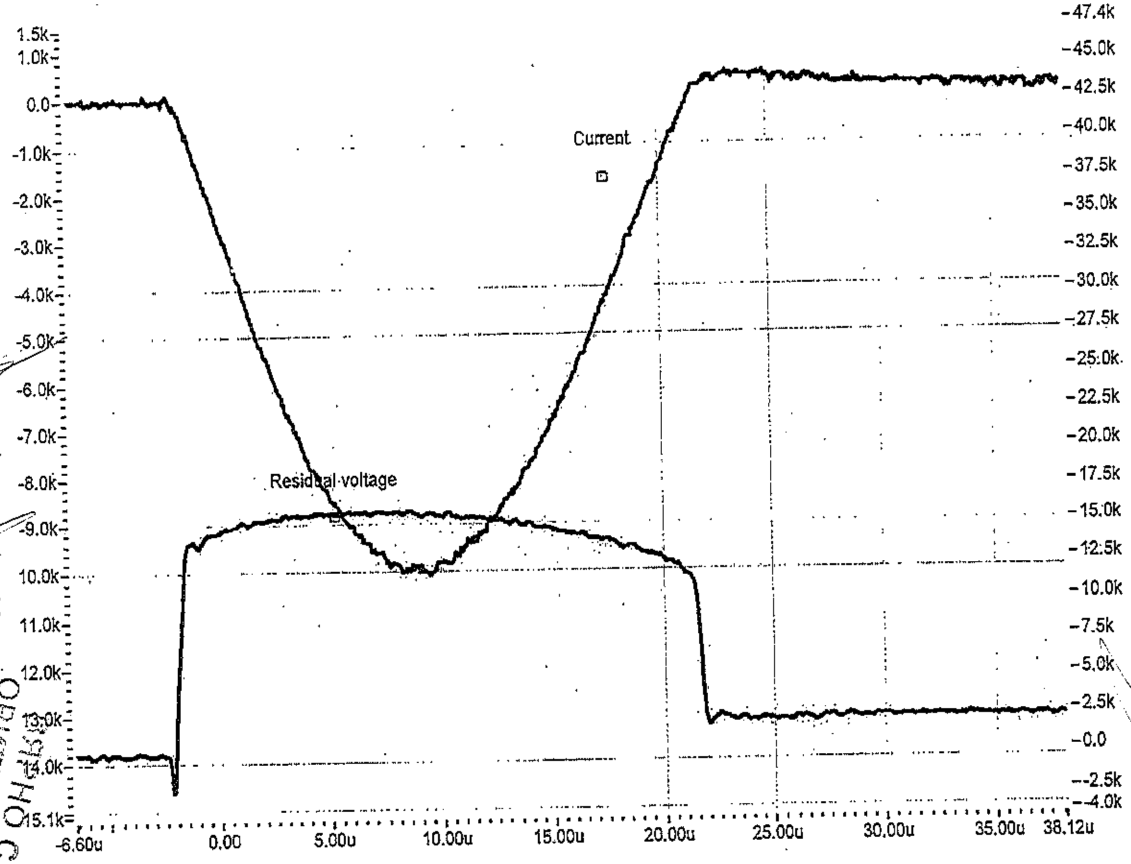
ВЯРНО С ОРИГИНАЛА



CESI PeC A5046538 Oscillogram n. 23

48

331



CESI PeC A5046538 Oscillogram n. 24

ВЯРНО С ОРИГИНАЛА

Test Report

Client	AREVA Parafoudres S.A. - Bagneres de Bigorre (France)
Tested equipment	Polymer housed metal-oxide surge arrester type VARISIL HE fitted with type SnD2 disconnector
Tests carried out	High current impulse operating duty test
Standards/Specifications	IEC 60099-4 (2004-05)
Test date	from November 30, 2005 to December 2, 2005

The results reported in this document relate only to the tested equipment.
Partial reproduction of this document is permitted only with the written permission from CESI.

No. of pages	24	No. of pages annexed	45
Issue date	December 14, 2005		
Prepared	BU PeC - M. Gregori Marco Gregori		
Verified	BU PeC - R. Malgesini		
Approved	BU PeC - M. de Nigris		

CESI
CENTRO ELETTROTECNICO SPERIMENTALE ITALIANO
Business Unit
Prove e Componenti
Il Responsabile del Laboratorio

ВЯРНО С ОРИГИНАЛА
334

Tests witnessed by: Mr F. Malpiece - AREVA Parafoudres S.A.

Identification of the object: Not requested

- dielectric tests with impulse voltage : peak voltage: ±3 %; time parameters: ±10 %
- dielectric tests with impulse current : peak value: ±3 %; time parameters: ±10 %
- dielectric tests with alternating voltage : voltage (rms): ±3 %

dielectric tests with direct voltage : voltage: ±3 %

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to confidence level of about 95%) and have to be considered as maximum values

Laboratory information

Receipt date of the sample	November 30, 2005
Test location	CESI – Via Rubattino 54 – Milan
CESI testing team	L. Podavitte
Test laboratory	P177
Activity code	46879G

A1001JG

ВЯРНО С ОРИГИНАЛА

386

ВЯРНО С
ОРИГИНАЛА

A1002IG

Content	page	test date
Test object characteristics	4	
Photograph of the test object	5	
Reference standard	6	
Reference standard	6	
Test carried out	6	
Test object identification	6	
Test procedure	7	
Visual inspection and summary of test result	8	
High current impulse operating duty test	9 - 17	November 26-28, 2005
Technical data	18 - 24	
Pages annexed:		
Oscillograms n. 43 pages		
AREVA document "Data & results for the accelerated ageing test", CESI n. A5057745/1, n.1 page		
AREVA document " Data & result for verification of the thermal equivalency"; CESI n. A5057745/2, n.1 page		

Test object characteristics

type: Polymer housed metal-oxide surge arrester (thermal equivalent)

electrical characteristics (assigned by the client)

Manufacturer's name	AREVA Parafoudres S.A. - Bagneres de Bigorre (France)
Nominal discharge current - I_N [kA]	10.0
Rated voltage – U_r [kV]	Uref x 1,035
Continuous operating voltage - U_c [kV]	Uref x 0,880
Reference current - I_{ref} [mA]	1,0
Line discharge class	1
Rated frequency - [Hz]	50 - 60

geometrical characteristics (measured with thermal insulation)

Total height [mm]	245
Number of sheds	n. 4 large – n. 3 small
Shed diameter [mm]	104 large - 74 small
Core diameter [mm]	48

other characteristics

Housing material	Silicone
Housing color	Grey

NOTE: The surge arresters were tested with the additional thermal insulation supplied by the Client.
The verification of the thermal equivalency according to annexe B was carried out by the Client
(see annexed document n. A5057745/2)

CSf

ВЯРНО С ОРИГИНАЛА

A1176IO

337

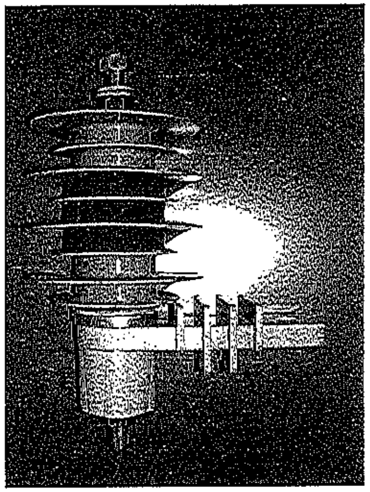


Photo no. 1

A1265TG

ВЯРНО С ОРИГИНАЛА

Reference standard

The test was carried according to the IEC 60099-4 (2004) Standard – Clause 8.5

" Metal-oxide surge arrester without gaps for a.c. system "

Test carried out

test carried out	number of sample tested
high current impulse operating duty test	3

Test object identification

test object names	identification of test sample (assigned by the CESI)
polymer housed metal-oxide surge arrester	OD1-OD2-OD3

ВЯРНО С ОРИГИНАЛА

Test procedure (Foreseen by the relevant standard)

- The power frequency reference voltage at $I_{ref} = 1{,}0$ mA has been measured
- The lightning impulse residual voltage at $I_N = 10$ kA has been measured
- The voltage correction factors have been calculated according to reference standard
- The preconditioning has been performed on surge arrester at ambient temperature according to reference standard as per the following procedure:
  - Twenty shots 8/20 µs at I_N have been applied superimposed to the power frequency at the voltage level $1{,}2 \cdot U_c'$. The shots have been applied in four groups of five impulses. The interval between impulses of the same group was 50-60 seconds while the interval between groups was 30 minutes. The polarity of the impulses was the same as that of the half cycle of power frequency voltage during which it occurred (positive) and they were applied 60 electrical degrees before the peak of the power frequency.
  - The samples have been let to cool down to ambient temperature
  - The first high current impulse having waveshape 4/10 µs and peak value equal to 100 kA has been applied
- The surge arrester section kept in an oven at the temperature of 60 °C till thermal equilibrium

The second high current impulse having waveshape 4/10 µs and peak value equal to 100 kA has been applied.
A time shorter than 100 ms after the application of the second high current impulse the sample has been energized at U_r' for 10 sec, and then at the voltage U_c' for 30 min. to verify the thermal stability.

- The lightning impulse residual voltage at $I_N = 10{,}0$ kA has been repeated two times.

ВЯРНО С
ОРИГИНАЛА
330

Visual inspection and summary test results

Variation of lightning impulse residual voltage at I_N

Sample	before test		after test		variation
	discharge current	residual voltage	discharge current	residual voltage	
	kA	kV	kA	kV	%
OD1	10,0	15,61	10,16	15,87	1,67
OD2	10,0	15,64	10,15	15,95	1,98
OD3	10,0	15,76	10,15	15,92	1,01

The visual inspection after the test has revealed no sign of physical damage. The variation of lightning impulse residual voltage before and after the test was less then 5%.
The disconnectors did not operate
The thermal stability was achieved. The oscillogram record of the two last shots doesn't reveal any sign of internal discharge.
All acceptance criteria are satisfied and therefore the test result is to be considered positive.

ВЯРНО С ОРИГИНАЛА

A14413G

High current impulse operating duty test.

Power frequency voltage-current characteristics.

Test circuit: A0019

Date: November 30, 2005

Sample No. OD1						
Oscillogram	voltage	current	current	Current	power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	µA
1	5,98	1,03	1,00	0,590	1,99	–

Sample No. OD2						
Oscillogram	voltage	current	current	Current	power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	µA
2	5,97	1,02	1,01	0,600	2,03	–

Sample No. OD3						
Oscillogram	voltage	current	current	Current	power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	µA
3	5,95	1,00	0,95	0,590	1,95	–

ВЯРНО С ОРИГИНАЛА

392

High current impulse operating duty test.

Lightning impulse residual voltage measurement before the test

Test circuit: A0120

Date: November 30, 2005

Sample	Requested current	Charging voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage
No.		kV	No.	µs	kA	kV
OD1	I_N	29,6	4	8,7/18,5	10,0	15,61
OD2		29,6	5		10,0	15,64
OD3		29,6	6		10,0	15,76

	Oscilloscope settings		
	sampling division	input	attenuation
	µs	V_{div}	
Current	5,0	0,5	50:5
Voltage	5,0	1,0	20:5

Notes:

ВЯРНО С ОРИГИНАЛА

393

Voltage correction factor

Date: November 30, 2005

Sample	U_{ref} [1]	KU_r [2]	KU_C [3]	U_r' [4]	U_c' [5]	U' [6]
No.	kV			kV	kV	kV
OD1	5,98	1,035	0,880	6,19	5,26	6,31
OD2	5,97			6,18	5,25	6,30
OD3	5,95			6,16	5,23	6,28

[1] U_{ref} : measured reference voltage
[2] KU_r : factor claimed by the manufacturer for calculation of U_r'
[3] KU_C : factor claimed by the manufacturer for calculation of U_c'
[4] U_r' : corrected rated voltage [4] = [1] × [2]
[5] U_c' : corrected continuous operating voltage [5] = [1] × [3]
[6] U' : corrected voltage to be applied during the conditioning [6] = 1.2 × [5]

A14421G

ВЯРНО С
ОРИГИНАЛА

394

High current impulse operating duty test. IEC 60099-4 Standard

Conditioning

Test circuit: A0015

Date: November 30, 2005

Imp.	Osc.	Sample No. OD1 charging	Sample No. OD1 peak current	Osc.	Sample No. OD2 Charging	Sample No. OD2 peak current	Osc.	Sample No. OD3 charging	Sample No. OD3 peak current
No.	No.	kV	kA	No.	kV	kA	No.	kV	kA
1	7	38,5	10,0		38,5	10,0		38,5	10,0
2		38,5	10,0		38,5	10,0		38,5	10,0
3		38,5	10,0		38,5	10,0		38,5	10,0
4		38,5	10,0		38,5	10,0		38,5	10,0
5	8	38,5	10,0	9	38,5	10,0	10	38,5	10,0
6		38,5	10,0		38,5	10,0		38,5	10,0
7		38,5	10,0		38,5	10,0		38,5	10,0
8		38,5	10,0		38,5	10,0		38,5	10,0
9		38,5	10,0		38,5	10,0		38,5	10,0
10	11	38,5	10,0	12	38,5	10,0	13	38,5	10,0
11		38,5	10,0		38,5	10,0		38,5	10,0
12		38,5	10,0		38,5	10,0		38,5	10,0
13		38,5	10,0		38,5	10,0		38,5	10,0
14		38,5	10,0		38,5	10,0		38,5	10,0
15		38,5	10,0		38,5	10,0		38,5	10,0
16		38,5	10,0		38,5	10,0		38,5	10,0
17		38,5	10,0		38,5	10,0		38,5	10,0
18		38,5	10,0		38,5	10,0		38,5	10,0
19		38,5	10,0		38,5	10,0		38,5	10,0
20	14	38,5	10,0	15	38,5	10,0	16	38,5	10,0

Power frequency voltage applied to the test sample	Sample No. OD1	Sample No. OD2	Sample No. OD3
	6,31	6,30	6,28

	Oscilloscope settings sampling division	Input	attenuation
	ms	V_{div}	
Current	10	0,5	50:5
Voltage	10	2,0	50:5

Notes:

A11521G

ВЯРНО С ОРИГИНАЛА

High current impulse operating duty test. IEC 60099-4 Standard

Application of the first high current impulse

Test circuit: A0121

Date: December 1, 2005

Sample	Impulse	Charging voltage	Oscillogram	Residual voltage	Discharge current	Current waveshape
No.	No.	kV	No.	kV	kA	
OD1	1	81,0 x 2	17	26,5	94,5	4,5/9,6 μs opposite polarity 6 %
OD2		81,0 x 2	18	26,6	94,5	
OD3		81,5 x 2	19	26,0	95,0	

	Oscilloscope settings		
	sampling division	input	attenuation
	μs	V_{div}	
Current	2	1,0	300:5
Voltage		1,0	50:5

Notes:

A115310

ВЯРНО С ОРИГИНАЛА

396

High current impulse operating duty test. IEC 60099-4 Standard

Application of the second high current impulse, of the rated voltage U_r' and evaluation of thermal stability

Test circuit: A0123-A0020-A0131

Sample No.: OD1

Preheating temperature: 61 °C

Date: December 01, 2005

Second high current impulse application

Oscillogram	Charging voltage	Residual voltage	Discharge current	Current waveshape
No.	kV	kV	kA	µs
20	81 x 2	28,4	94,0	4,5/9,6 µs opposite polarity 6 %

U_r' voltage application

Oscillogram	Time	Voltage	Current	Current	Power
No.	s	kV	+ mA$_{cr}$	- mA$_{cr}$	W
21	0	6,19	31,0	50,0	---
22	10		22,0	32,0	---

U_r' voltage application

Oscillogram	Time	Voltage	Current	Current	Power
No.	min	kV	+ mA$_{cr}$	- mA$_{cr}$	W
23	0	5,26	4,60	7,60	11,3
	5		1,64	2,6	3,7
	10		1,54	1,88	2,84
24	15		1,53	1,68	2,55
	20		1,54	1,54	2,36
	25		1,51	1,51	2,17
25	30		1,50	1,50	2,10

continued

ВЯРНО С ОРИГИНАЛА

397

Continued

Sample No.: OD2

Preheating temperature: 60 °C

Date: December 01, 2005

Second high current impulse application

Oscillogram	Charging voltage	Residual voltage	Discharge current	Current waveshape
No.	kV	kV	kA	µs
26	83 x 2	28,0	97	4,5/9,6 µs opposite polarity 6 %

U_r' voltage application

Oscillogram	Time	Voltage	Current	Current	Power
No.	s	kV	+ mA$_{cr}$	- mA$_{cr}$	W
27	0	6,18	35	84	—
28	10		23	34	—

U_c' voltage application

Oscillogram	Time	Voltage	Current	Current	Power
No.	min	kV	+ mA$_{cr}$	- mA$_{cr}$	W
29	0	5,25	5,10	8,40	12,50
	5		1,72	2,77	3,86
	10		1,59	2,31	3,28
30	15		1,56	2,11	2,98
	20		1,55	1,93	2,58
	25		1,52	1,75	2,46
31	30		1,50	1,60	2,38

continued

Continued

Sample No.: OD3

Preheating temperature: 61 °C

Date: December 01, 2005

Second high current impulse application

Oscillogram	Charging voltage	Residual voltage	Discharge current	Current waveshape
No.	kV	kV	kA	µs
32	83 x 2	29,5	97,0	4,5/9,6 µs opposite polarity 6 %

U_c' voltage application

Oscillogram	Time	Voltage	Current	Current	Power
No.	s	kV	+ mA_{cr}	- mA_{cr}	W
33	0	6,16	30,0	48,0	—
34	10		20,0	31,0	—

U_c' voltage application

Oscillogram	Time	Voltage	Current	Current	Power
No.	min	kV	+ mA_{cr}	- mA_{cr}	W
35	1	5,23	4,9	7,5	11,7
	5		1,61	2,06	3,15
	10		1,57	1,8	2,52
36	15		1,34	1,47	2,21
	20		1,31	1,43	1,96
	25		1,25	1,30	1,81
37	30		1,20	1,30	1,74

continued

ВЯРНО С ОРИГИНАЛА

High current impulse operating duty test. IEC 60099-4 Standard

Lightning impulse residual voltage measurement after the test

Test circuit: A0120

Date: December 2, 2005

Sample	Requested current	Charging voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage
No.		kV	No.	µs	kA	kV
OD1	I_N	30,0	38	8,6/18,6	10,14	15,81
		30,0	39		10,16	15,87
OD2		30,0	40		10,18	15,96
		30,0	41		10,15	15,95
OD3		30,0	42		10,16	15,89
		30,0	43		10,15	15,92

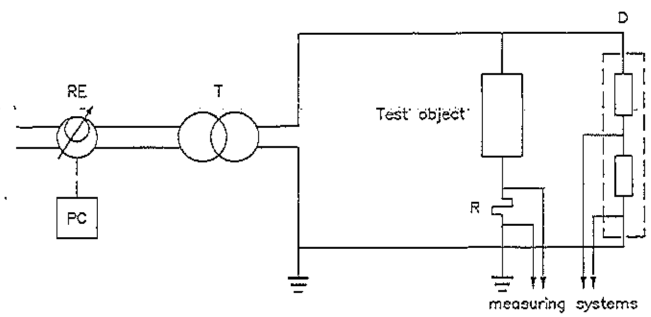
	Oscilloscope settings		
	sampling division	input	attenuation
	µs	V_{div}	
Current	5,0	0,5	50:5
Voltage	5,0	1,0	20:5

Notes:

ВЯРНО С ОРИГИНАЛА

400

Circuit A0019



Power frequency supply

RE - programmable supply type LARCET A.C. Power Source 5000 P.S.; CESI no. 23702-32191
PC - personal computer
T - voltage transformer type SPECIALTRASFO; power 30 kVA; voltage 200 V/15-30 kV

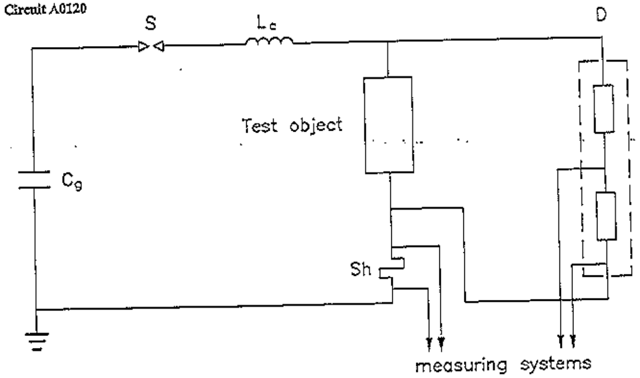
Current measuring system
R - Current shunt CESI N°.31120; R=941,4 Ω
- Electro optical system CESI N°.--; attenuation 5:5
OSC - Oscilloscope type SONY TEKTRONIX RTD 710; CESI N°. 6318

Voltage measuring system
D - Voltage divider SAGI; CESI N°.11120
- Electro optical system CESI N°.11520/11524; attenuation 5:5
OSC - Oscilloscope type SONY TEKTRONIX RTD 710; CESI N°.6318

ВЯРНО С ОРИГИНАЛА

401

Circuit A0120



Impulse generator

No. of stages	2
Cg	2,49 µF
Lc	18 µH
S	- Spark-gap

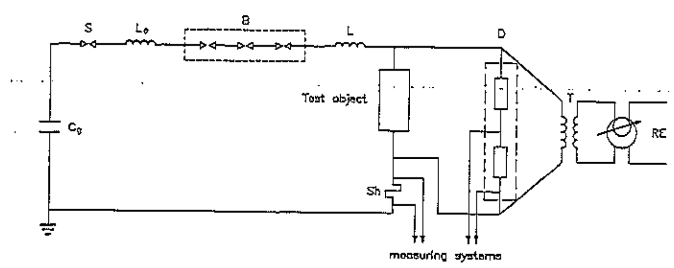
Voltage measuring system.

D	- Voltage divider SAGI; CESI No.13027
	- Electro optical system CESI No. 11521/522
OSC	- Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.2)

Current measuring system

Sh	- Current shunt CESI No.6042; R= 2 mΩ ; peak current= 250 kA
	- Electro optical system CESI No. 11517/518
OSC	- Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.1)

Circuit A0015



Impulse generator

No. of stages: 1
C_g - Capacitor 4,98 µF
L - Inductance of the circuit
L_e - Inductor 10 µH
S - Spark gap
Resistor blocks has been added
Power frequency supply
RE - Regulator type specialtrasfo; power 20 kVA; voltage 380 V/ 220 V
T - Transformer type Pivi; power 30 kVA; voltage 220 V/ 15 kV
B - Blocking gap

Current measuring system
Sh_1 - Current shunt CESI No.6042; R = 0,002 Ω
- Electro optical system CESI No.11517/11518; attenuation 20:5
OSC - Oscilloscope type Tektronix 540A; CESI No.13217 (on channel No.1)

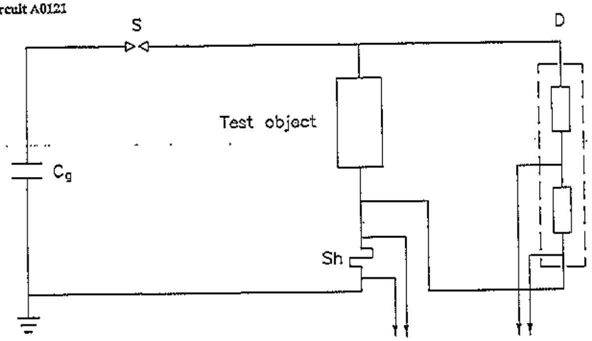
Voltage measuring system
D - Voltage divider SAGI ; CESI No.1120; k = 1010
- Electro optical system CESI No.11520/11521; attenuation 50:5
OSC - Oscilloscope type Tektronix 540A; CESI No.13217 (on channel No.2)

A0015IG

ВЯРНО С ОРИГИНАЛА

403

Circuit A0121



Impulse generator

No. of stages 2
Cg 3,32 µF

S - Spark-gap

Voltage measuring system.
D - Voltage divider (not used)

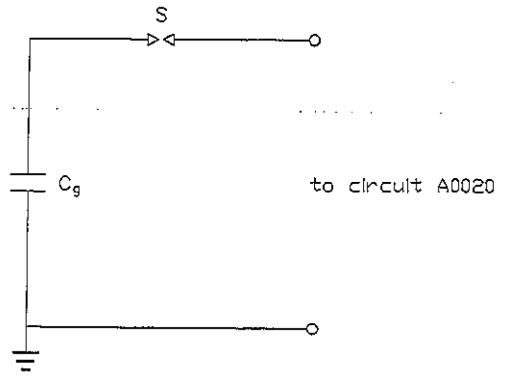
Current measuring system
Sh - Current shunt CESI No.6042; R= 2 mΩ ; peak current= 250 kA
- Electro optical system CESI No11521/522
OSC - Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.1)

A01211O

ВЯРНО С ОРИГИНАЛА

404

Circuit A0123



Impulse generator circuit

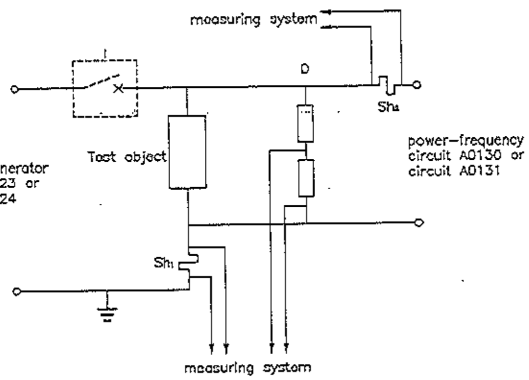
No. of stages 2
C_g 3,32 µF

S - spark-gap

A01231O

405

Circuit A0020



Impulse generator circuit A0124

I - Circuit-breaker

Impulsive current measuring system

Sh_1 - Current shunt CESI No.60,42; R= 2 mΩ
- Electro optical system CESI No.11517/518; attenuation 300:5

OSC_1 - Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.1)

Power frequency circuit A0130

Voltage measuring system.

D - Voltage divider SAGI; CESI No.13027
- Electro optical system CESI No.8009/8015; attenuation 50:5

OSC_1 - Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.2)

OSC_2 - Oscilloscope type SONY TEKTRONIX RTD 710A; CESI No.9090 (on channel No.2)

Power frequency current measuring system

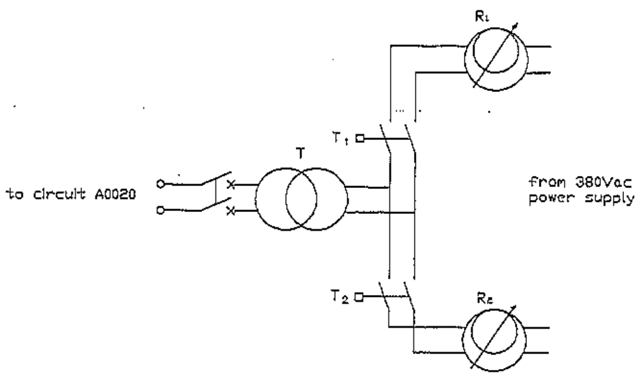
Sh_2 - Current shunt CESI R= 500 Ω - Electro optical system CESI No.8011/8017; attenuation 300:5 – 5:5

OSC_2 - Oscilloscope type TEKTRONIX TDS 744A; CESI No.13937 (on channel No.1)

A00201G

ВЯРНО С ОРИГИНАЛА
406

Circuit A0131

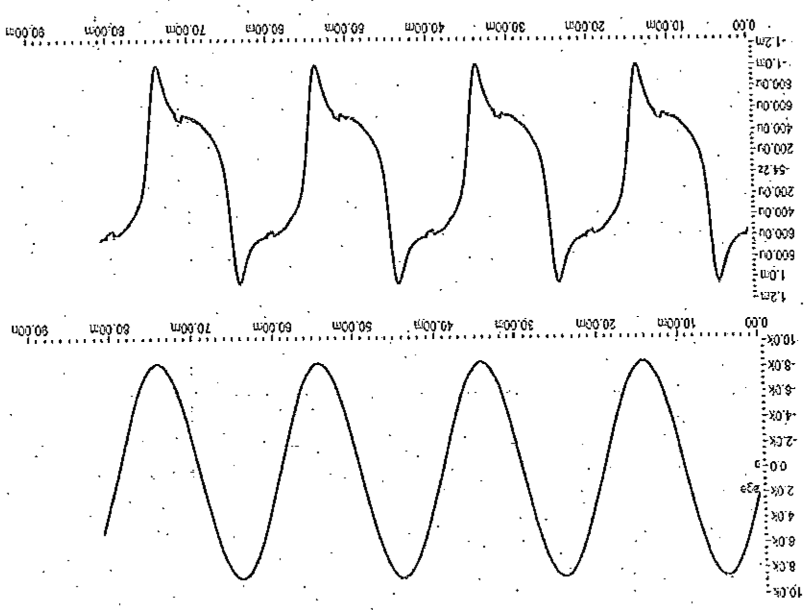


Power-frequency circuit

from 380Vac power supply
R_1 single-phase voltage regulator CORMES; power 20 kVA; voltage 380/04220 Vac
R_2 single-phase voltage regulator CORMES; power 10 kVA; voltage 380/04220 Vac
T_1 voltage transformer type SPECIALTRASFO; power 30 kVA; voltage 200-400 V/15-30 kV

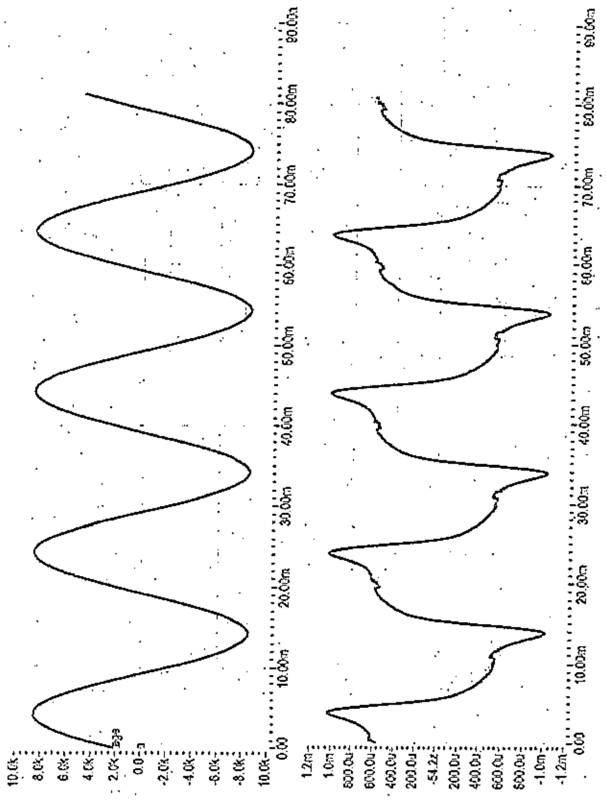
A0131JG

407



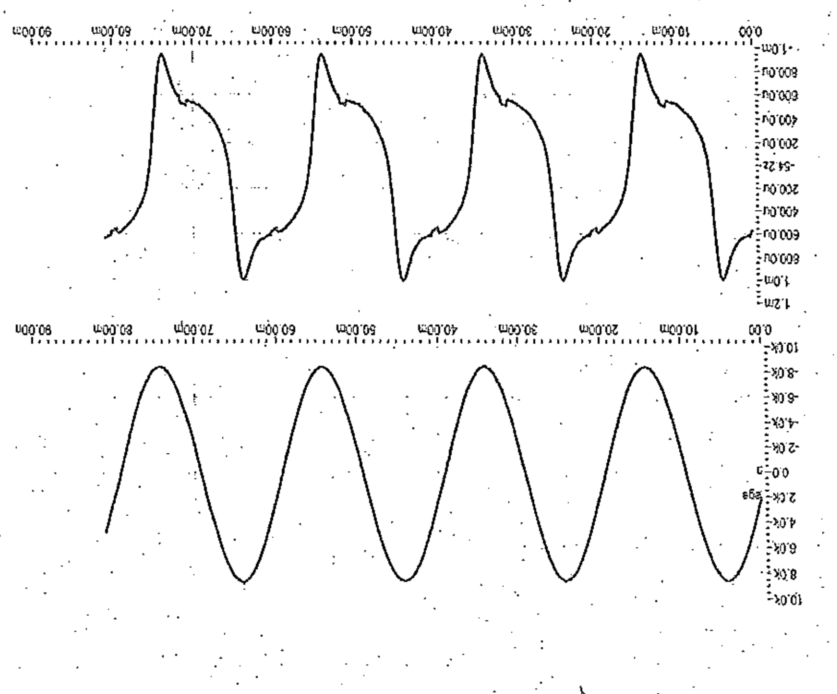
CESI PoC A5055428 Oscillogram n. 1

ВЯРНО С
ОРИГИНАЛ



CESI PoC A5055428 Oscillogram n. 2

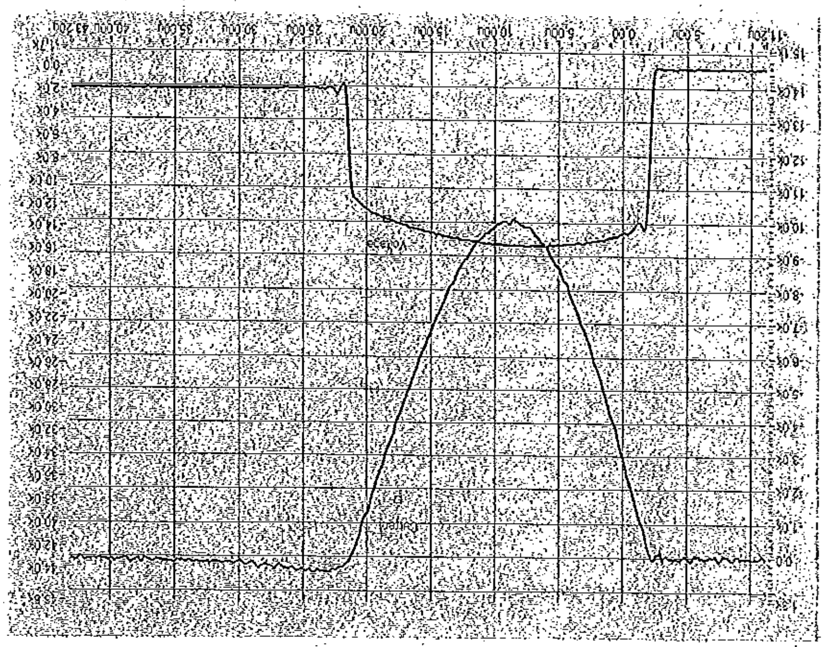
ВЯРНО С ОРИГИНАЛА



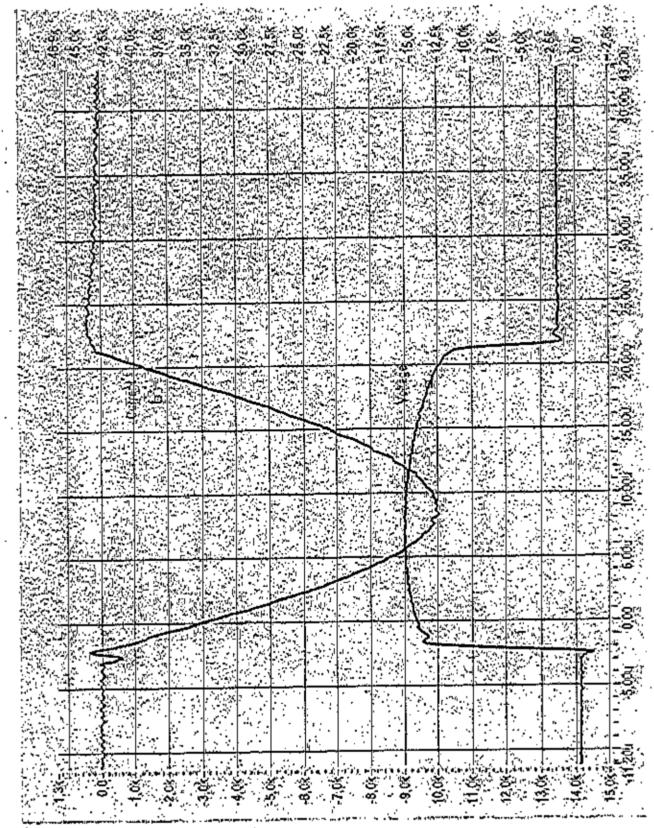
CESI-PeC A5055428 Oscillogram n. 3

ВЯРНО С ОРИГИНАЛА

ВЯРНО С ОРИГИНАЛА

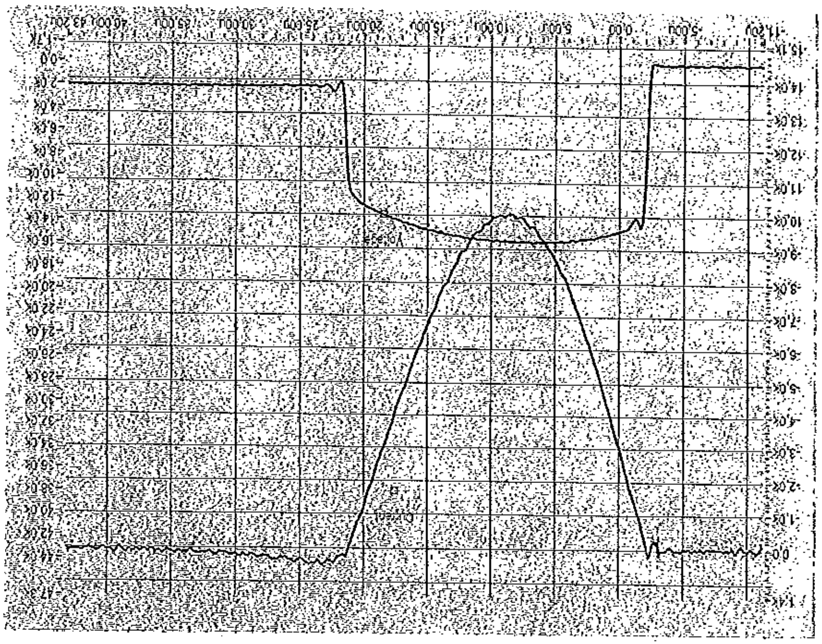


CESI PeC A5055428 Oscillogram n. 4

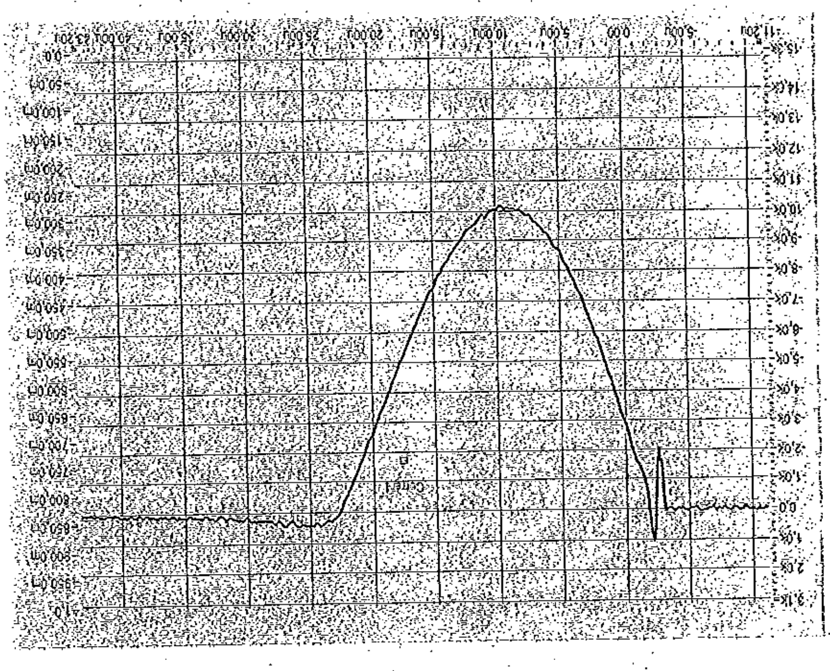


CESI PoC A5055428 Oscillogram n. 5

ВЯРНО С
ОРИГИНАЛА



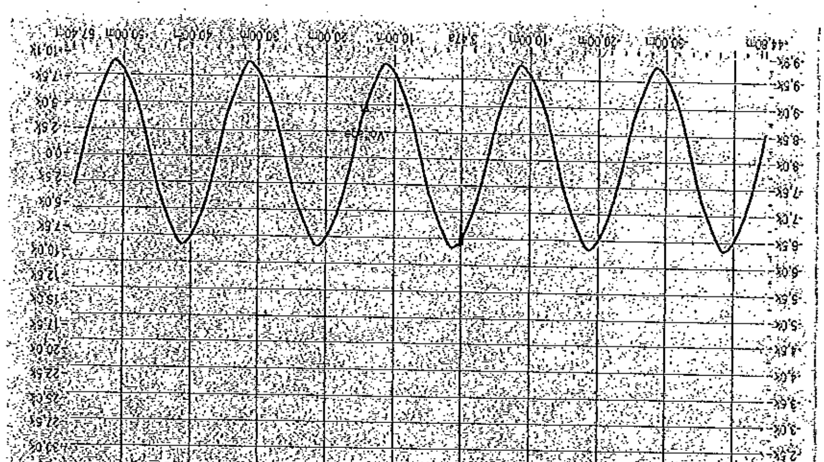
CESI PoC A5055428 Oscillogram n. 6



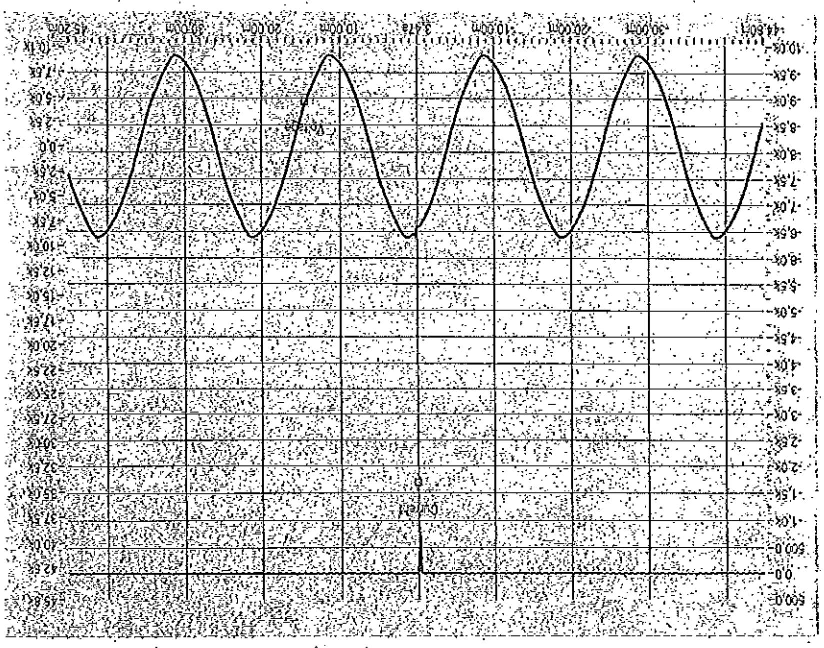
CESI PeC A5055428 Oscillogram n. 7

ВЯРНО С ОРИГИНАЛА

ВЯРНО С ОРИГИНАЛА



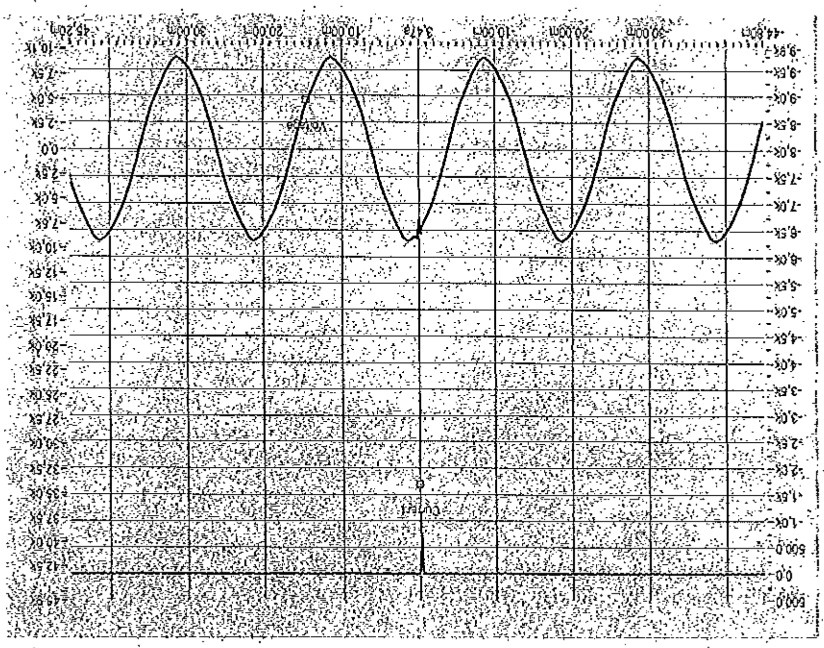
CESI PoC A5055428 Oscillogram n. 8



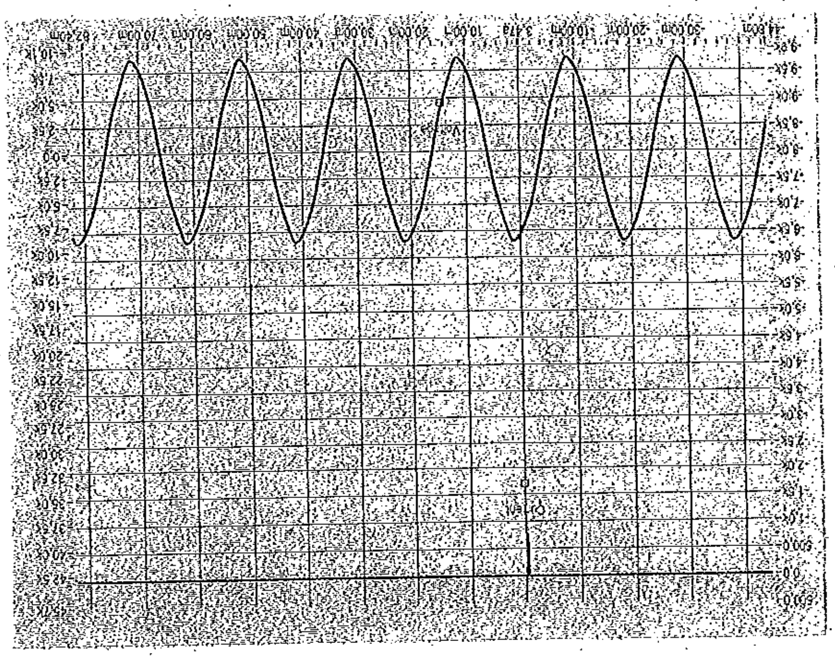
CESI PoC A5055428 Oscillogram n. 9

ВЯРНО С
ОРИГИНАЛА

ВЯРНО С
ОРИГИНАЛА

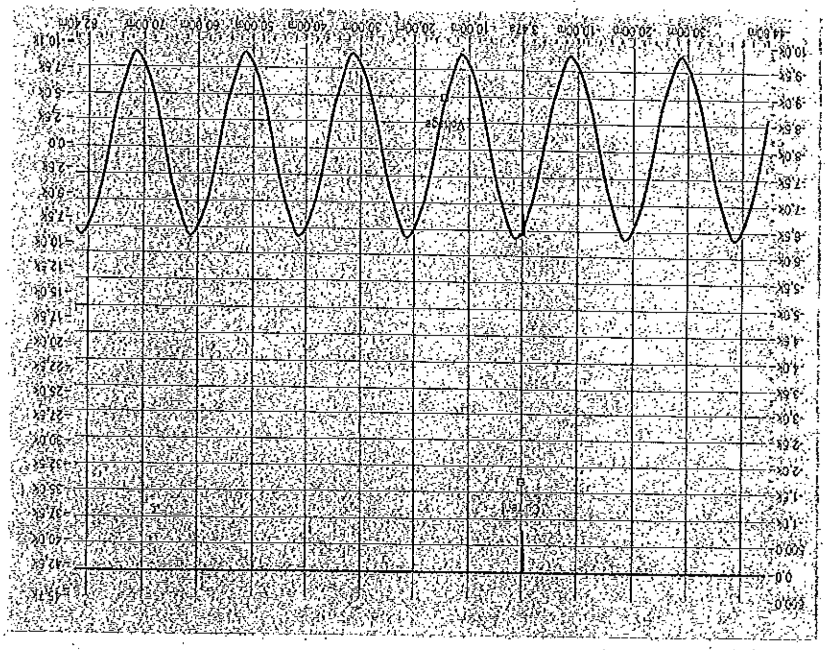


CESI PcC A5055428 Oscillogram n. 10

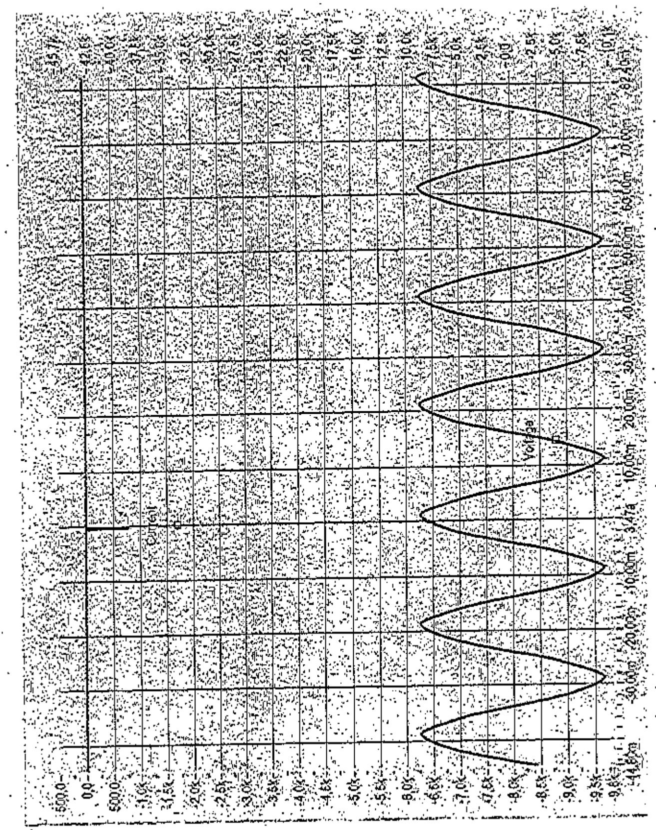


CESI PoC A5055428 Oscillogram n. 11

ВЯРНО С ОРИГИНАЛА

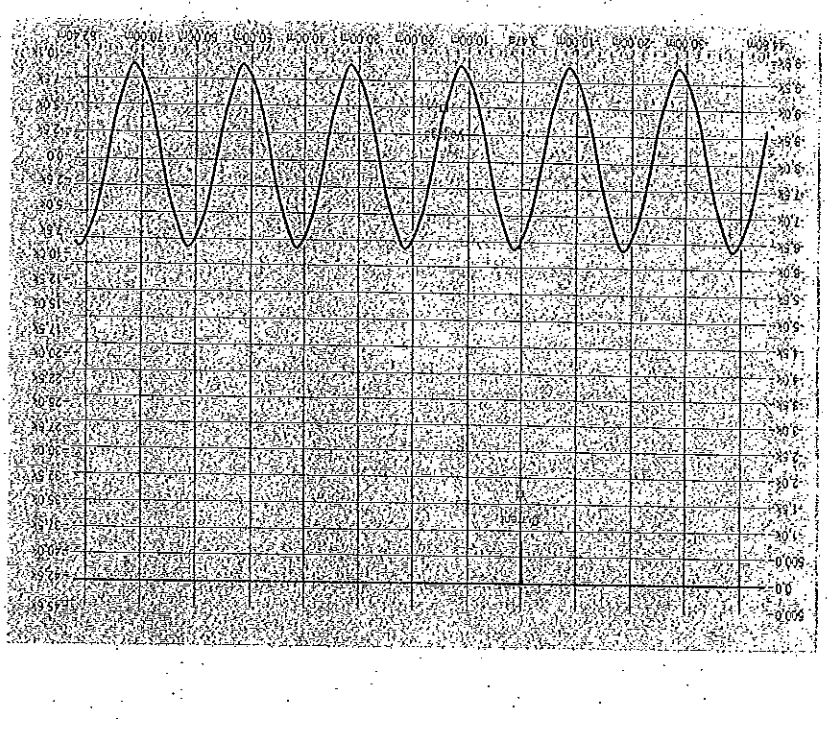


CESI PoC A5055428 Oscillogram n. 12

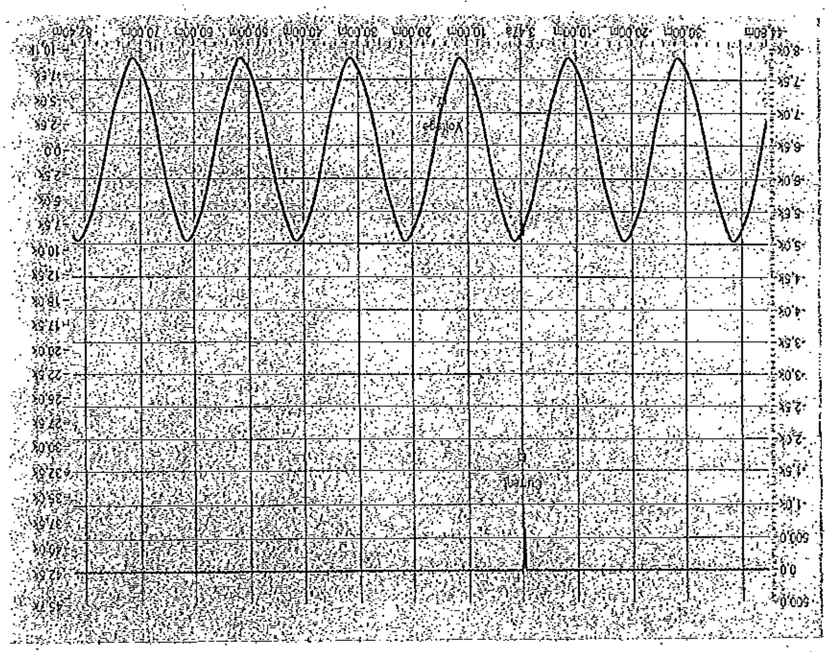


CESI PoC A5055428 Oscillogram n. 13

" ВЯРНО С "
ОРИГИНАЛА

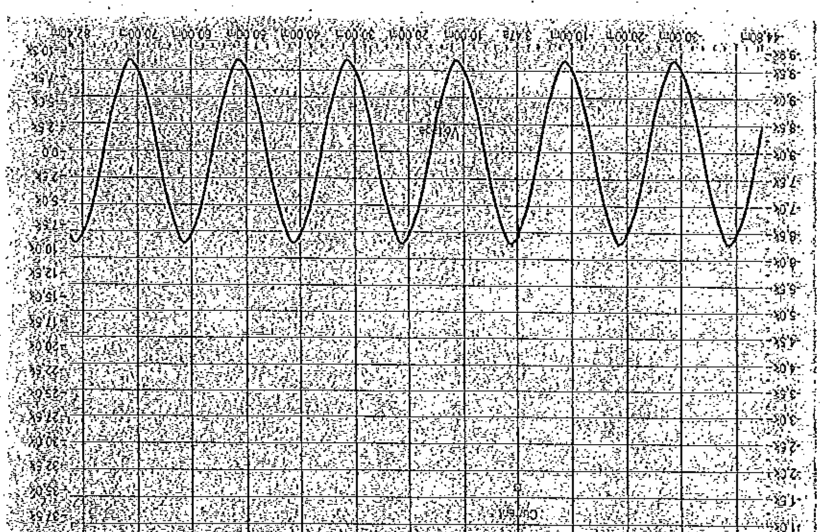


CESI PoC A5055428 Oscillogram n. 14

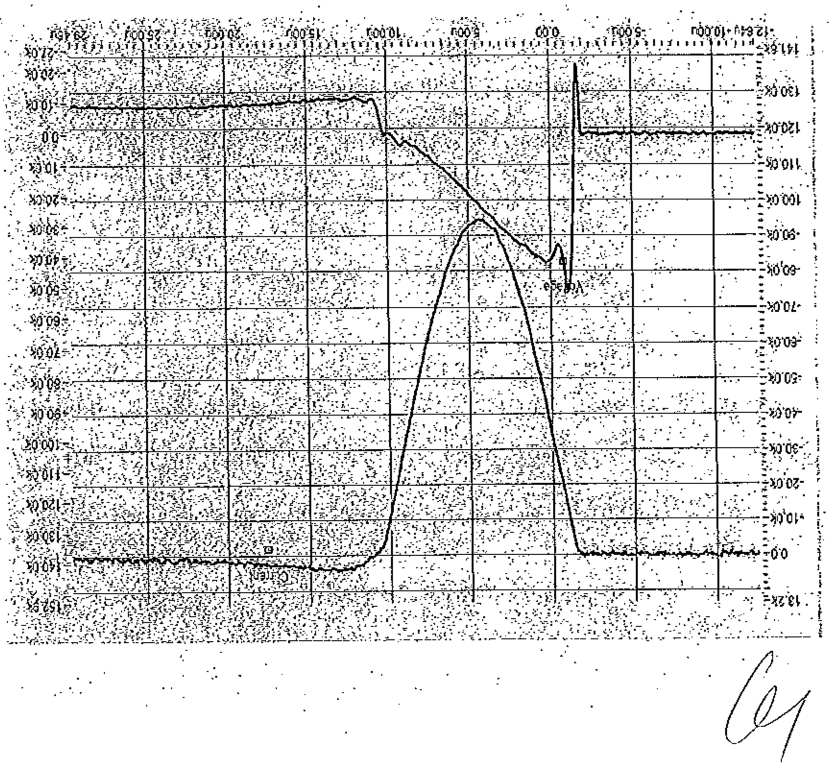


CESI PoC A5055428 Oscillogram n. 15

ВЯРНО С
ОРИГИНАЛА
422

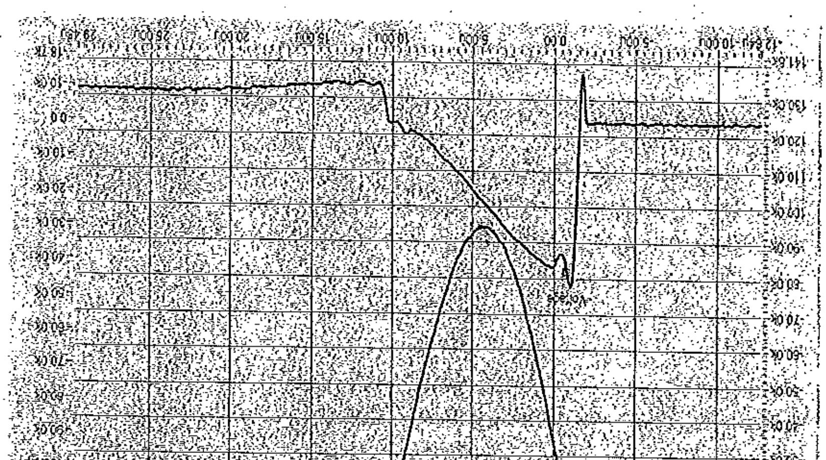


CESI PeC A5055428 Oscillogram n. 16

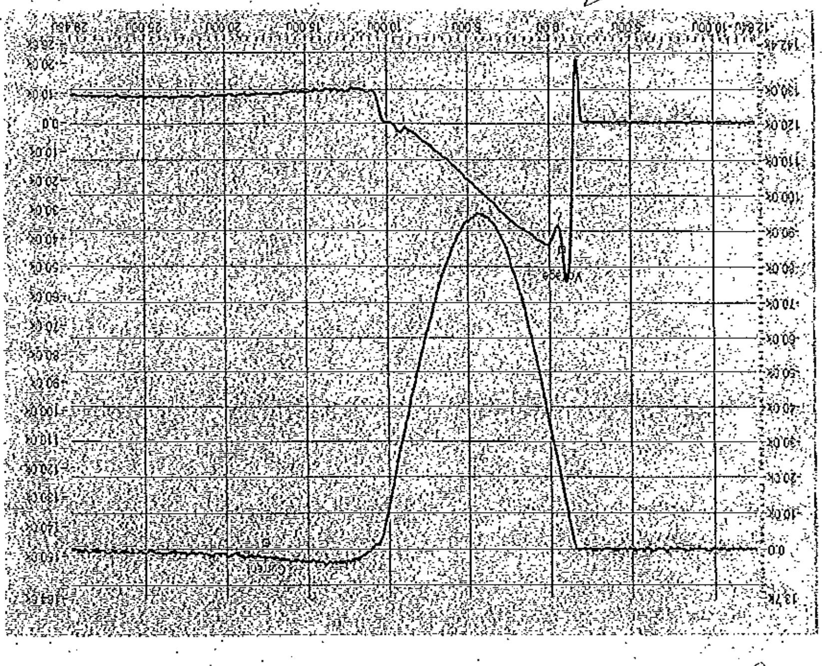


CESI PoC A5055428 Oscillogram n. 17

ВЯРНО С
ОРИГИНАЛА

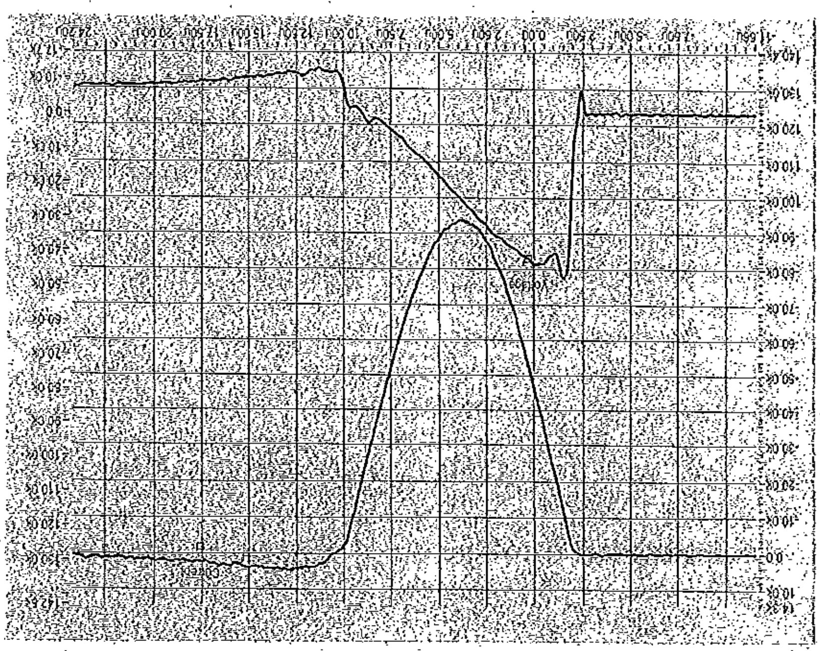


CESI PoC A5055428 Oscillogram n. 18

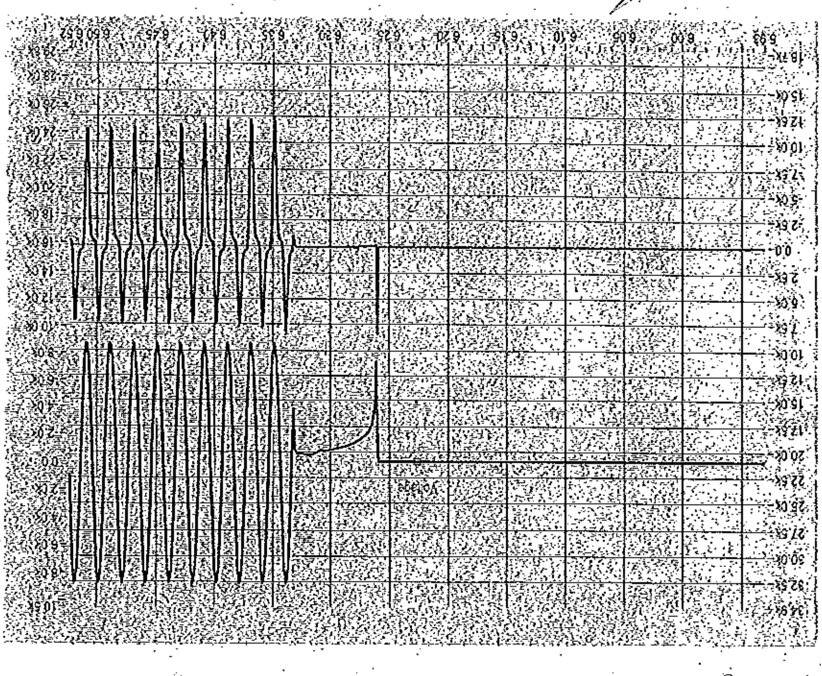


CESI PeC A5055428 Oscillogram n. 19

ВЯРНО С
ОРИГИНАЛА



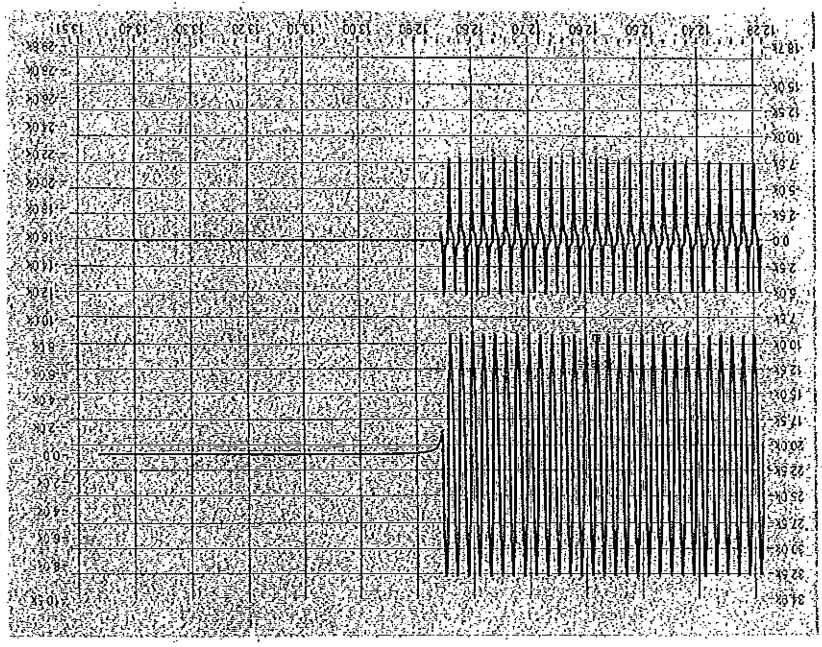
CESI PeC A5055428 Oscillogram n. 20



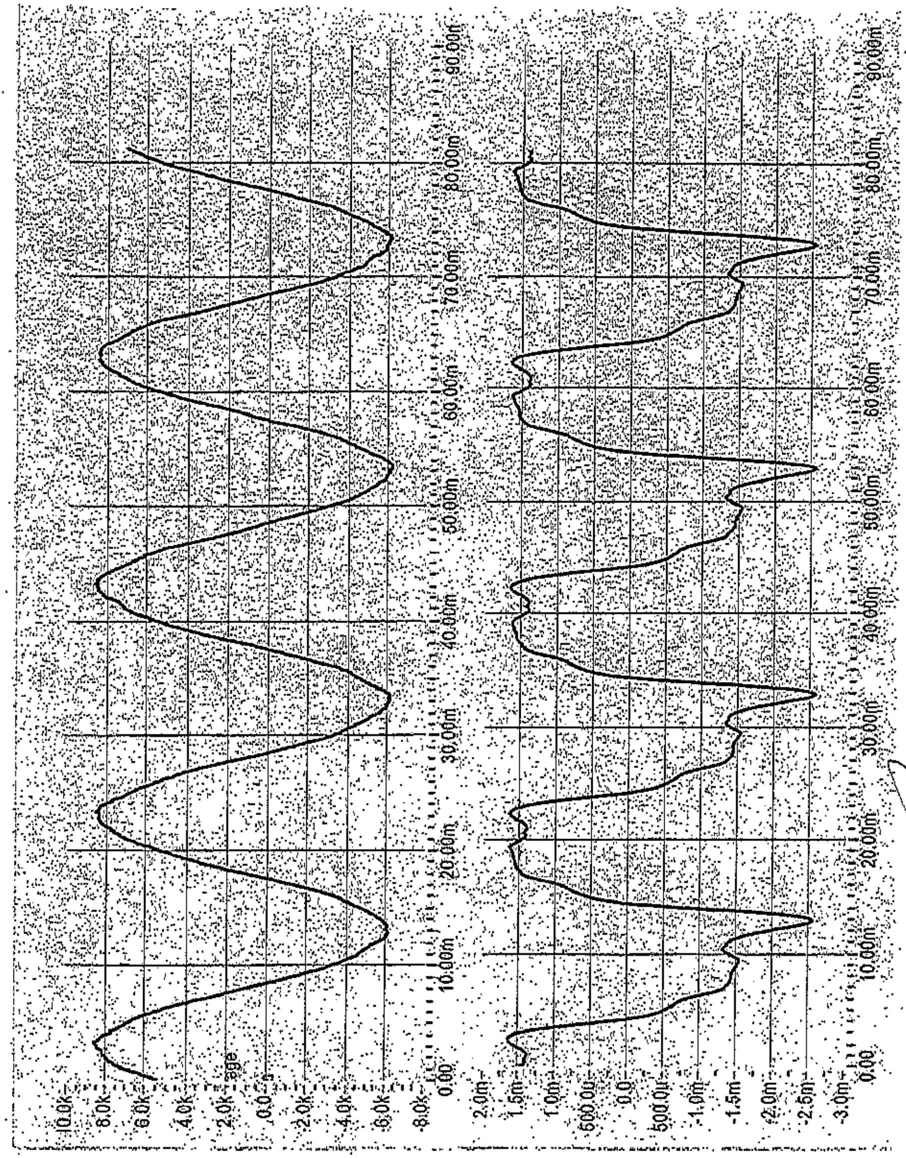
CESI PoC A5055428 Oscillogram n. 21

ВЯРНО С
ОРИГИНАЛА

ВЯРНО С
ОРИГИНАЛА



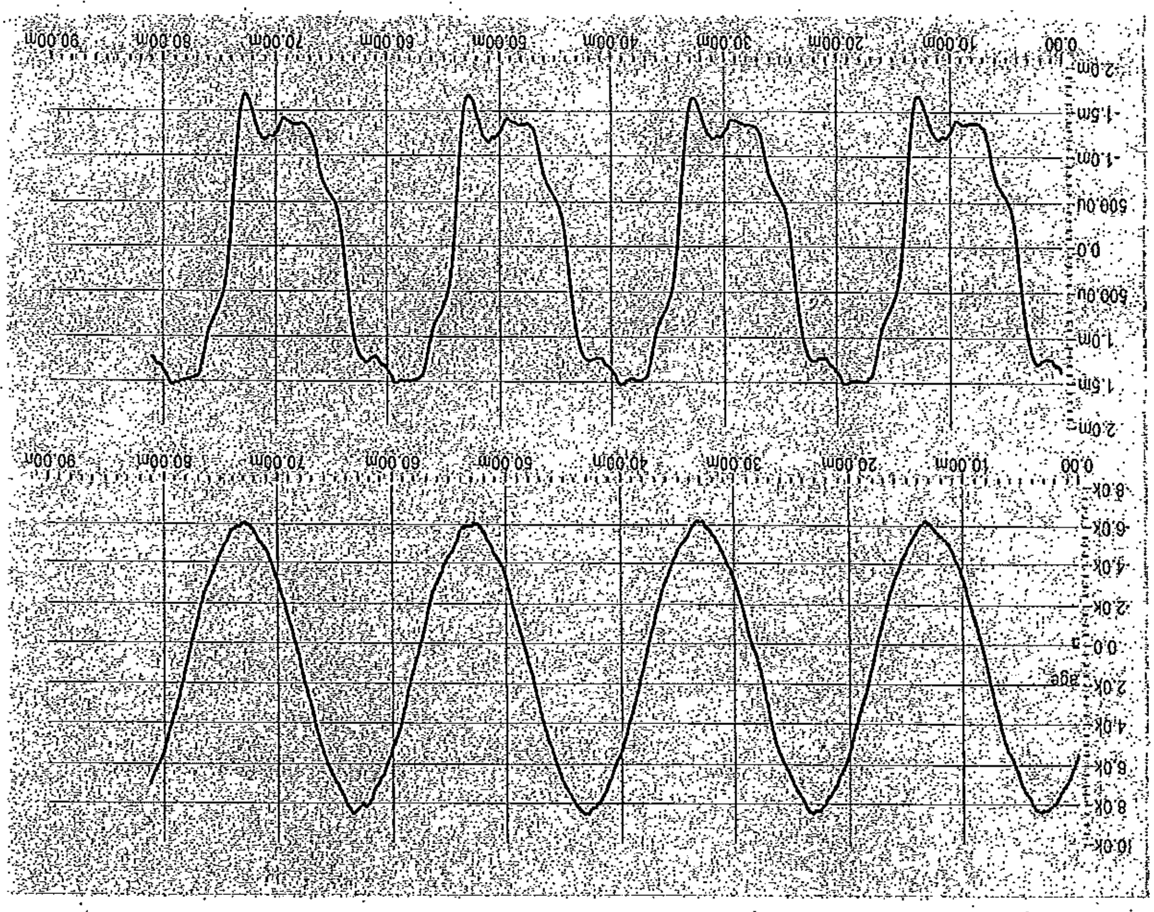
CESI PeC A5055428 Oscillogram n. 22



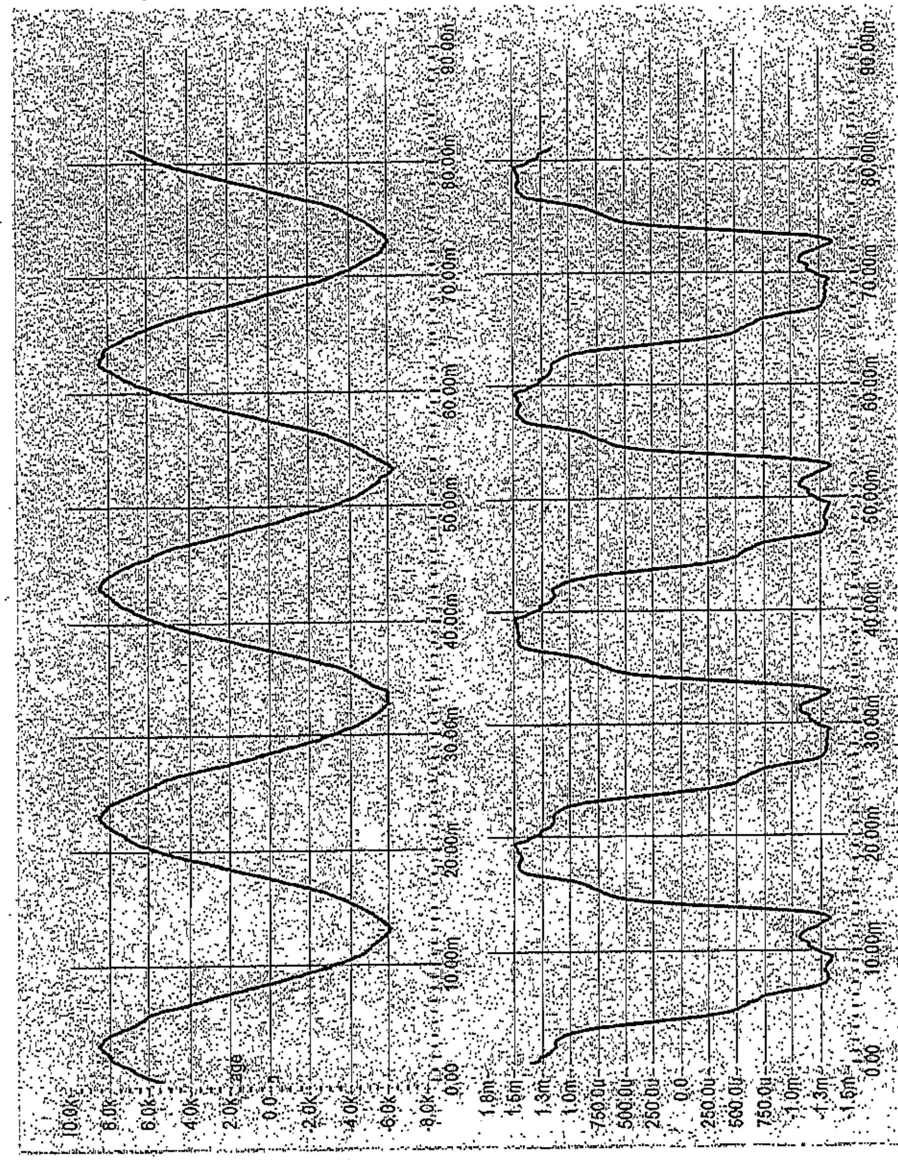
CESI PeC A5055428 Oscillogram n. 23

ВЯРНО С ОРИГИНАЛА

ВЯРНО С ОРИГИНАЛА

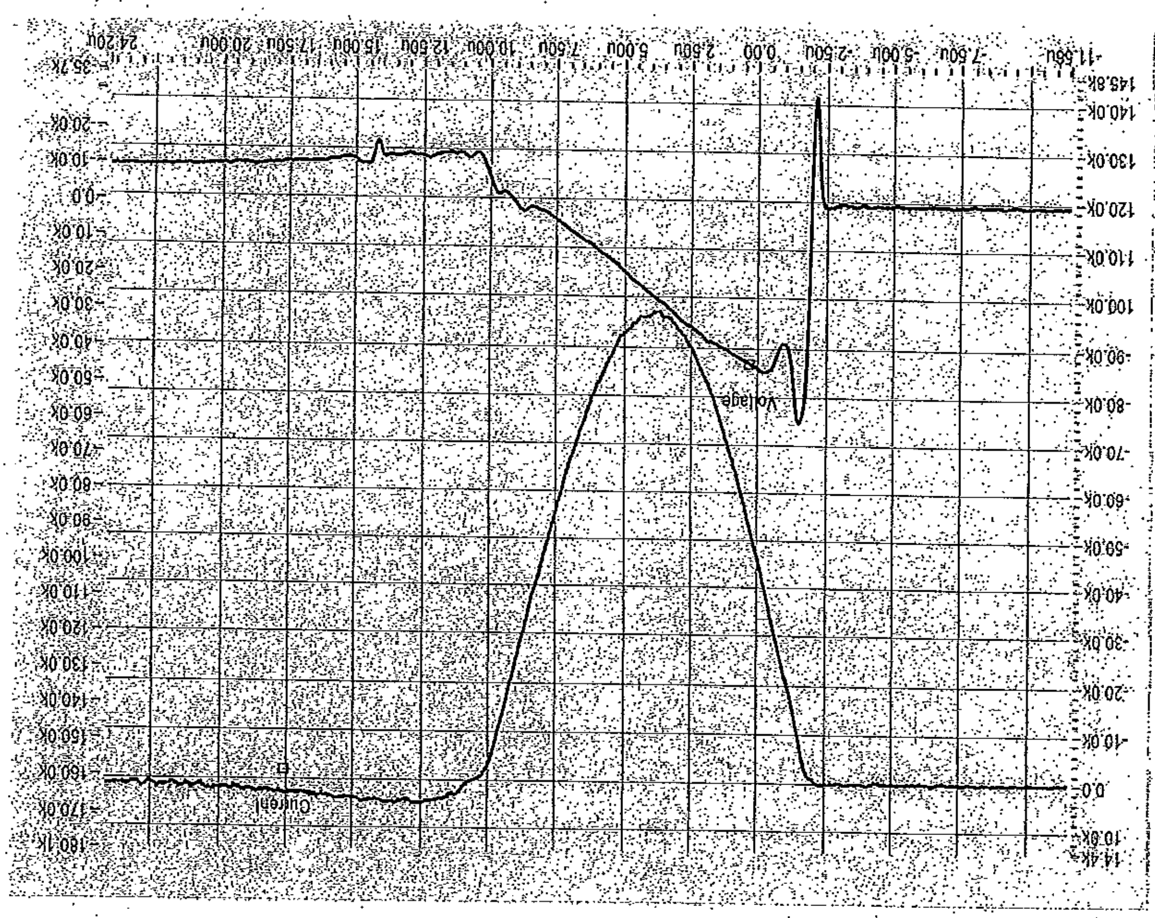


CESI PeC A5055428 Oscillogram n. 24

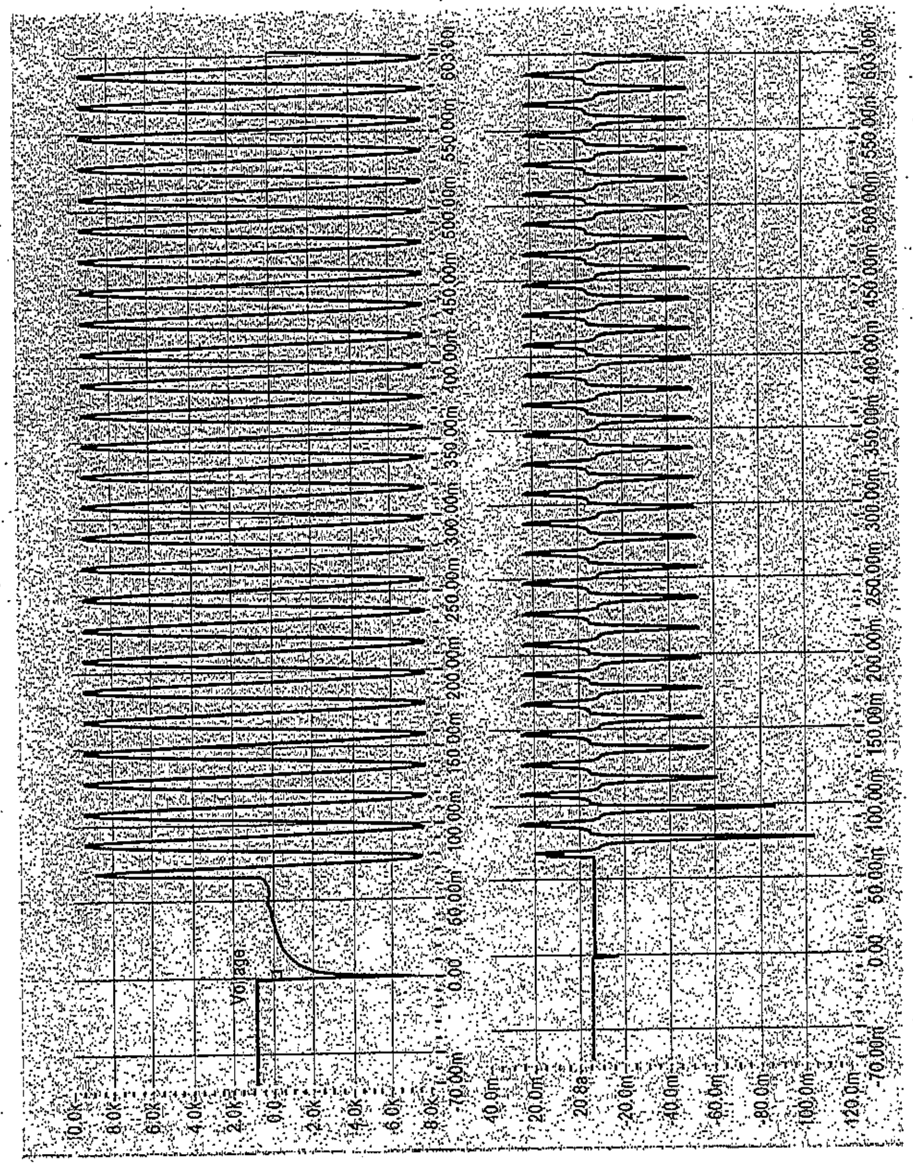


CESI PeC A5055428 Oscillogram n. 25

...РНО С
...ГИНАЛА

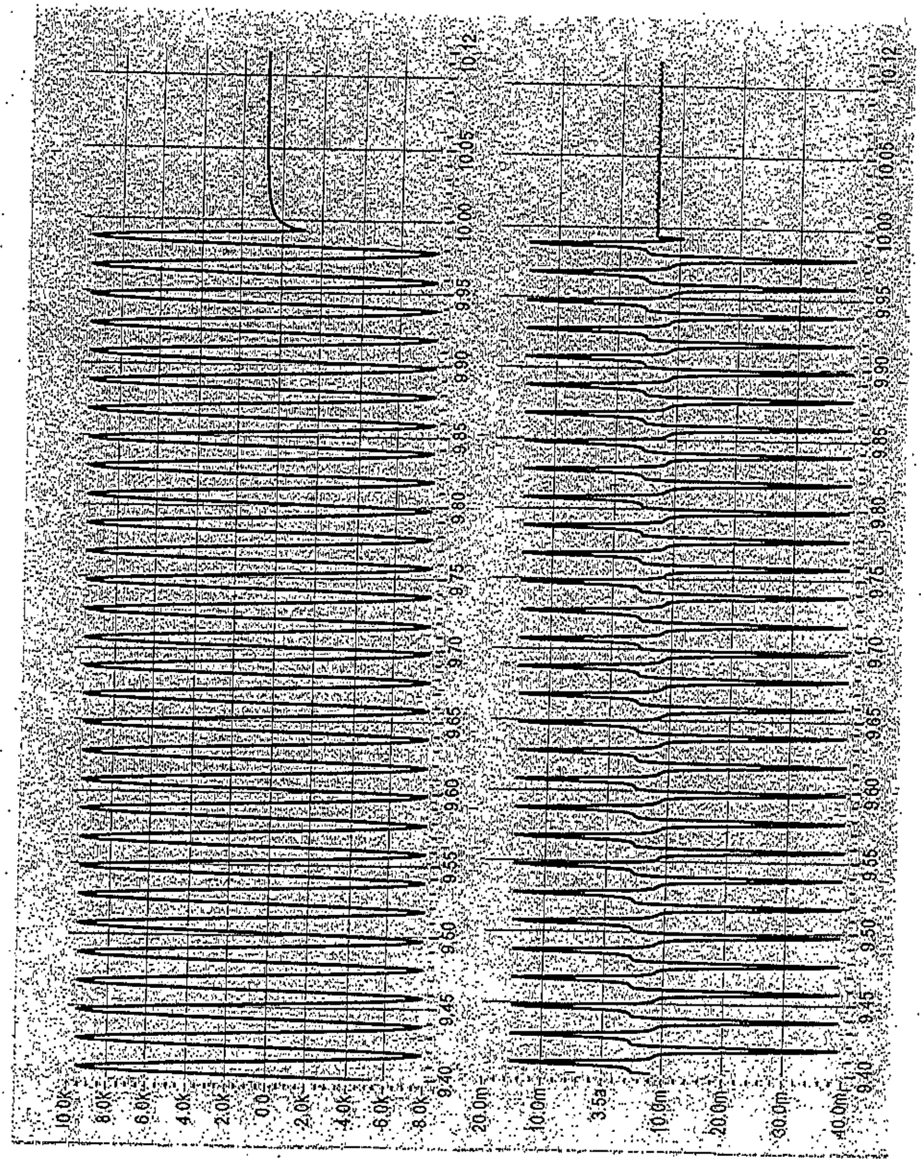


CESI PeC A5055428 Oscillogram n. 26

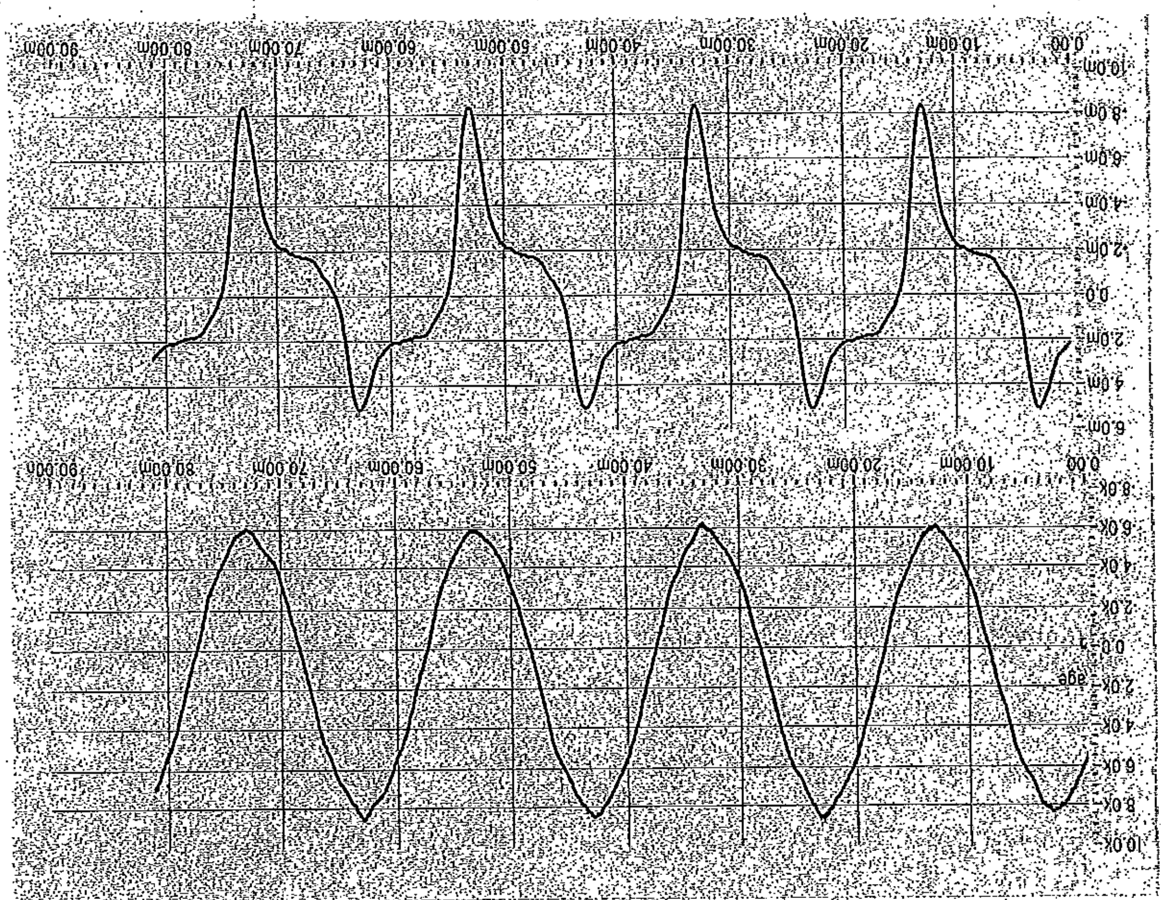


CESI PeC A5055428 Oscillogram n. 27

ВЯРНО С
ОРИГИНАЛА



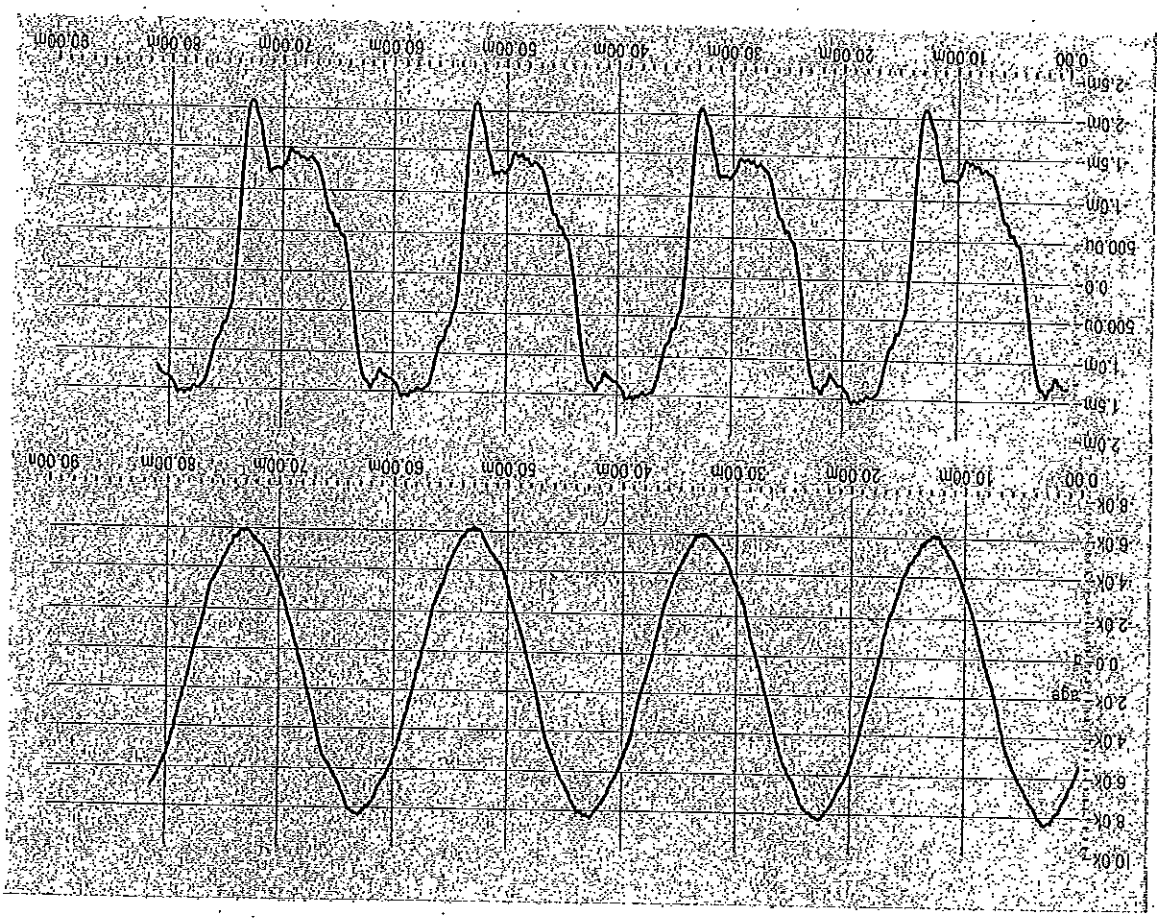
CESI PeC A5055428 Oscillogram n. 28



CESI PeC A5055428 Oscillogram n. 29

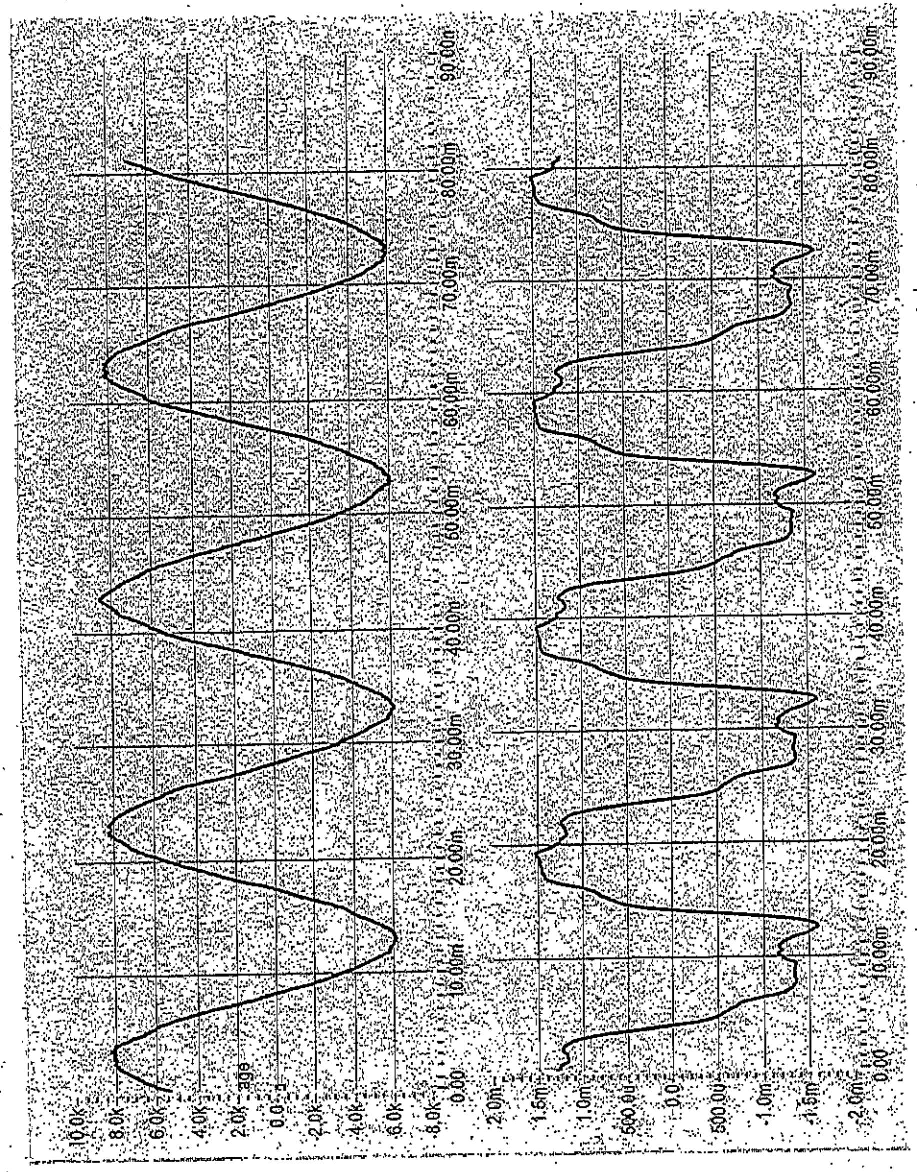
ВЯРНО С ОРИГИНАЛА

ВЯРНО С ОРИГИНАЛА



CESI PeC A5055428 Oscillogram n. 30

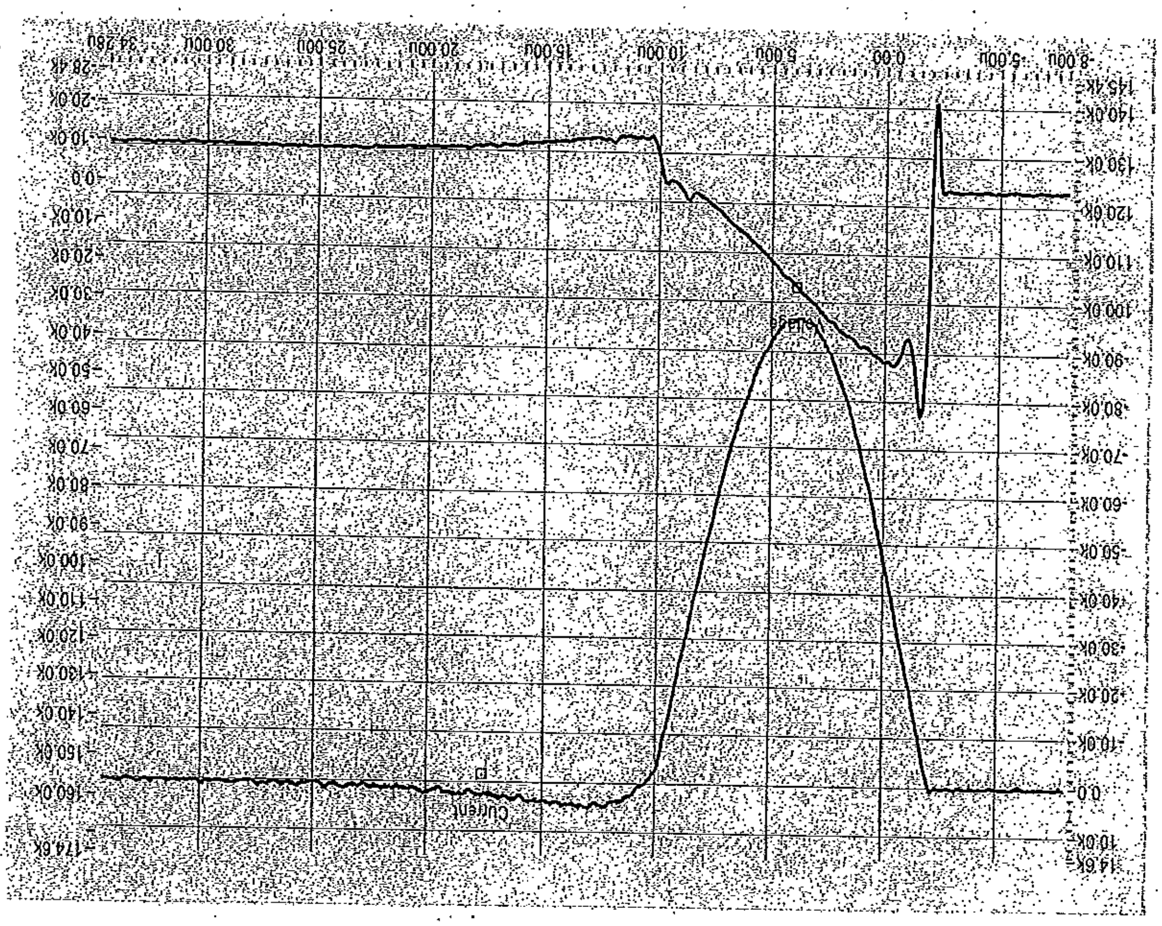
437



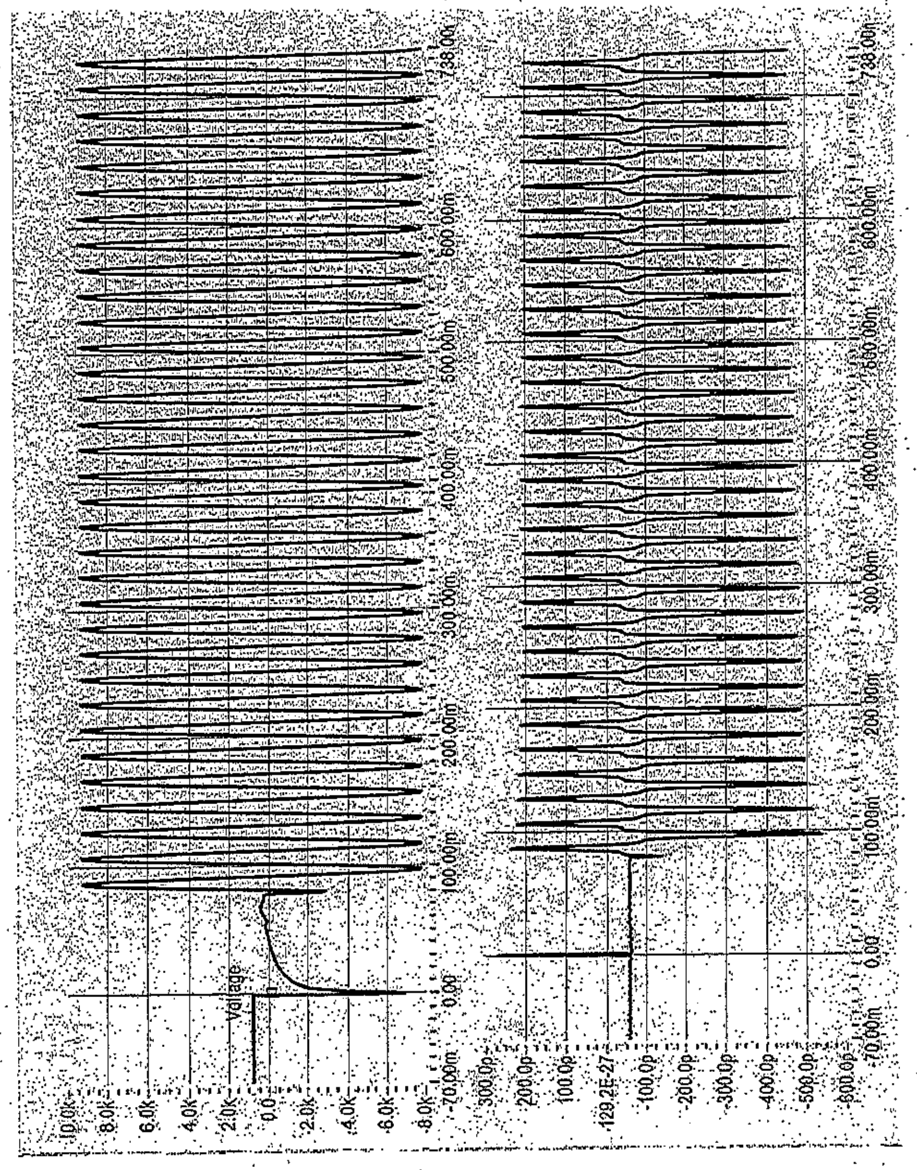
CESI PeC A5055428 Oscillogram n. 31

ВЯРНО С ОРИГИНАЛА

ВЯРНО С ОРИГИНАЛА



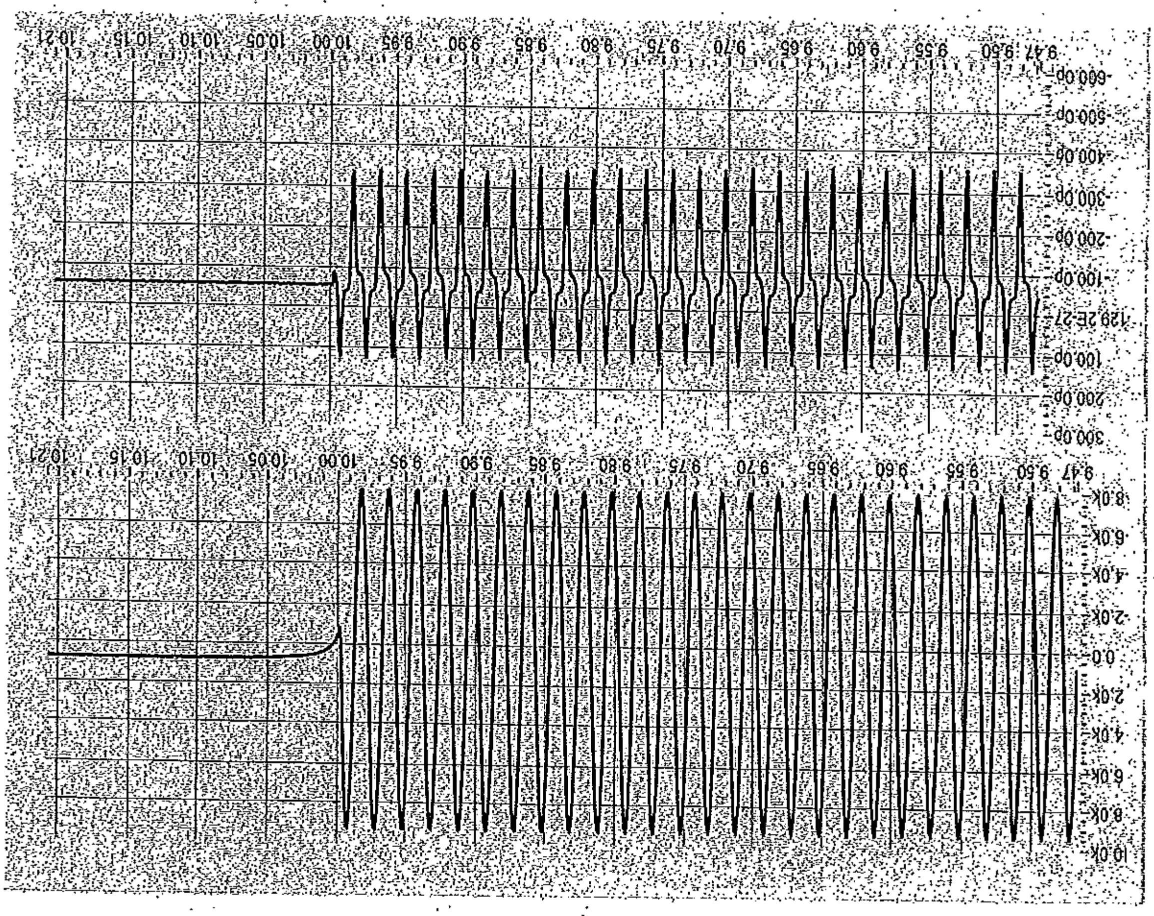
CESI PeC A5055428 Oscillogram n. 32



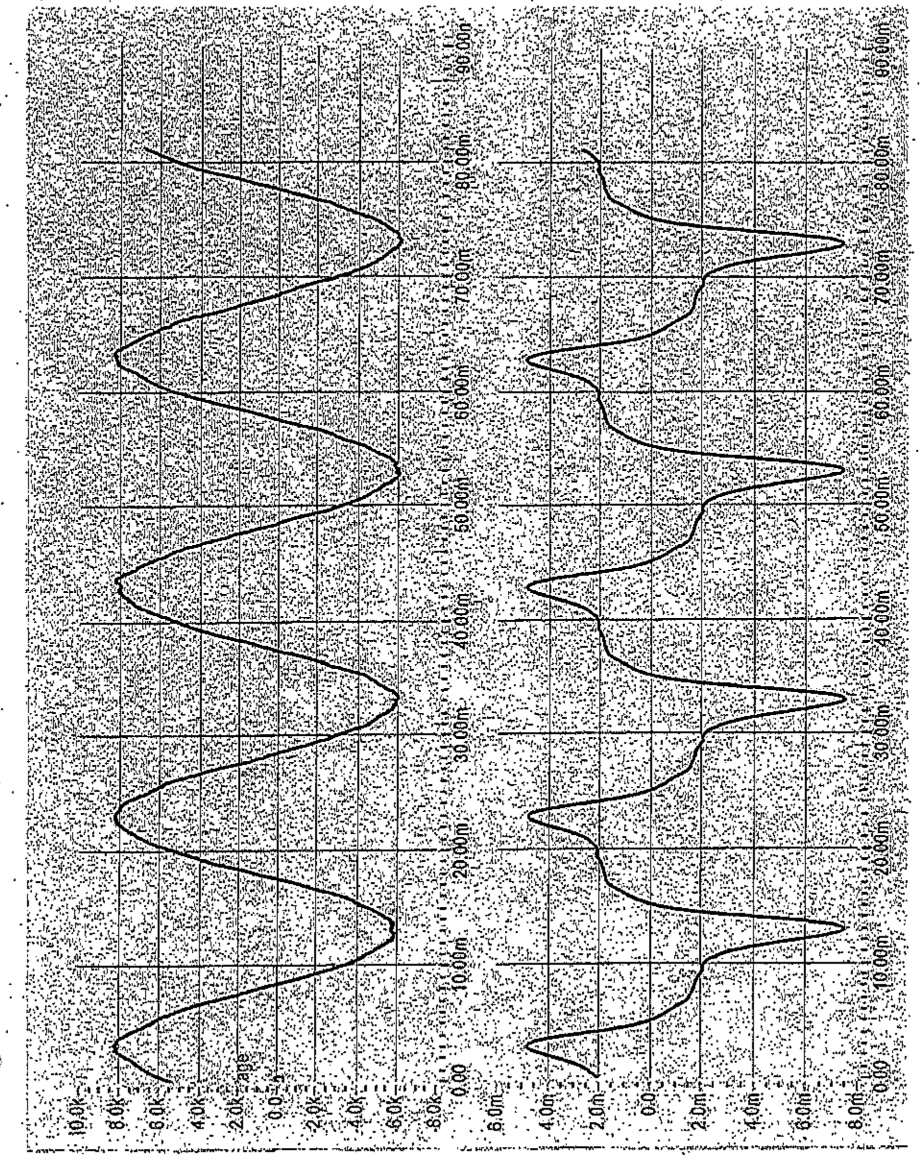
CESI PeC A5055428 Oscillogram n. 33

ВЯРНО С ОРИГИНАЛА

ВЯРНО С ОРИГИНАЛА

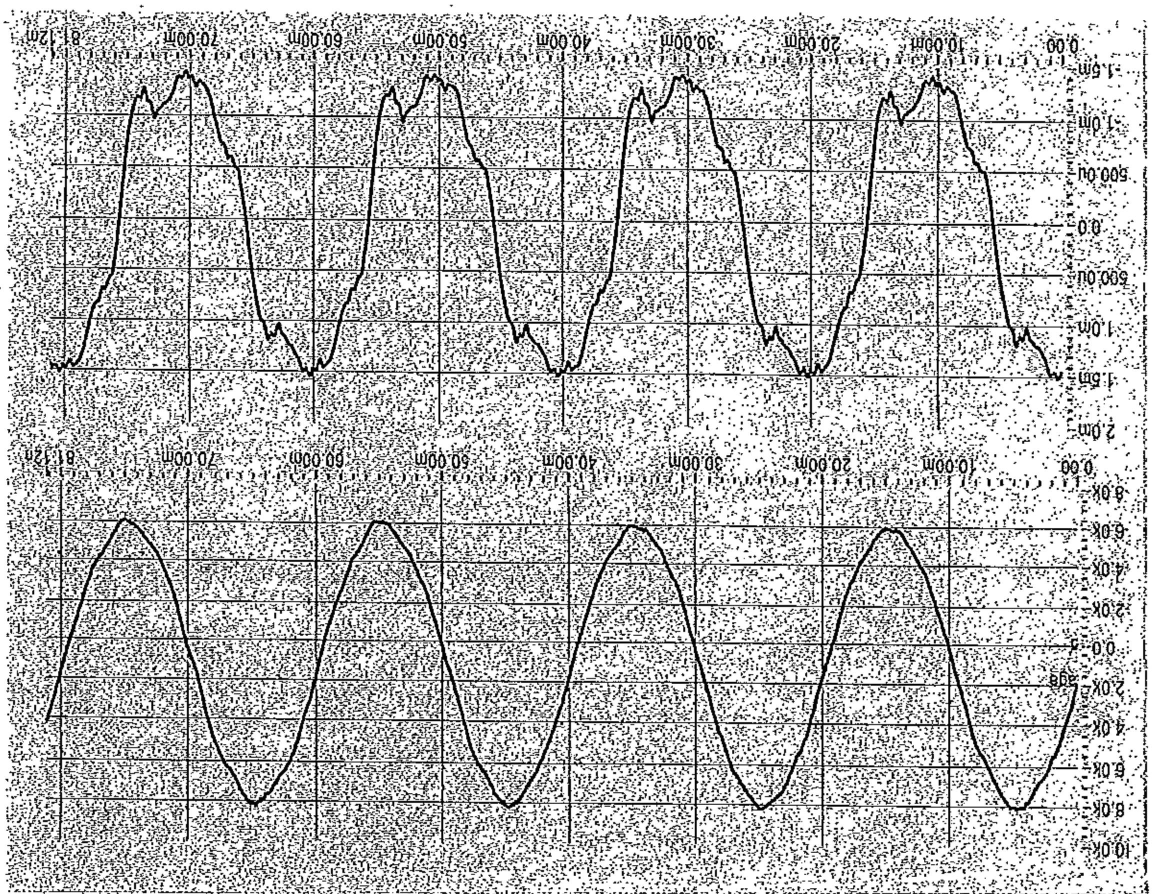


CESI PeC A5055428 Oscillogram n. 34

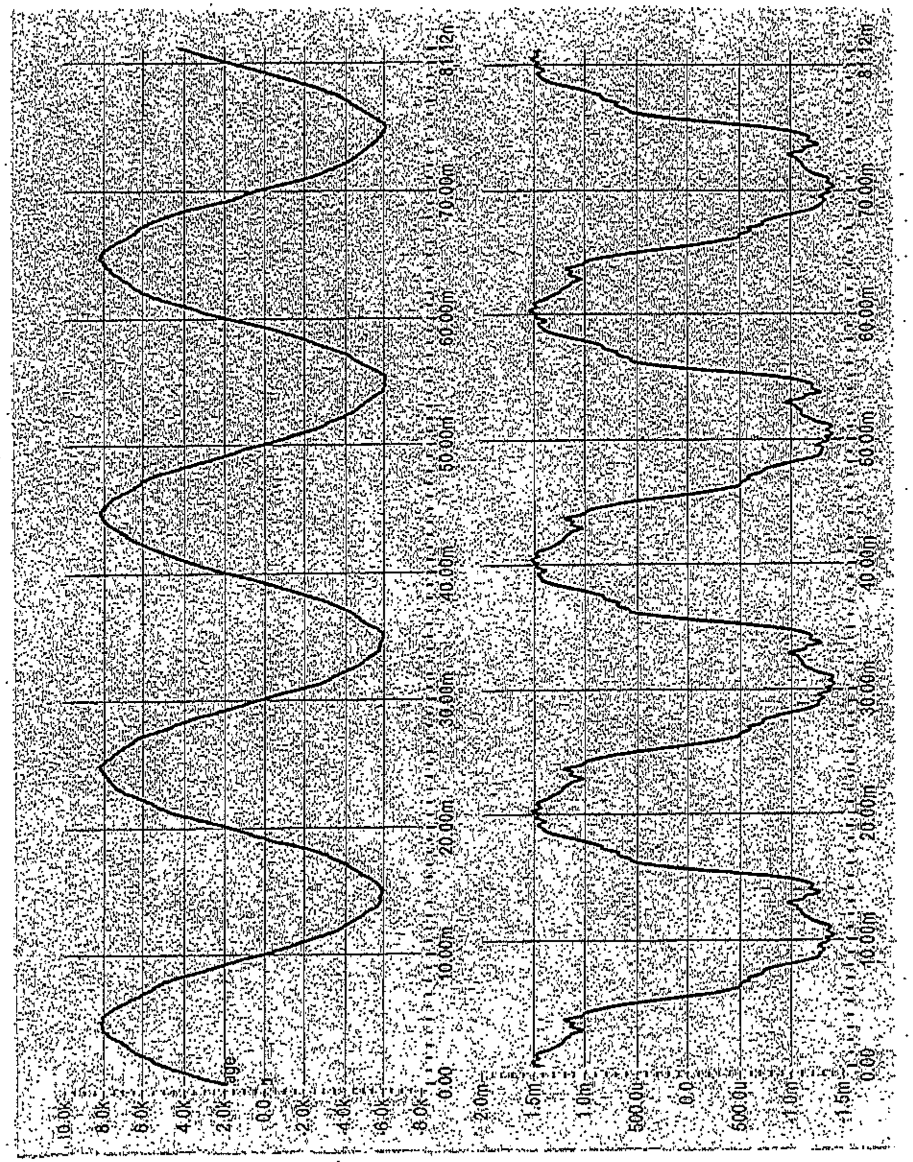


CESI PeC A5055428 Oscillogram n. 35

412



CESI PeC A5055428 Oscillogram n. 36

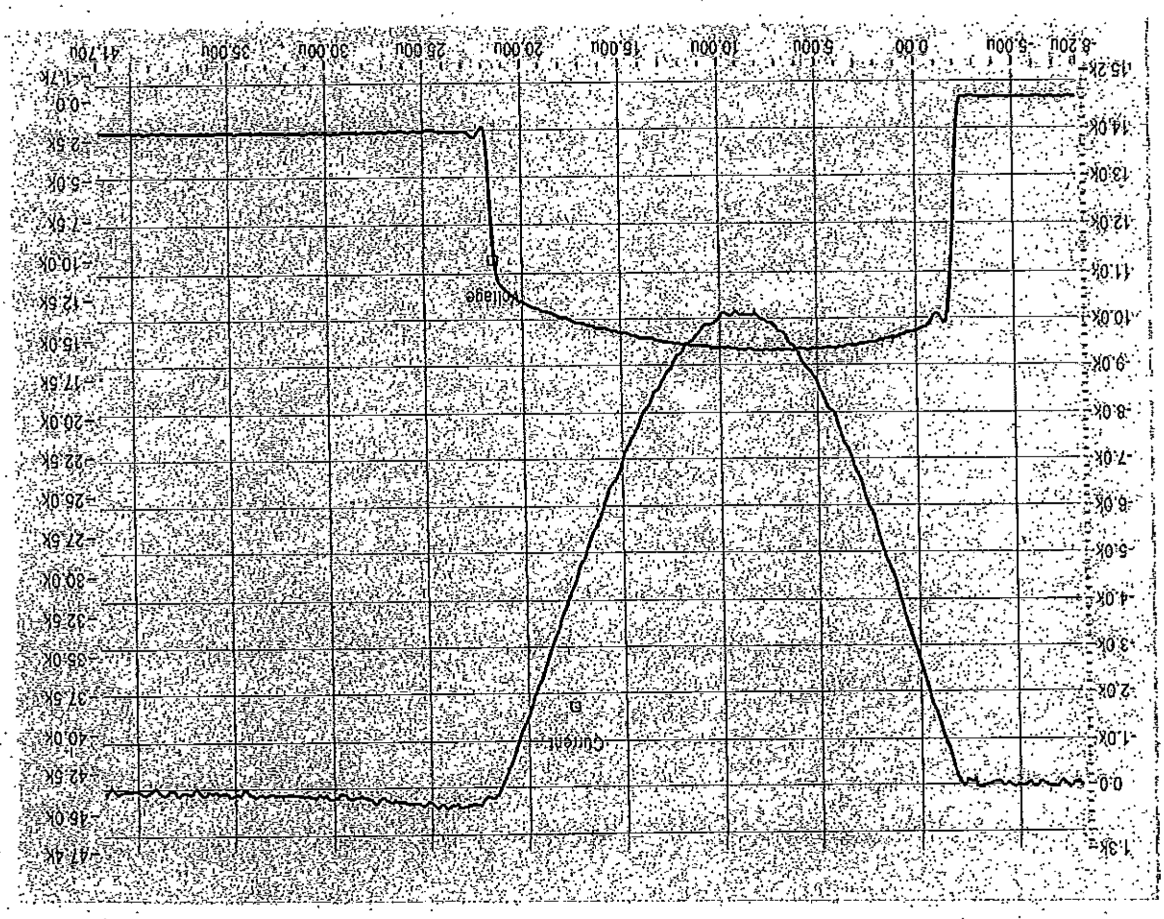


CESI PeC A5055428 Oscillogram n. 37

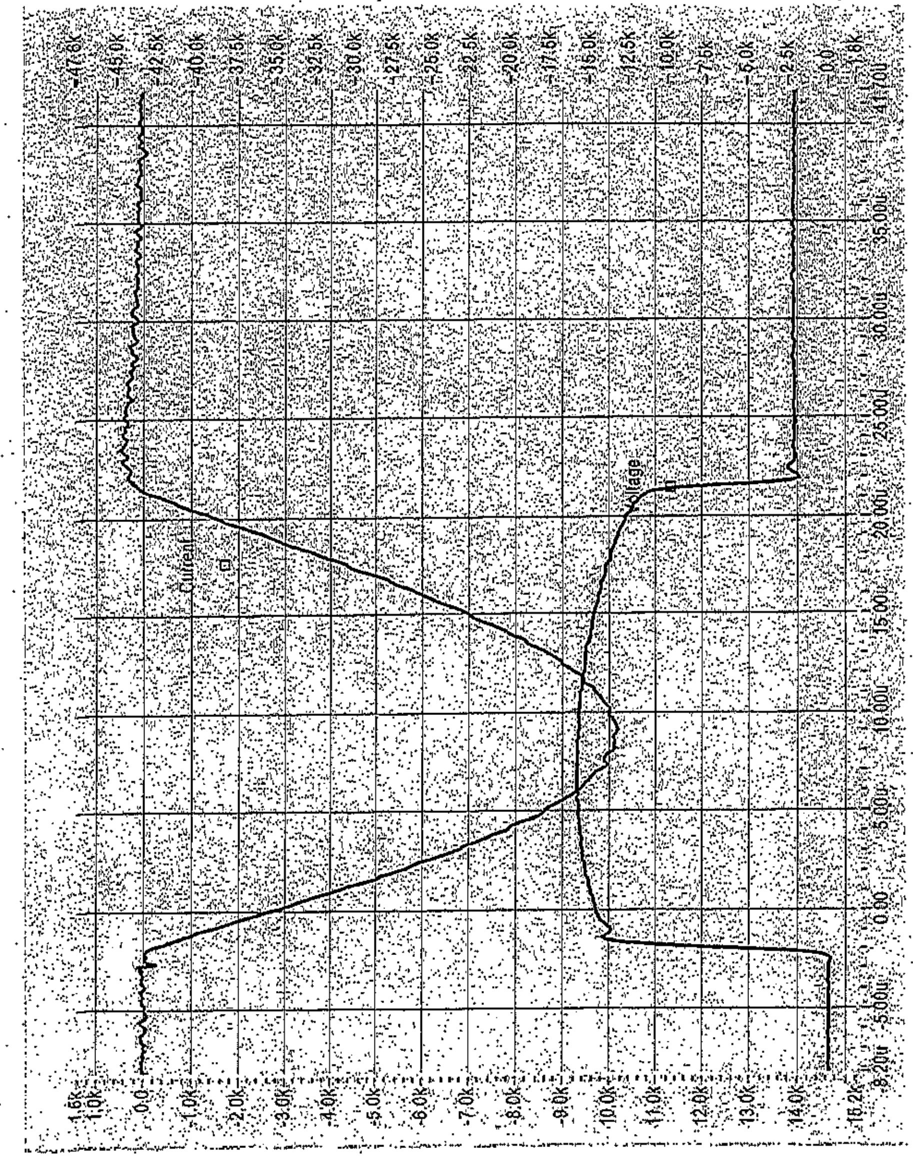
ВЯРНО С ОРИГИНАЛА

111

ВЯРНО С
ОРИГИНАЛА



CESI PeC A5055428 Oscillogram n. 38

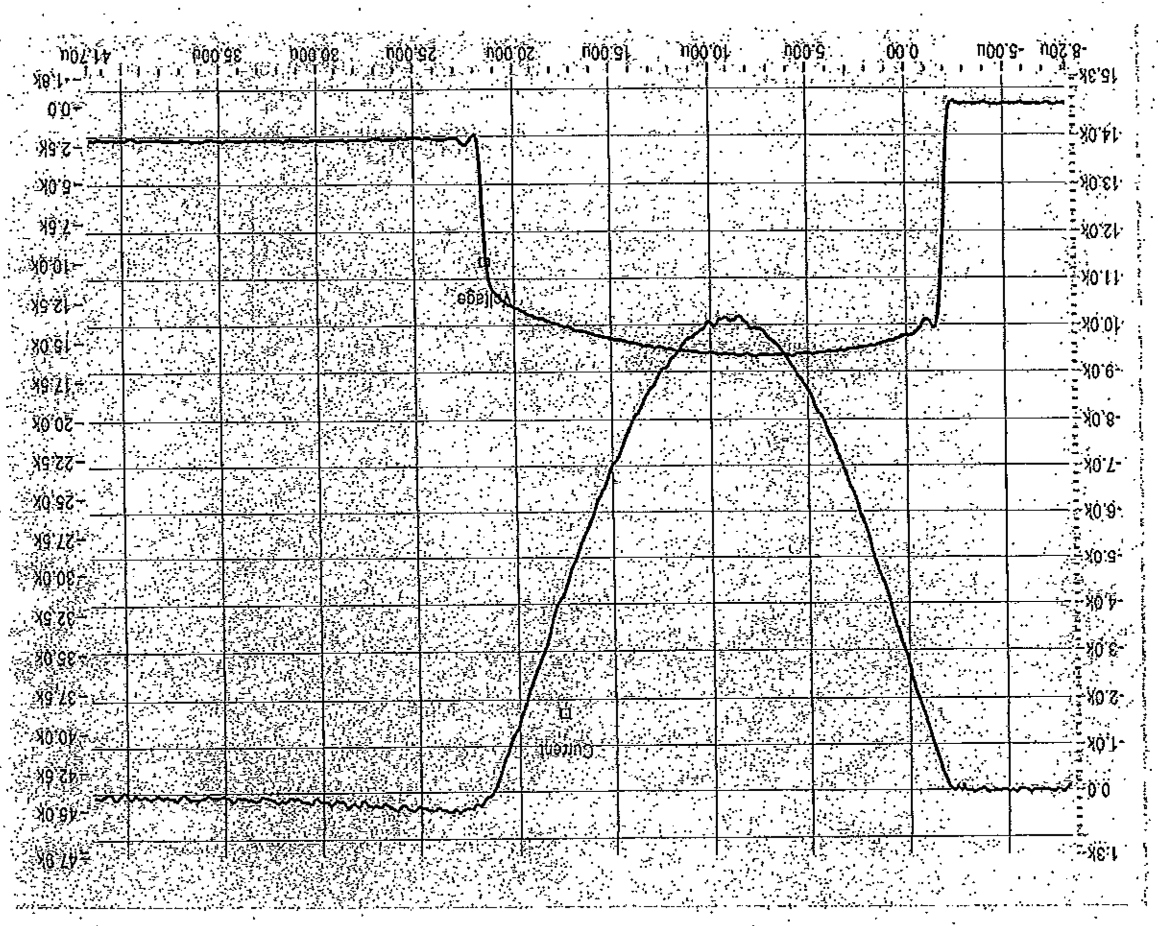


CESI PeC A5055428 Oscillogram n. 39

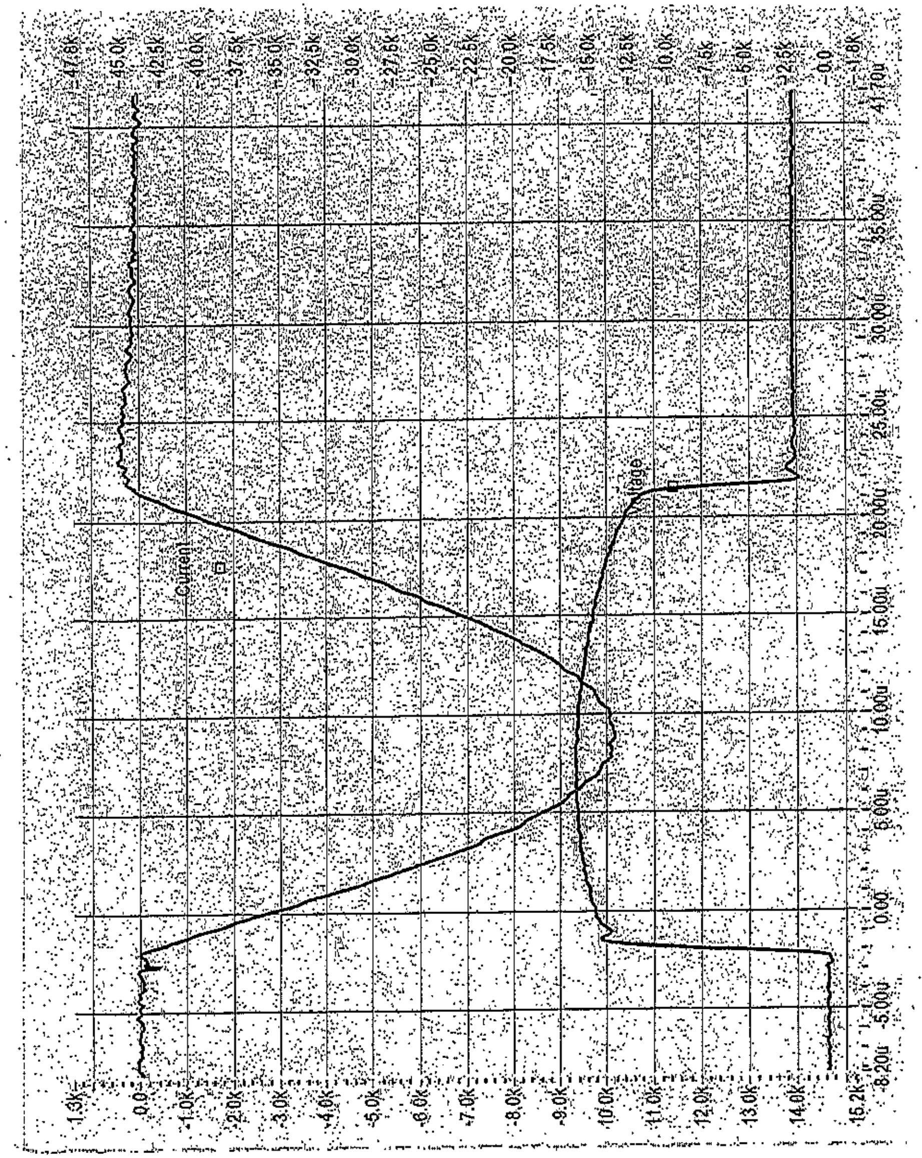
ВЯРНО С
ОРИГИНАЛА

416

ВЯРНО С ОРИГИНАЛА



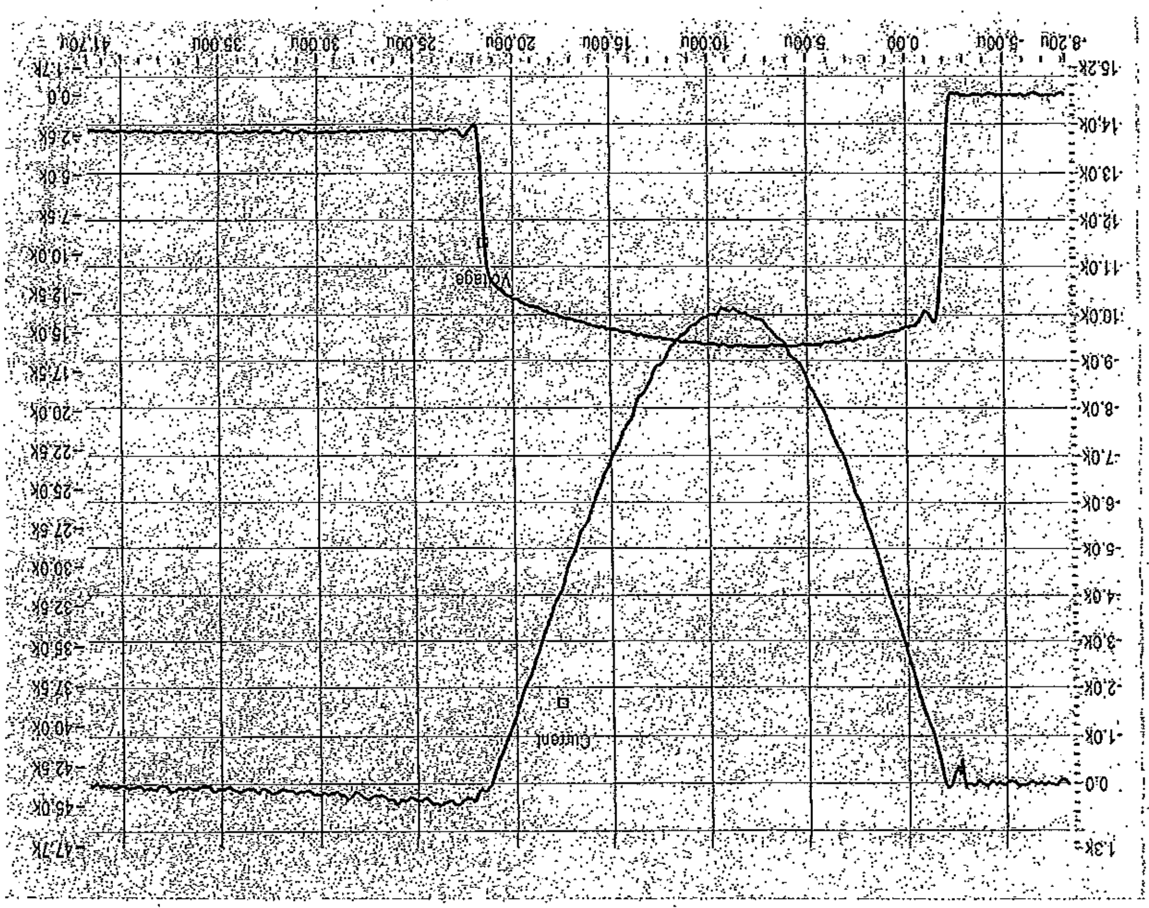
CESI PeC A5055428 Oscillogram n. 40



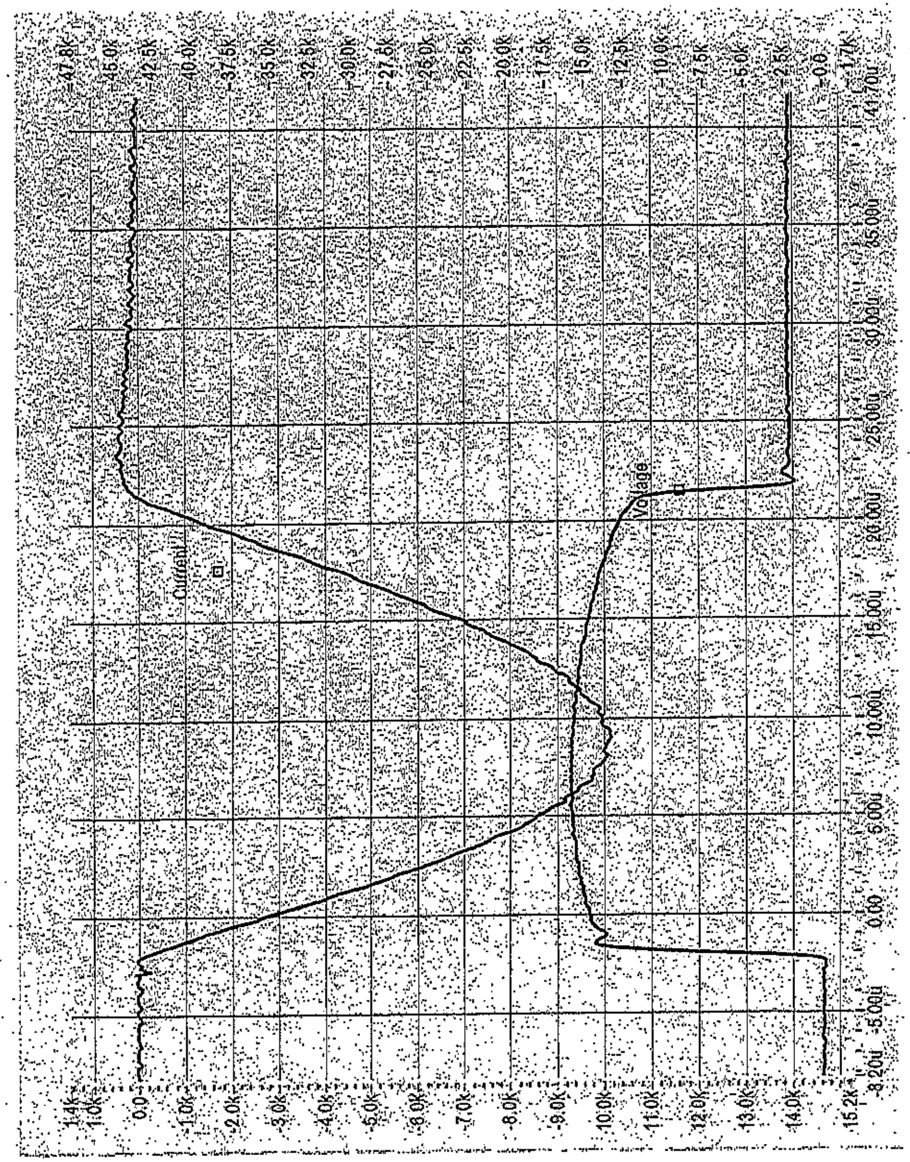
CESI PeC A5055428 Oscillogram n. 41

ВЯРНО С
ОРИГИНАЛА
418

ВЯРНО С
ОРИГИНАЛА



CESI PeC A5055428 Oscillogram n. 42



CESI PeC A5055428 Oscillogram n. 43

ВЯРНО С ОРИГИНАЛА

DATA & RESULTS FOR THE ACCELERATED AGEING TEST
performed on metal oxide varistor blocks intended for VARISIL Type HE surge arresters

Test conditions : according to the requirements and the procedure defined in clause 8.5.2 of IEC 60099-4 - Edition 2.0 (May 2004)

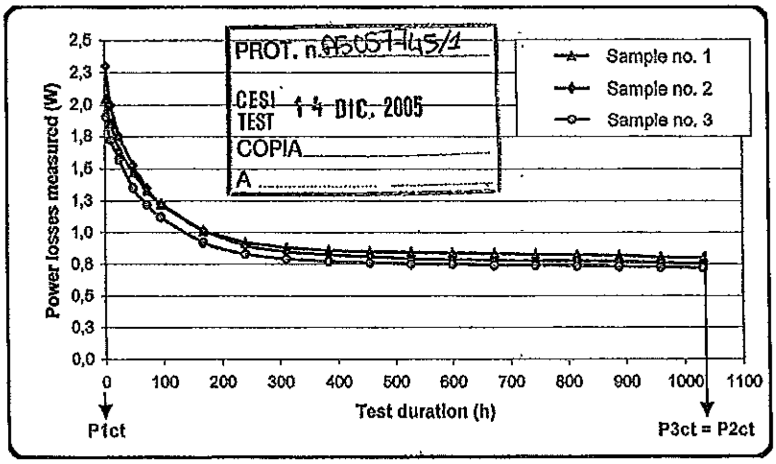
Test samples : 3 sliced parts of HE surge arrester built with a single MOV block rated 6 kV   Test temperature : 115 +/- 3 °C   Total test duration : 1032 h

Test voltage : Uct = Uc x (1 + D x H) x Uref / Urefmin

where : Uc = 5100 V rms is the continuous operating voltage of a MOV block rated 6 kV
D = 12 %/m is the maximum distortion of voltage distribution within the HE range *(1)*
H = 0,326 m is the maximum total height within the HE range *(1)*
Uref = 5855 V peak/V2 is the reference voltage at 1 mA peak a.c. of the test samples
Urefmin = 5800 V peak/V2 is the specified minimum reference voltage for a MOV block rated 6 kV

Uct = 5350 V rms

Testing time (h)	Sample no. 1	Sample no. 2	Sample no. 3	
2	2,05	2,30	1,90	= P1ct
10	1,85	2,00	1,72	
24	1,65	1,76	1,57	
48	1,47	1,53	1,35	
72	1,33	1,35	1,22	
96	1,22	1,23	1,12	
168	1,01	1,02	0,92	
240	0,92	0,90	0,83	
312	0,88	0,85	0,79	
384	0,86	0,83	0,77	
456	0,85	0,81	0,76	
528	0,85	0,79	0,75	
600	0,84	0,79	0,75	
672	0,84	0,78	0,74	
744	0,83	0,78	0,74	
816	0,83	0,78	0,74	
888	0,82	0,77	0,73	
960	0,81	0,76	0,73	
1032	0,80	0,75	0,72	= P3ct = P2ct



CONCLUSION : as both P2ct <= 1.1 x P3ct and P2ct <= P1ct for all three test samples, the high current impulse operating duty test according to clause 9.7.5 of IEC 60099-4 can be performed on new MOV blocks at Usr and Usc without any additional correction

Note (1) : the values indicated refer to VARISIL Type HE 36 surge arrester which represents both the longest unit and the highest specific voltage stress per unit length

ВЯРНО С ОРИГИНАЛА

451

ВЯРНО С ОРИГИНАЛА

153

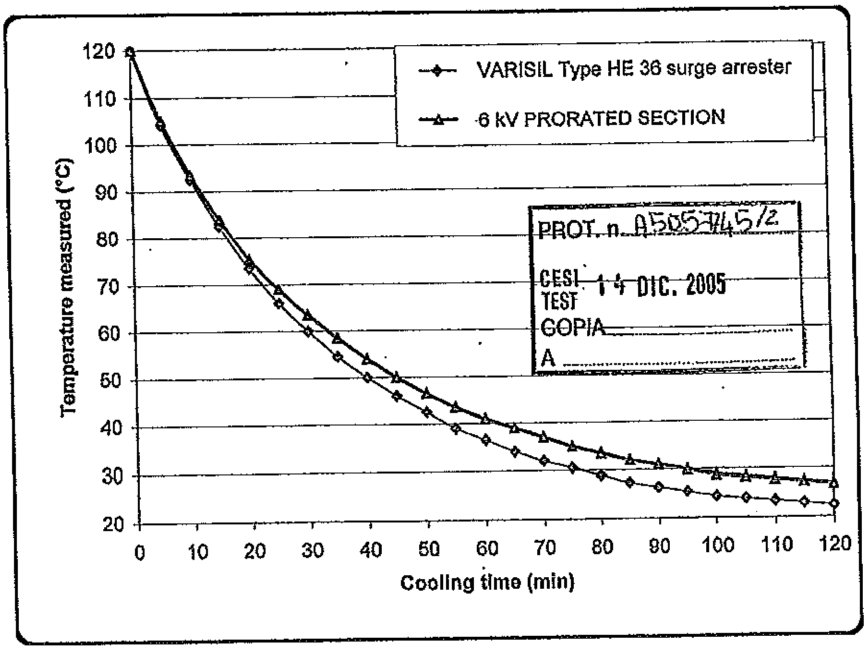
DATA & RESULTS FOR VERIFICATION OF THE THERMAL EQUIVALENCY between VARISIL Type HE 36 complete surge arrester and 6 kV PRORATED SECTION under test

Test conditions : according to the requirements and the procedure defined in clause 10.8.5.3.2 and Annex B of IEC 60099-4 - Edition 2.0 (May 2004)

Still air ambient temperature : 17 +/- 2 °C Time delay to reach the temperature of 120 °C by application of a power frequency overvoltage : app. 32 min

In both cases, the temperature was measured at a single point of the MO varistor located between 1/2 and 1/3 of the test sample length from its energised end

Cooling time (min)	VARISIL Type HE 36 surge arrester	6 kV PRORATED SECTION
0	120,0	120,0
5	104,0	105,0
10	92,5	93,5
15	82,5	84,0
20	73,5	75,5
25	66,0	69,0
30	60,0	63,5
35	54,5	58,5
40	50,0	54,0
45	46,0	50,0
50	42,5	46,5
55	39,0	43,5
60	36,5	41,0
65	34,0	39,0
70	32,0	37,0
75	30,5	35,0
80	29,0	33,5
85	27,5	32,0
90	26,5	31,0
95	25,5	30,0
100	24,5	29,0
105	24,0	28,5
110	23,5	28,0
115	23,0	27,5
120	22,5	27,0



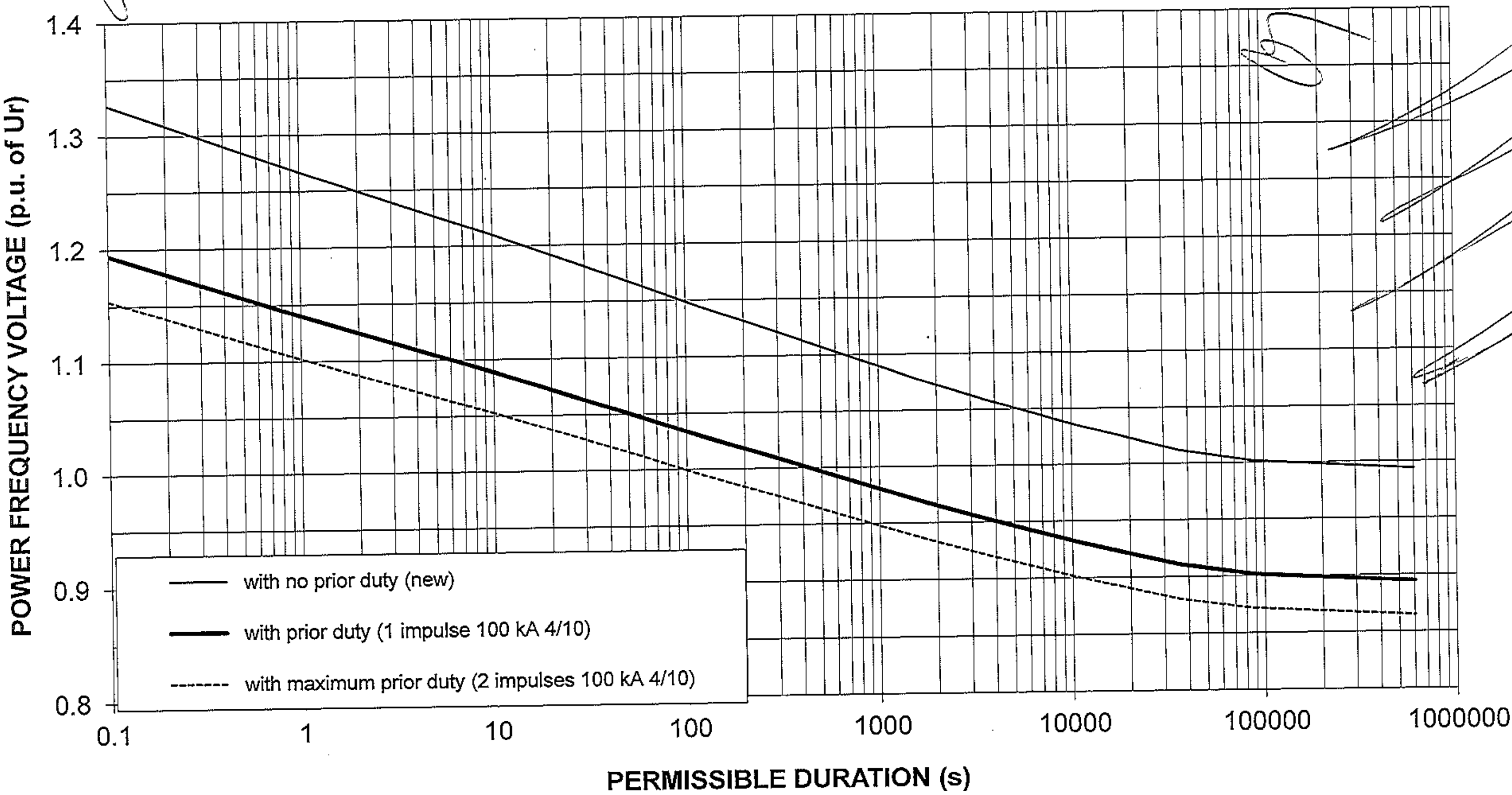
U(t) gamme HE-S

	U / Ur			U / Uc		
temps (s)	**neuf**	**1 x 100 kA**	**2 x 100 kA**	**neuf**	**1 x 100 kA**	**2 x 100 kA**
0.1	1.327	1.194	1.154	1.561	1.405	1.358
0.5	1.285	1.157	1.118	1.512	1.361	1.315
1	1.267	1.140	1.102	1.491	1.342	1.297
5	1.227	1.104	1.067	1.444	1.299	1.256
10	1.210	1.089	1.053	1.424	1.281	1.238
60	1.163	1.047	1.012	1.368	1.231	1.190
120	1.144	1.030	0.995	1.346	1.211	1.171
300	1.121	1.009	0.975	1.319	1.187	1.147
600	1.103	0.993	0.960	1.298	1.168	1.129
1800	1.075	0.968	0.935	1.265	1.138	1.100
3600	1.059	0.953	0.921	1.246	1.121	1.084
10800	1.035	0.932	0.900	1.218	1.096	1.059
36000	1.012	0.911	0.880	1.191	1.072	1.036
86400	1.002	0.902	0.872	1.179	1.061	1.026
604800	0.994	0.895	0.865	1.169	1.052	1.017

ВЯРНО С ОРИГИНАЛА

433

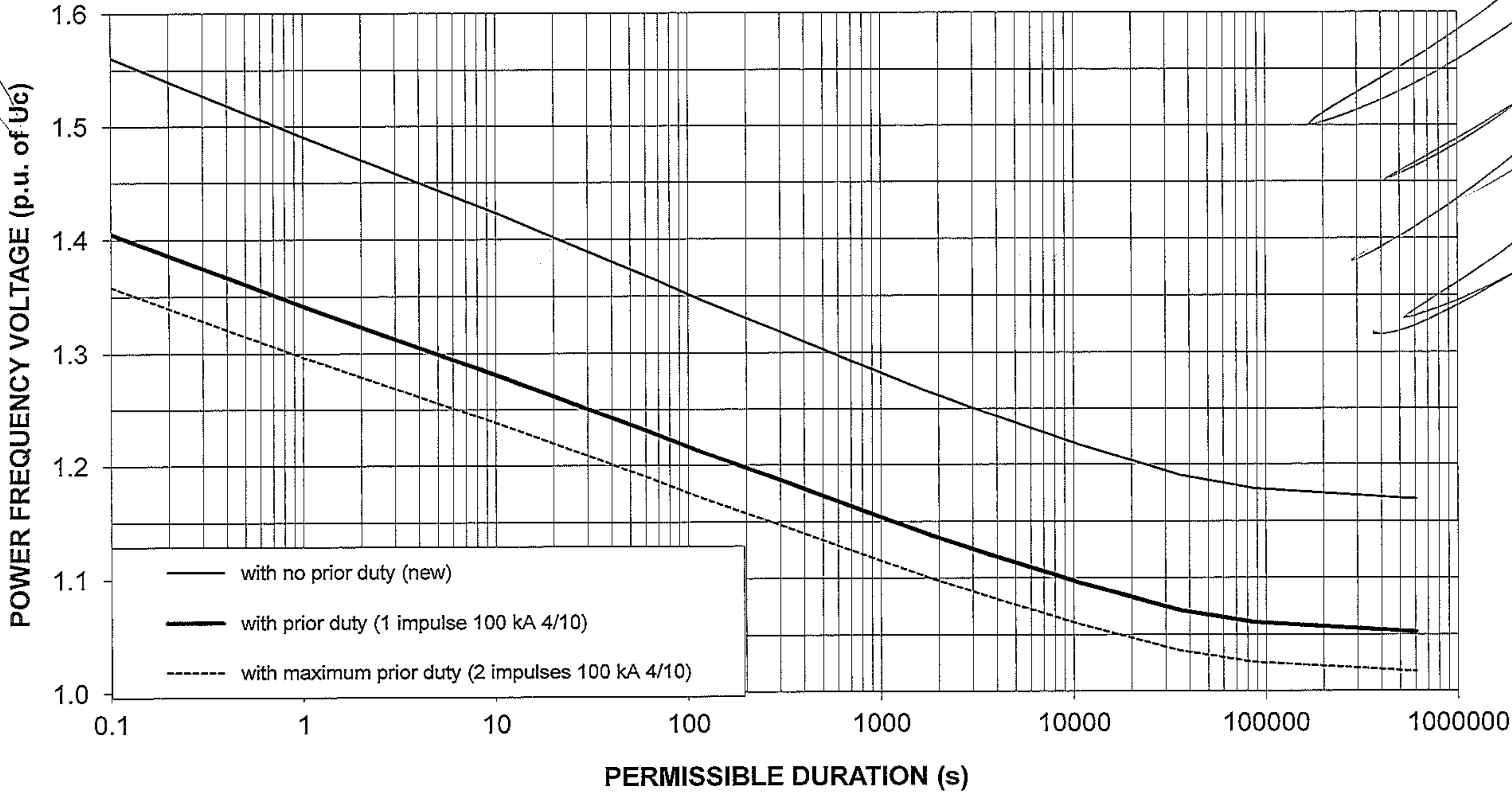
MINIMUM TEMPORARY OVERVOLTAGE WITHSTAND CAPABILITY of VARISIL Type HE-S Surge Arresters according to Annex D of IEC 60099-4



Document TRIDELTA ref. UT 8998 01 XX / E rev. 01 dated January 4, 2010

ВЯРНО С ОРИГИНАЛА

MINIMUM TEMPORARY OVERVOLTAGE WITHSTAND CAPABILITY of VARISIL Type HE-S Surge Arresters according to Annex D of IEC 60099-4

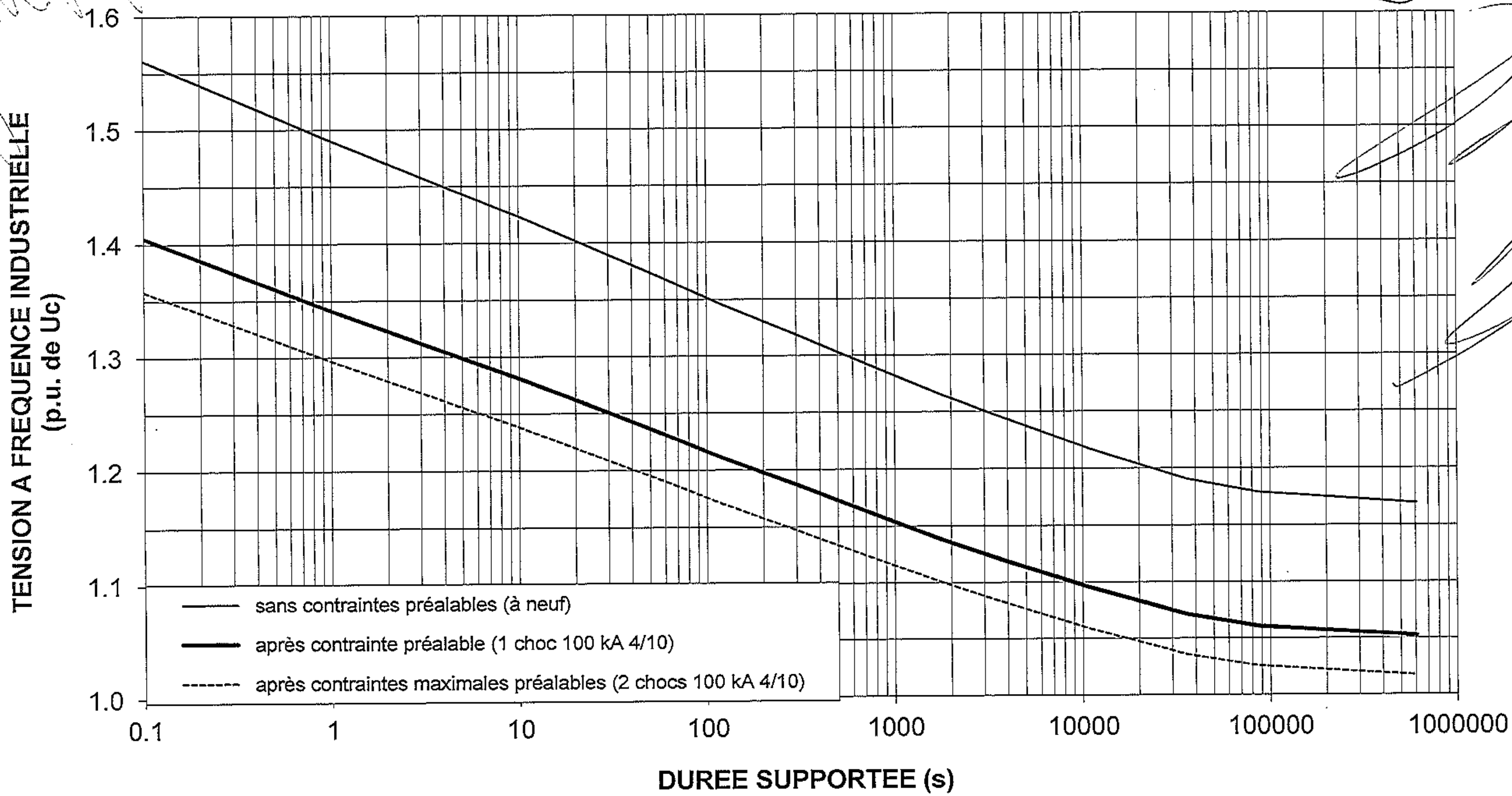


Document TRIDELTA ref. UT 8998 01 YY / E rev. 01 dated January 4, 2010

ВЯРНО С ОРИГИНАЛА

455

TENUE MINIMALE AUX SURTENSIONS TEMPORAIRES des parafoudres VARISIL HE-S selon Annexe D de la CEI 60099-4



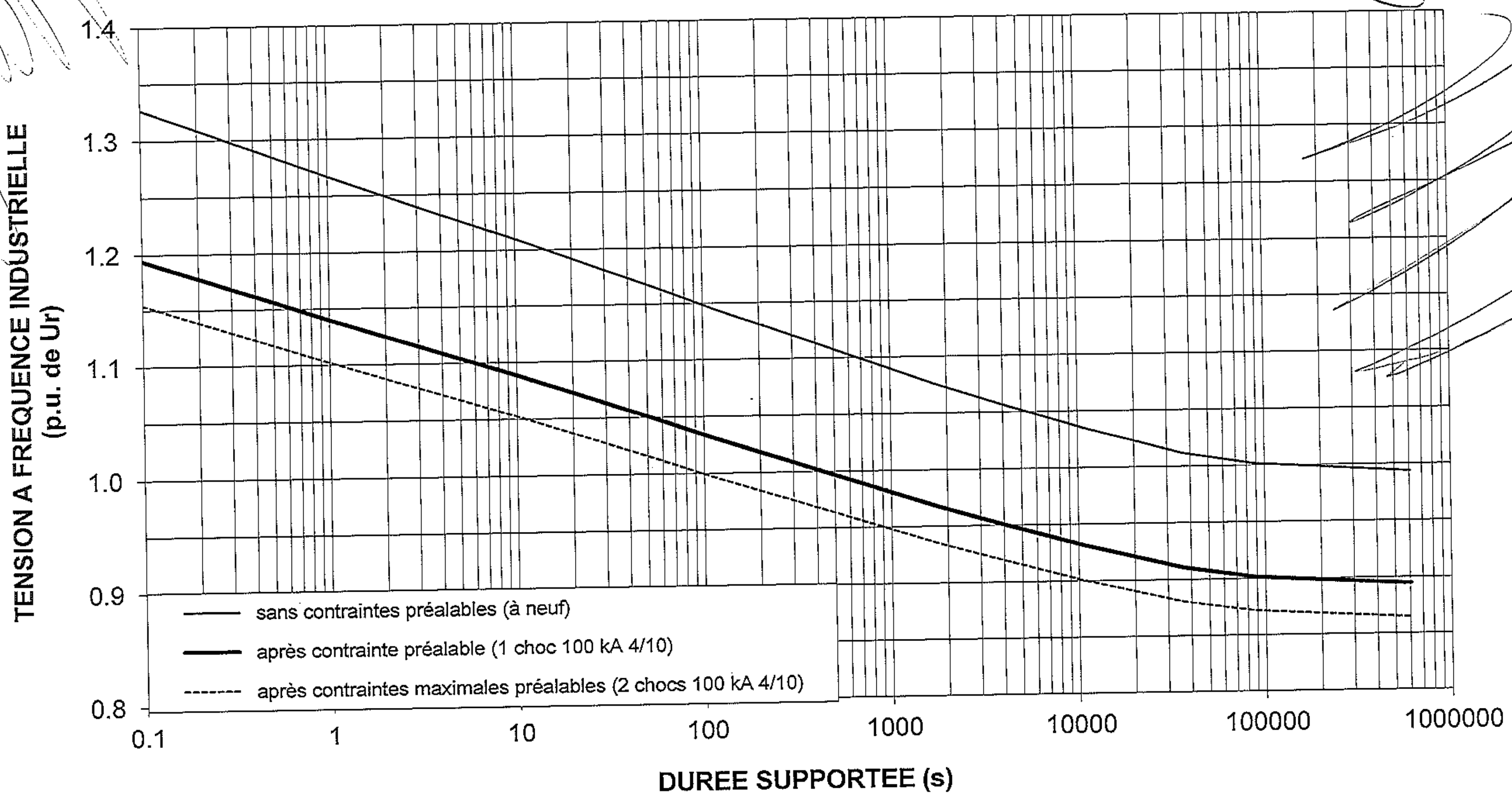
Document TRIDELTA réf. UT 8998 01 YY / F rév. 01 du 04/01/2010

ВЯРНО С ОРИГИНАЛА

456

TENUE MINIMALE AUX SURTENSIONS TEMPORAIRES
des parafoudres VARISIL HE-S selon Annexe D de la CEI 60099-4

ВЯРНО С ОРИГИНАЛА



Document TRIDELTA réf. UT 8998 01 XX / F rév. 01 du 04/01/2010

Client	**TRIDELTA PARAFOUDES S.A.**
Address of the Client	Boulevard de l'Adour - BP 256 - 65202 Bagneres de Bigorre Cedex (France)
Manufacturer	TRIDELTA PARAFOUDRES S.A.
Tested samples/items	Disconnector type S3D2 for metal oxide surge arrester
Tests carried out	Long-duration current impulse withstand test
Standards/Specifications	IEC 60099-4 – Edition 2.2 (2009-05)
Tests date	**from** September 12, 2011 **to** September 13, 2011

Deutscher Akkreditierungs Rat DAT-PL-284/08-00

Testing laboratory accredited ISO/IEC 17025: 2005 in the fields of:
High-Voltage Equipment and their Components
Transformers and their Components
Low-Voltage Switching Devices and Switchgears
Electromagnetic Compatibility (EMC)

No. of pages 20 **No. of pages annexed** 8

Issue date September 14, 2011

Prepared PPR - Gregori Marco

Verified PPR - Vidori Mauro, TPI - Sironi Alberto

Approved PMI - The Manager - Arcidiaco Lorenzo

CESI S.p.A.
Testing & Certification Division
Testing Operations Area
"Milan Platform"
Manager

PUBBLICATO B1027449 (PAD - 1535460)

A1000IG rev.6

ВЯРНО С ОРИГИНАЛА

453

Tests witnessed by: —

Mr. Frederic Malpiece	TRIDELTA Parafoudres S.A.
Mr A. Athanasas	PUBLIC POWER CORPORATION

Identification of the object: Not requested

Test evaluation
With reference to the Standards/Specifications listed in the first page and the characteristics of the tested sample assigned by manufacturer, the carried out tests passed SUCCESSFULLY.

The data necessary to permit repetition of the tests are contained in the document marked: —

The measurement uncertainties of the test results reported in this document are the following:

- dielectric tests with impulse voltage	: peak voltage: ± 3 %	time parameters: ± 10 %	
- dielectric tests with impulse current	: peak value: ± 3 %	time parameters: ± 10 %	
- dielectric tests with alternating voltage	: voltage (rms): ± 3 %	time parameters: ± 3,5 %	
- dielectric tests with direct voltage	: voltage: ± 3 %	time parameters: ± 3,5 %	
- partial discharge measurement	: up to 10 pC: ± 1 pC	above 10 pC: ± 10 %	
- atmospheric conditions	: temperature: ± 2 °C	pressure: ± 0,133 kPa	humidity: ± 10 %

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to confidence level of about 95%) and have to be considered as maximum values.

Laboratory information

Receipt date of the sample	September 12, 2011
Test location	CESI – Via Rubattino 54 – Milan
CESI testing team	Mr. L. Podavitte – Mr. I. Guacci
Test laboratory	P177
Activity code	AE11PMI018

ВЯРНО С ОРИГИНАЛА

content	page a	test date
Test object characteristics	4	
Pictures of the test sample	from 5 to 6	
Reference standard	7	
Test carried out	7	
Test object identification	7	
Test procedure	8	
Visual Inspection	9	
Power frequency voltage characteristics	10	September 12, 2011
Lightning impulse residual voltage measurement before the test	11	September 12, 2011
Switching impulse residual voltage test	12	September 12, 2011
Voltage correction factor and energy calculations	13	September 12, 2011
Long duration current impulse withstand test	14	September 12&13, 2011
Lightning impulse residual voltage measurement after the test	15	September 13, 2011
Check the integrity of the internal parts with an additional shot	16	September 13, 2011
Technical data of the test circuit	from page 17 to 20	
Pages annexed:		
oscillograms n. 8 pages		

ВЯРНО С ОРИГИНАЛА

Test object characteristics

type: Disconnector type S3D2 for metal oxide surge arrester

The table below lists the electrical characteristics (assigned by the client) of the surge arresters for which the disconnectors are designed

electrical characteristics (assigned by the client)

Manufacturer's name	**TRIDELTA PARAFOUDRES S.A.**
Nominal discharge current – I_n [kA]	10
Rated voltage – U_r [kV]	1,035 x Uref
Continuous operating voltage - U_c [kV]	0,880 x Uref
Reference current - $I_{ref.}$ [mA]	1,0
Line discharge class	1
Standard rated frequency - [Hz]	50/60
year of manufacture	2011

ВЯРНО С ОРИГИНАЛА

461

Pictures of the sample

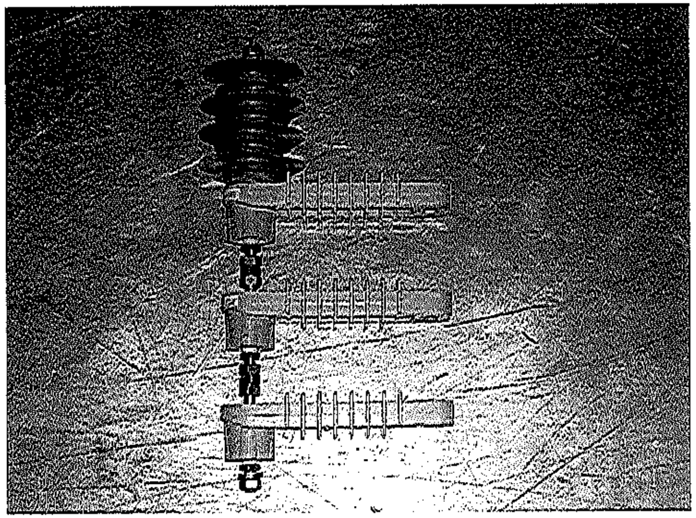


Photo no. 1

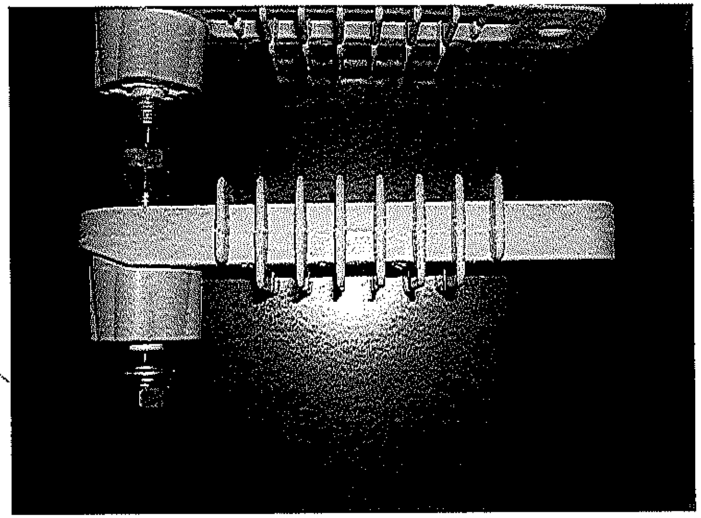


Photo no. 2

ВЯРНО С ОРИГИНАЛА

462

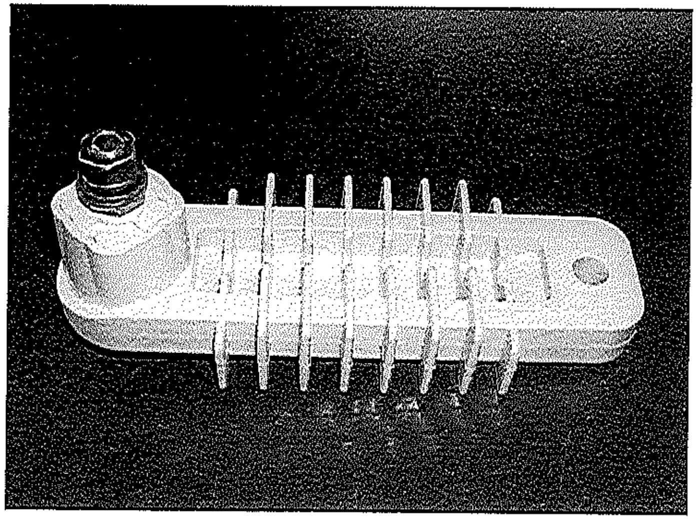


Photo no. 3

Photo no. 4

ВЯРНО С
ОРИГИНАЛА

463

Reference Standard

IEC 60099-4 (2009/05) – Edition 2.2 - Clause 8.6.2.1
"Metal-oxide surge arresters without gaps for a.c. systems"

Test carried out	Number of samples tested
Long-duration current impulse withstand test	3

Test object identification

Test object name	Identification of test sample (given by CESI)
Disconnector type S3D2 for metal oxide surge arrester	1LD – 2LD – 3LD

ВЯРНО С ОРИГИНАЛА

A1265IG

Test procedure

The test has been performed on three disconnectors connected in series.
A suitable surge arrester section was supplied by the Client.
It was used , as part of the circuit in this frame, connected in series with the test samples, to get proper impulse current waves and power frequency current flowing through the disconnectors.

The test procedure consisted of the following sequence:

a) Measurement of the power frequency reference voltage at the reference current

b) Measurement of the lightning impulse residual voltage at nominal discharge current

c) Measurement of the switching impulse residual voltage at the lowest current peak prescribed by the standard in table 4 that is 125 A

d) Calculation of the specified energy associated to each long duration current impulse according to clause 8.4.2 of the reference standard

e) Application of eighteen long duration current impulses with the specified energy and a virtual duration of 2000 μs in six groups of three operations each.
- intervals between operations of the same group: 60 seconds
- interval between different groups: as required to cool down the samples to near ambient temperature

f) Measurement of the lightning impulse residual voltage at nominal discharge current for comparison with initial value

g) After cooling down to near ambient temperature cooling down to near ambient temperature application of a nineteenth impulse to check the sample integrity

The disconnectors did not operate.

The acceptance criteria are fulfilled. The test result is positive.

ВЯРНО С
ОРИГИНАЛА

465

Visual inspection after the test

The disconnectors withstood the full procedure without operation and without showing any visible damage.

ВЯРНО С ОРИГИНАЛА

160

Long-duration current impulse withstand test.

Reference voltage test.

Test circuit: A0019

Date: September 12, 2011

Oscillogram	Voltage	current	current	current	power	3rd harmonic amplitude
		Sample No. 1LD-2LD-3LD				
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	µA
1	6,05	0,97	1,05	0,56	1,70	—

ВЯРНО С ОРИГИНАЛА

467

Long-duration current impulse withstand test.

Lightning impulse residual voltage measurement before the test

Test circuit: A0120

Date: September 12, 2011

Sample	Requested current	Charging Voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage
No.		kV	No.	µs	kA	kV
1LD-2LD-3LD	I_n	28,0	2	8,5/17,6	10,00	15,61

Notes:

ВЯРНО С ОРИГИНАЛА

168

Long-duration current impulse withstand test.

Switching impulse residual voltage test.

Test circuit: A0122

Date: September 12, 2011

Sample	Requested current	Charging voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage
No.	A	kV	No.	µs	A	kV
1LD-2LD-3LD	125	12,7	3	30/61,0	129	11,28

Notes:

Long duration current impulse withstand test.

Voltage correction factor and energy calculations

Date: September 12, 2011

Sample	U_{ref} [1]	kU_r [2]	kU_c [3]	U_r' [4]	U_c' [5]
No.	kV	kV	kV	kV	kV
1LD-2LD-3LD	6,05	1,035	0,880	6,262	5,324

[1] U_{ref} : measured reference voltage
[2] kU_r : maximum guarantees factor for calculation of Ur
[3] kU_c : maximum guarantees factor for calculation of Uc
[4] U_r' : corrected rated voltage [4] = [1] × [2]
[5] U_c' : corrected continuous operating voltage [5] = [1] × [53

Sample	U_r'	U_L	V_{res}	T	Z	W	W'
No.	kV	kV	kV		kV	kJ	kJ/kV
1LD-2LD-3LD	6,262	20,04	11,28	2000	30,68	6,442	1,029

V_{res} : switching impulse residual voltage
U_L , T , Z : see table 5 of IEC 60099-4 standard
W : $= V_{res} \times (U_L - V_{res}) \times (T / Z)$

ВЯРНО С ОРИГИНАЛА

A1176IG

+
Long duration current impulse withstand test.

Test circuit: A0017

Date: September 12, 2011

Sample	Impulse	Charging voltage V_c	Oscillogram	Peak current I	Residual voltage V_r	Energy E
No.	No.	kV	No.	A	kV	kJ
1LD-2LD-3LD	1	35,8		255,0	11,49	6,45
	2	35,8		256,0	11,57	6,50
	3	36,0	4	256,0	11,64	6,55
	4	36,0		257,0	11,59	6,53
	5	36,0		256,0	11,60	6,55
	6	36,0		256,0	11,66	6,56
	7	36,0		256,0	11,77	6,54
	8	36,0		257,0	11,65	6,54
	9	36,0	5	256,0	11,68	6,56
	10	36,0		256,0	11,78	6,57
	11	36,0		256,0	11,66	6,54
	12	36,0		256,0	11,73	6,55
	13	36,0		256,0	11,72	6,56
	14	36,0		256,0	11,68	6,53
	15	36,0		256,0	11,65	6,55
	16	36,0		256,0	11,61	6,54
	17	36,0		256,0	11,68	6,56
	18	36,0	6	256,0	11,74	6,57

Notes:

Measured waveshape	
virtual duration	virtual total duration
µs	µs
2010	2540

continued

471

Long-duration current impulse withstand test.

Lightning impulse residual voltage measurement after the test

Test circuit: A0120

Date: September 13, 2011

Sample	Requested Current	Charging voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage
No.		kV	No.	µs	kA	kV
1LD-2LD-3LD	I_n	28,0	7	8,5/17,6	10,10	15,60

Notes:

ВЯРНО С ОРИГИНАЛА

472

Long duration current impulse withstand test.

(check the integrity of the internal parts with an additional shot at ambient temperature)

Test circuit: A0017

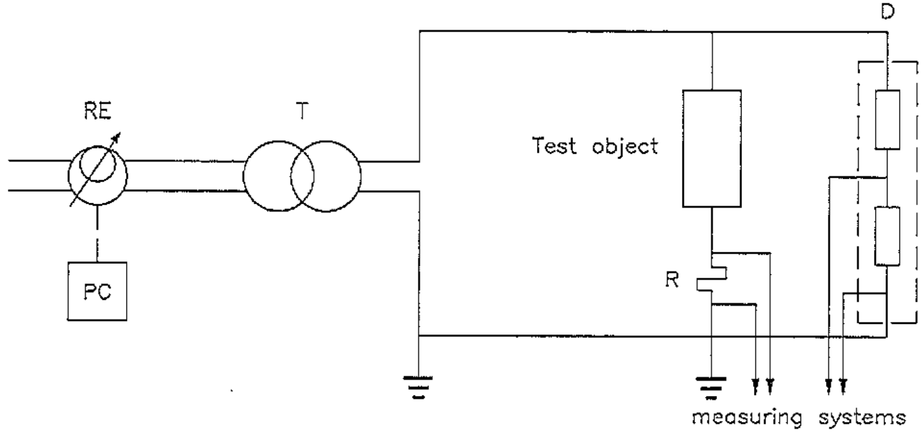
Date: September 13, 2011

Sample	Impulse	Charging voltage V_c	Oscillogram	Peak current I	Residual voltage V_r	Energy E
No.	No.	kV	No.	A	kV	kJ
1LD-2LD-3LD	19	36,0	8	257	11,62	6,52

Notes:

Measured waveshape	
virtual duration	virtual total duration
µs	µs
2010	2540

Circuit A0019



Power frequency supply

RE - programmable supply type PACIFIC A.C. Power Source 140 ASX.; CESI no. 0560408
PC - personal computer
T - voltage transformer type SPECIALTRASFO; power 30 kVA; voltage 200 V/15-30 kV

Current measuring system

R - Current shunt CESI No.31120; R= 941,4 Ω
- Electro optical system CESI No.11517/518
OSC - Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122;
- CESI No 056227- 0562226 (on channel No.1)

Voltage measuring system

D - Voltage divider SAGI; CESI No.11120
- Electro optical system CESI No.11521/522
OSC - Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122;
- CESI No 056227- 0562226 (on channel No.2)

Software system:

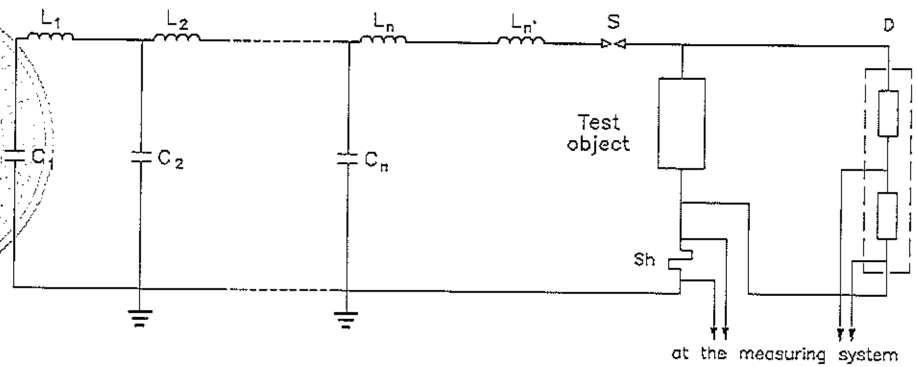
SW - S.A.D. Surge arrester version 1.0

ВЯРНО С ОРИГИНАЛА

474

A0019IG

Circuit A0017



Impulse generator

$C_1 \dots C_{14}$	- capacitors 0,83 μF
$L_1 \dots L_{13}$	- inductors 7 mH
L_{14}	- inductor 14 mH

S : - spark gap

A surge arrester section has been added

Voltage measuring system.

D	- Voltage divider SAGI; CESI No.11120
	- Electro optical system CESI No 11521/11522
OSC	- Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122;
	- CESI No 056227- 0562226 (on channel No.2)

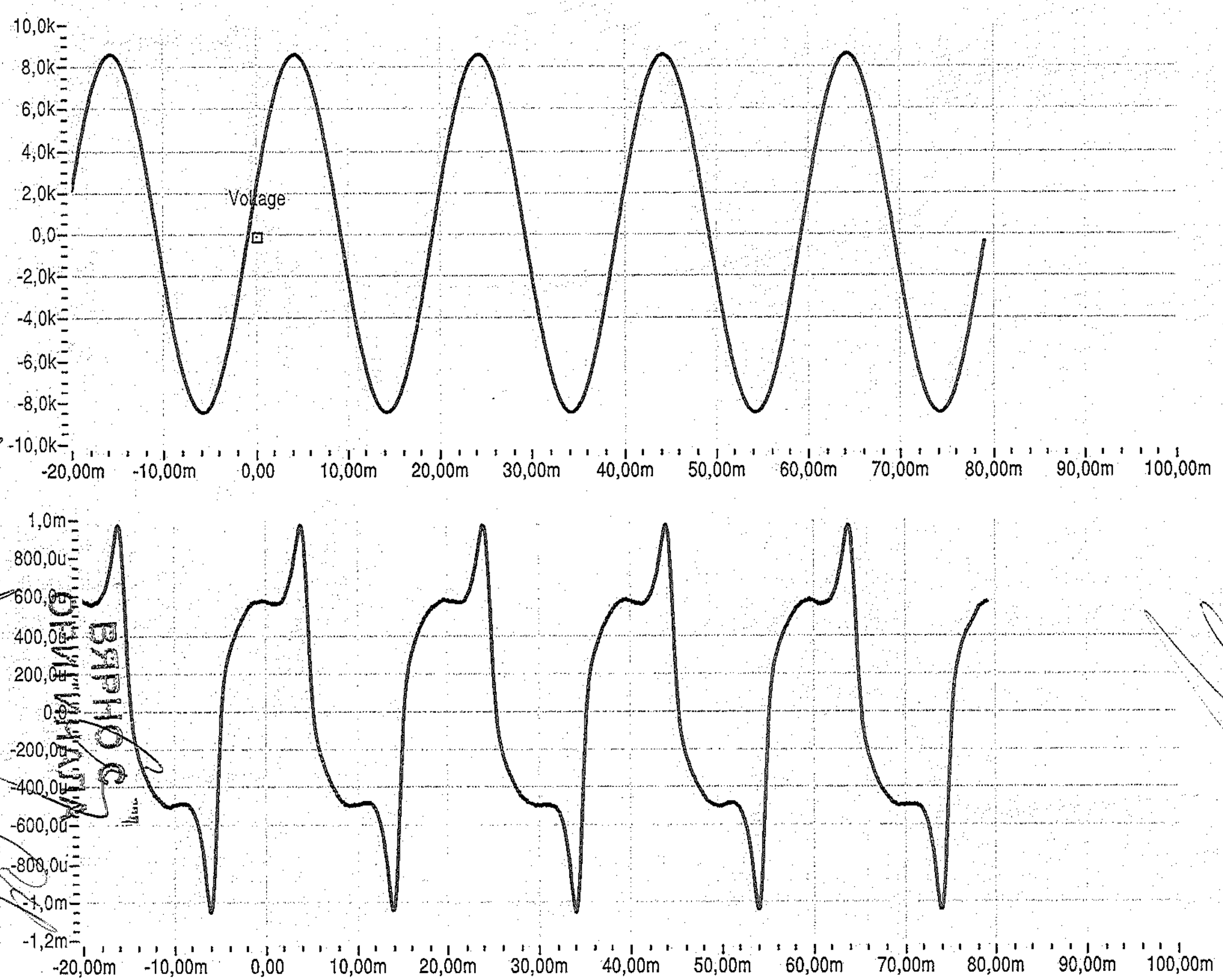
Current measuring system

Sh	- Current shunt CESI No.6039; R= 20 m Ω
	- Electro optical system CESI No11517/11518
OSC	- Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122;
	- CESI No 056227- 0562226 (on channel No.1)

Software system:

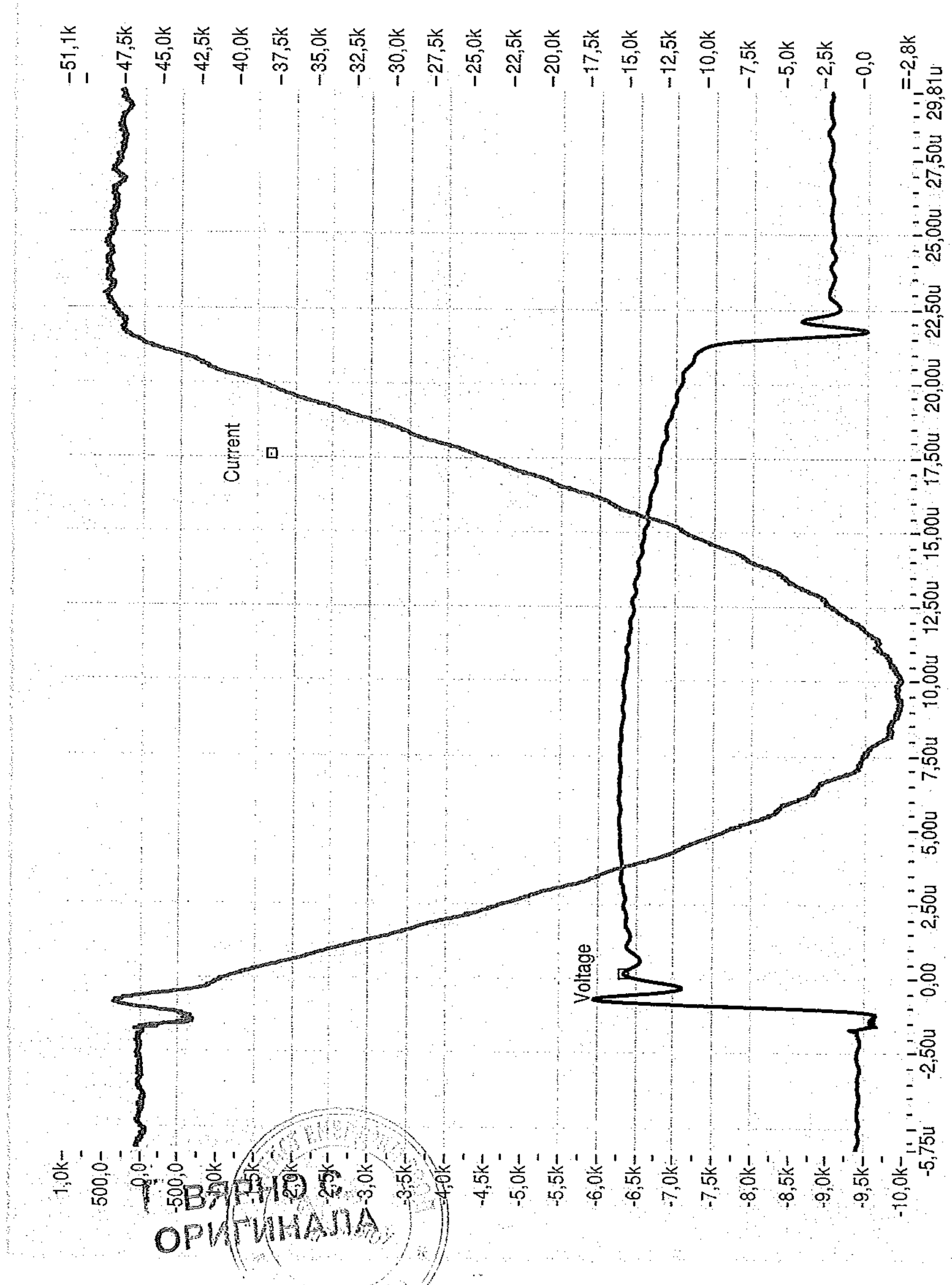
SW - S.A.D. Surge arrester version 1.0

477

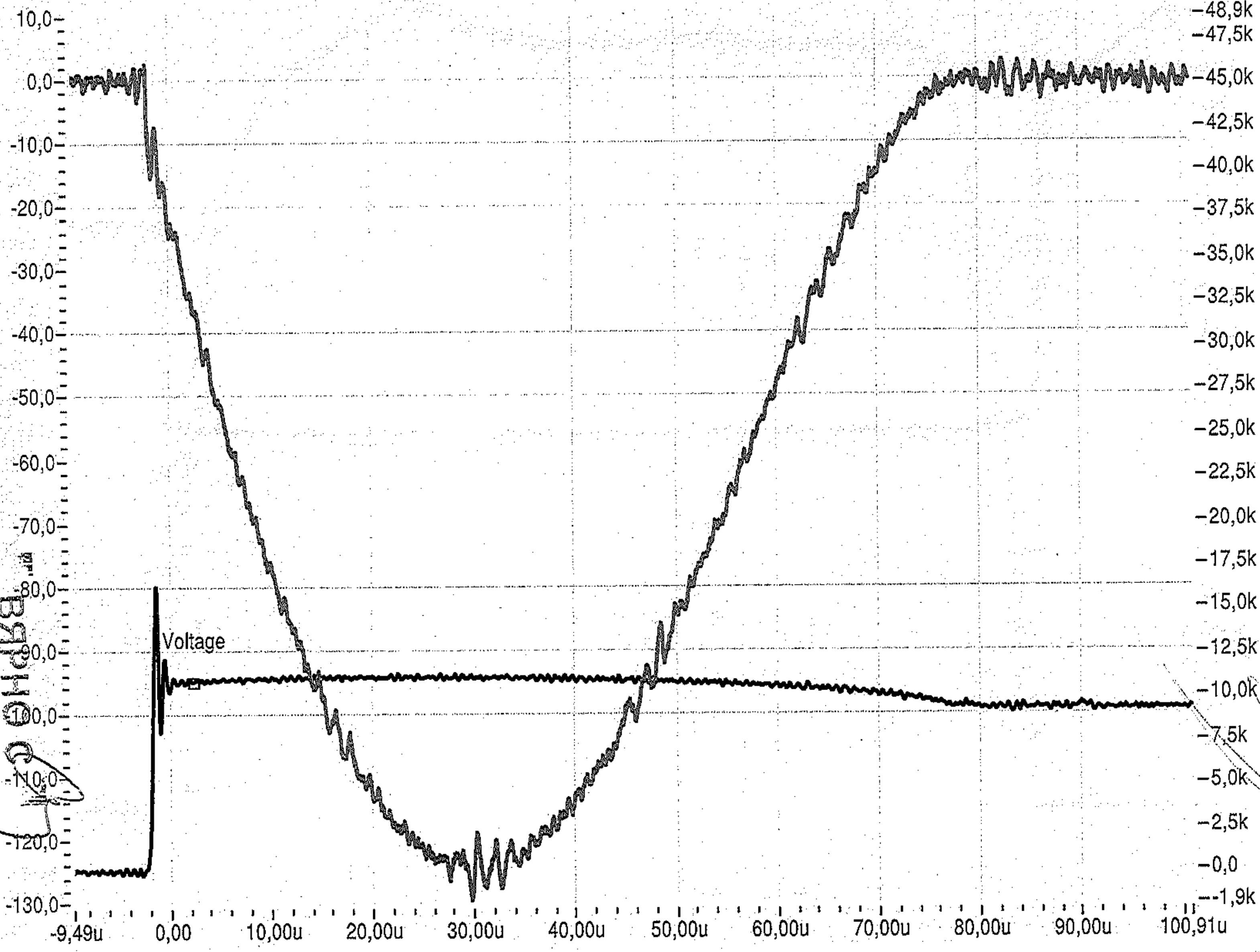


CESI B1027449 Oscillogram n. 1

ВЯРНО С ОРИГИНАЛА



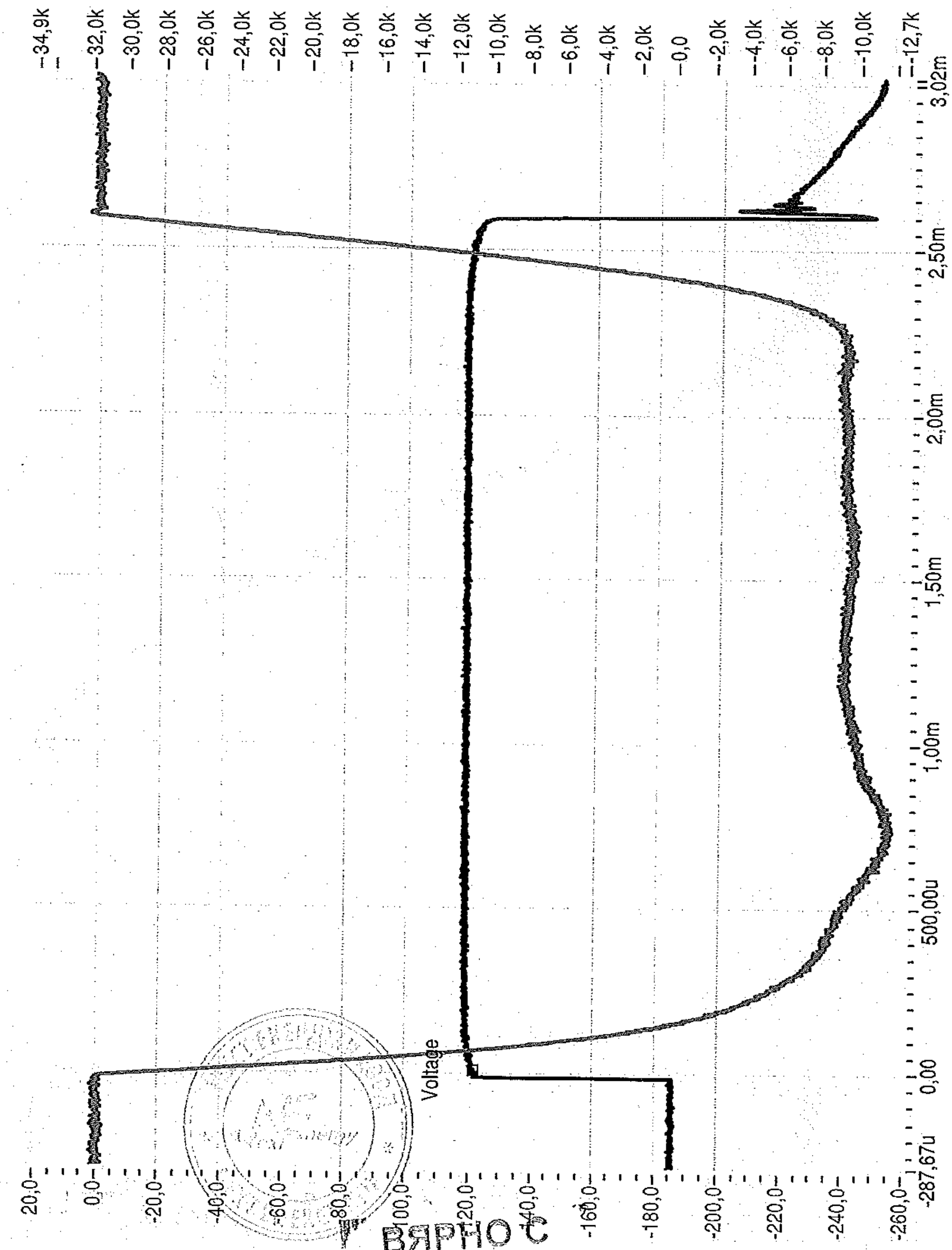
CESI B1027449 Oscillogram n. 2



CESI B1027449 Oscillogram n. 3

ВЯРНО С ОРИГИНАЛА

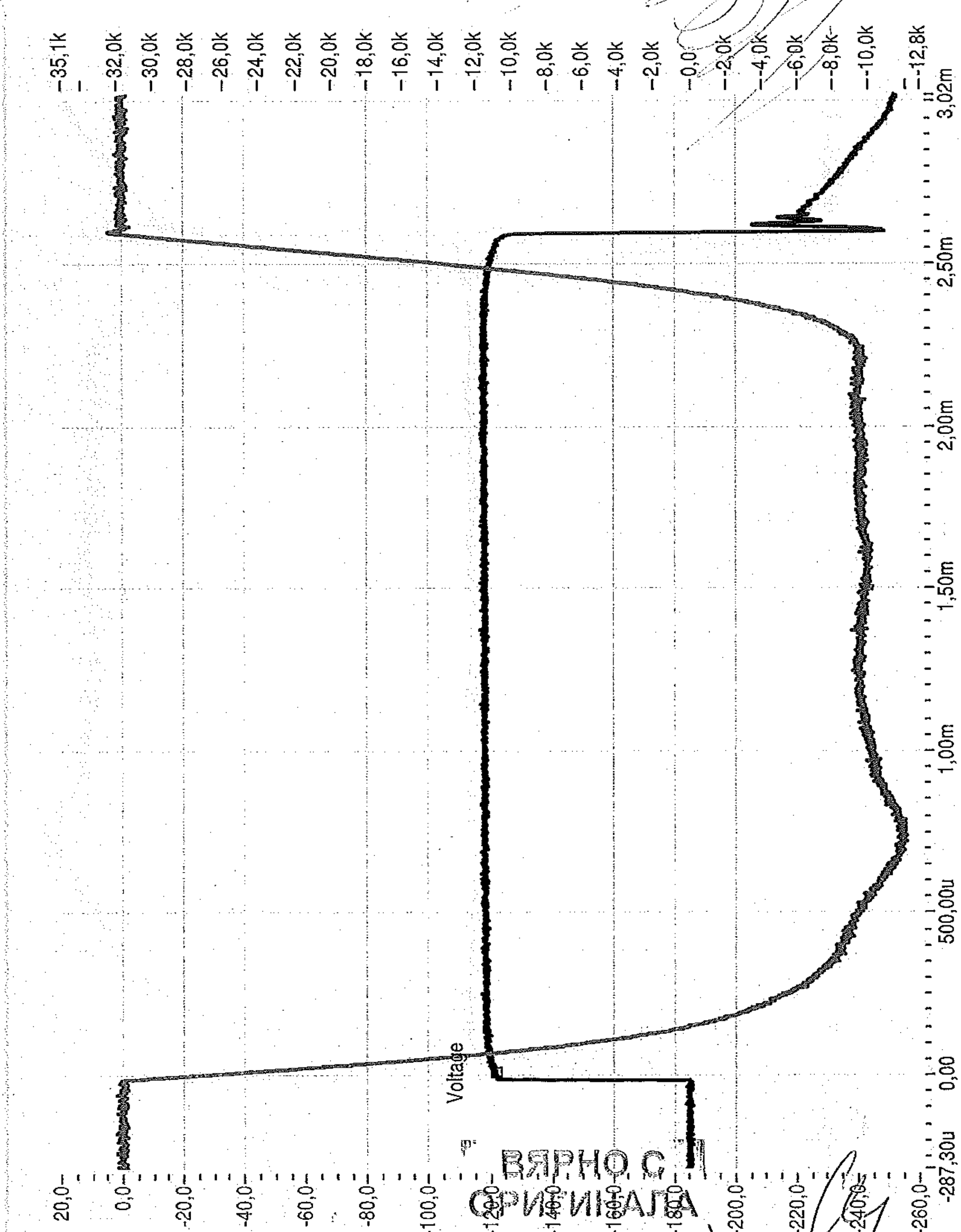
130



ВЯРНО С
ОРИГИНАЛА

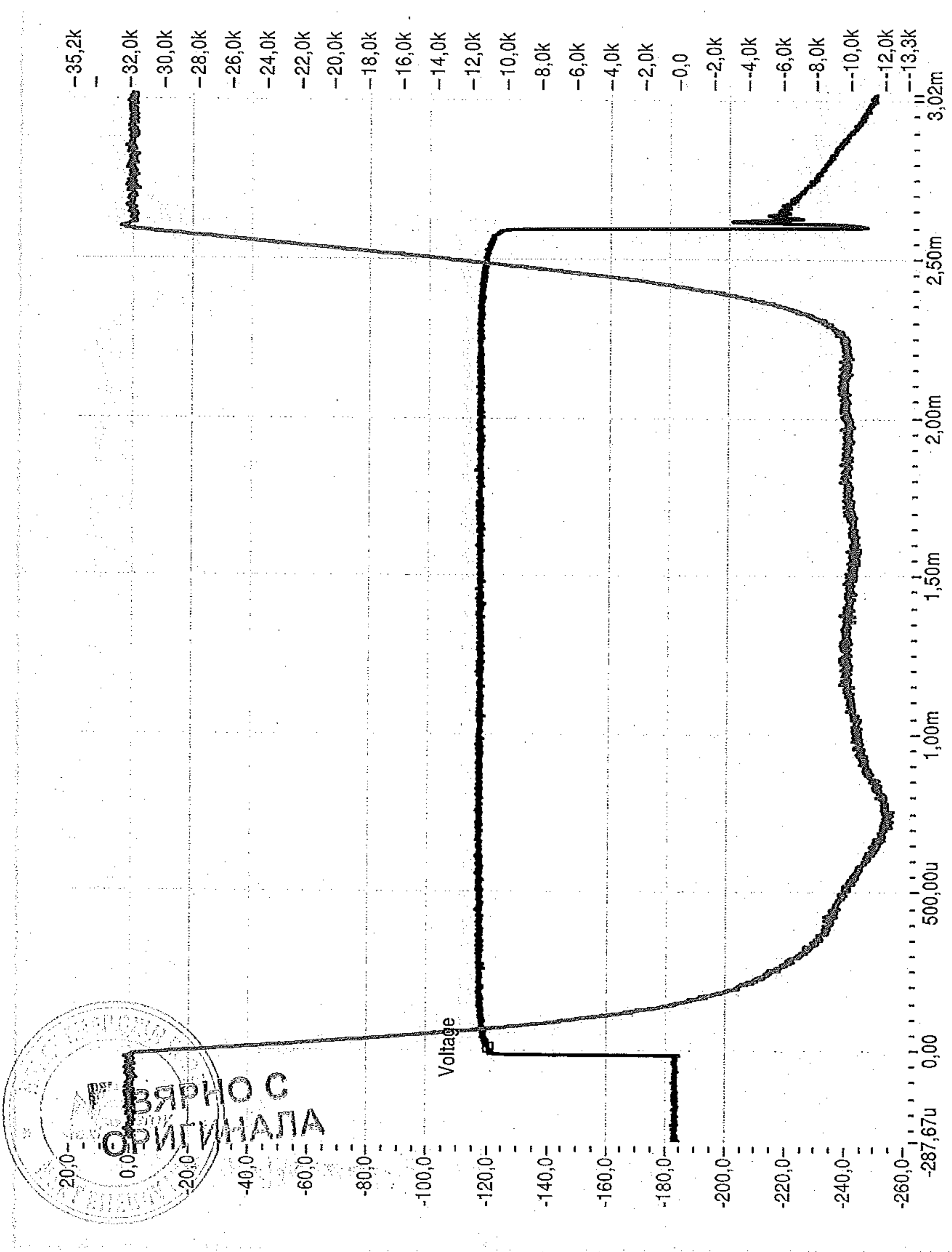
CESI B1027449 Oscillogram n. 4

431

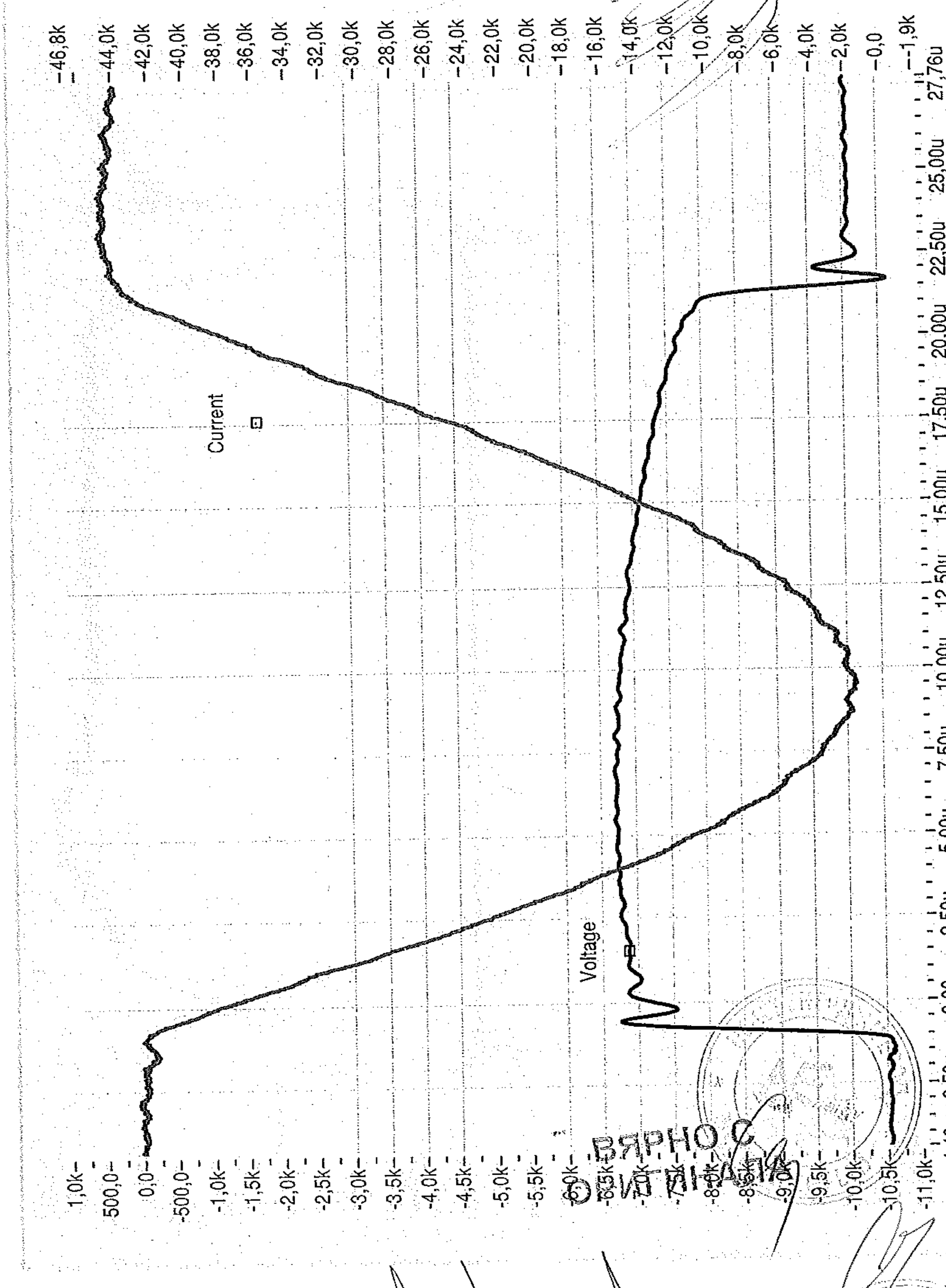


CESI B1027449 Oscillogram n. 5

182

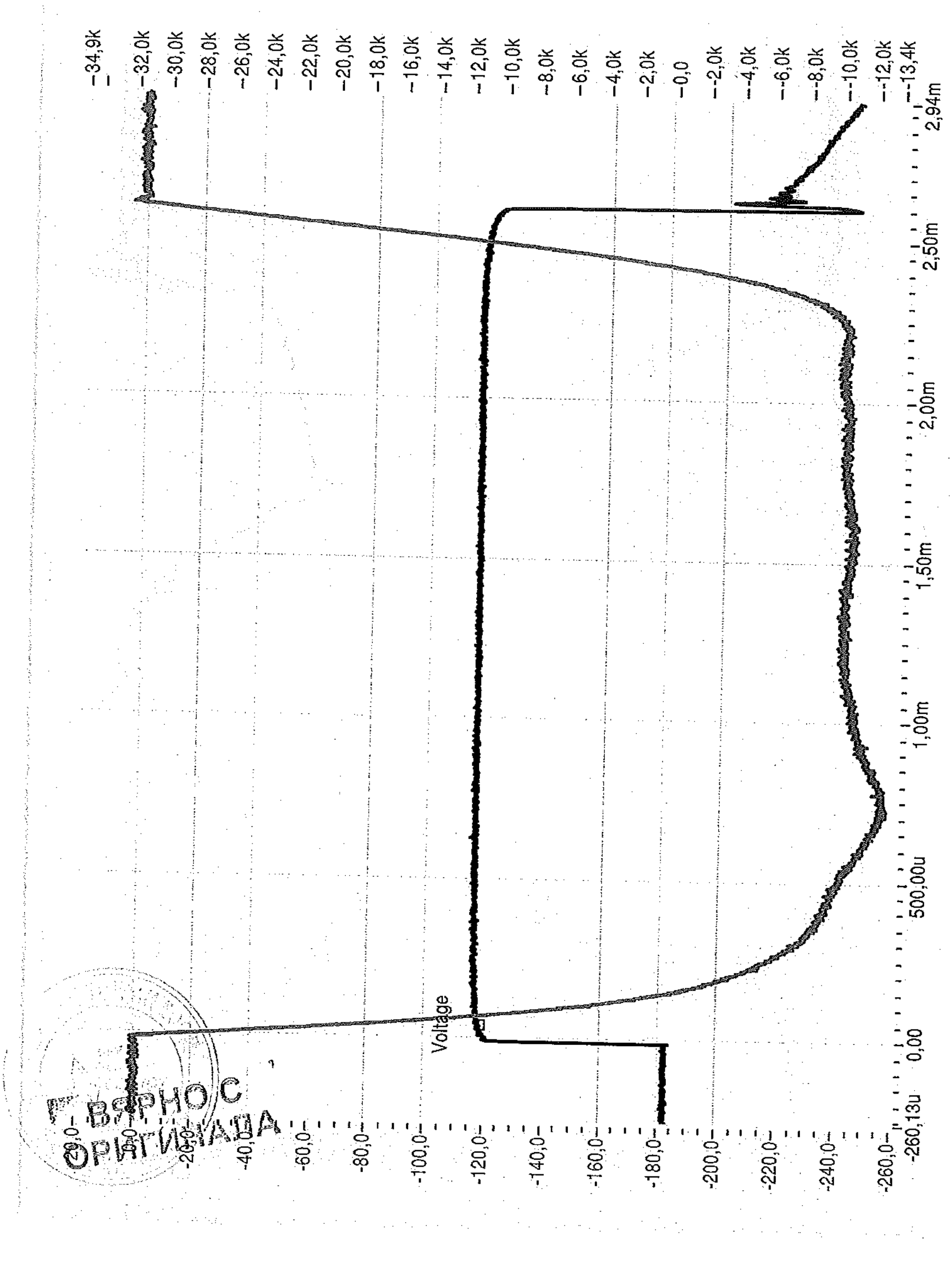


CESI B1027449 Oscillogram n. 6



ВЯРНО С ОРИГИНАЛА

CESI B1027449 Oscillogram n. 7



ВЯРНО С ОРИГИНАЛА

CESI B1027449 Oscillogram n. 8

435

CESI

Test Report

Client	TRIDELTA PARAFOUDES S.A.
Address of the Client	Boulevard de l'Adour - BP 256 - 65202 Bagneres de Bigorre Cedex (France)
Manufacturer	TRIDELTA PARAFOUDRES S.A.
Tested samples/items	Disconnector type S3D2 for metal oxide surge arrester
Tests carried out	Operating duty test
Standards/Specifications	IEC 60099-4 – Edition 2.2 (2009-05)
Tests date	from September 12, 2011 to September 14, 2011

Deutscher Akkreditierungs Rat DAR
DAT-PL-284/08-00

Testing laboratory accredited ISO/IEC 17025: 2005 in the fields of:
High-Voltage Equipment and their Components
Transformers and their Components
Low-Voltage Switching Devices and Switchgears
Electromagnetic Compatibility (EMC)

No. of pages	24	**No. of pages annexed**	15
Issue date	September 14, 2011		
Prepared	PPR - Gregori Marco		
Verified	PPR - Vidori Mauro, TPI - Sironi Alberto		
Approved	PMI - The Manager - Arcidiaco Lorenzo		

CESI S.p.A.
Testing & Certification Division
Testing Operations Area
"Milan Platform"
Manager
Lorenzo Arcidiaco

ВЯРНО С ОРИГИНАЛА

138

A1000IG rev.6

437

Tests witnessed by:

Mr. Frederic Malpiece	TRIDELTA Parafoudres S.A.
Mr A. Athanasas	PUBLIC POWER CORPORATION

Identification of the object: Not requested

Test evaluation
With reference to the Standards/Specifications listed in the first page and the characteristics of the tested sample assigned by manufacturer, the carried out tests passed SUCCESSFULLY.

The data necessary to permit repetition of the tests are contained in the document marked: —

The measurement uncertainties of the test results reported in this document are the following:

- dielectric tests with impulse voltage	: **peak voltage: ± 3 %**	**time parameters: ± 10 %**	
- dielectric tests with impulse current	: **peak value: ± 3 %**	**time parameters: ± 10 %**	
- dielectric tests with alternating voltage	: **voltage (rms): ± 3 %**	**time parameters: ± 3,5 %**	
- dielectric tests with direct voltage	: **voltage: ± 3 %**	**time parameters: ± 3,5 %**	
- partial discharge measurement	: **up to 10 pC: ± 1 pC**	**above 10 pC: ± 10 %**	
- atmospheric conditions	: **temperature: ± 2 °C**	**pressure: ± 0,133 kPa**	**humidity: ± 10 %**

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to confidence level of about 95%) and have to be considered as maximum values.

Laboratory information

Receipt date of the sample	September 12, 2011
Test location	CESI – Via Rubattino 54 – Milan
CESI testing team	Mr. L. Podavitte
Test laboratory	P177
Activity code	AE11PMI018

content	page	test date
Test object characteristics	4	
Pictures of the test object	from 5 to 6	
Reference standard	7	
Test carried out	7	
Test object identification	7	
Test procedure	8	
Visual inspection and summary of test result	9	
High current operating duty test	from page 10 to 16	September 12 to 14, 2011
Technical data	from page 17 to 24	
Pages annexed:		
Oscillograms n. 15 pages		

ВЯРНО С ОРИГИНАЛА

Test object characteristics

type: Disconnector type S3D2 for metal oxide surge arrester

The table below lists the electrical characteristics (assigned by the client) of the surge arresters for which the disconnectors are designed

electrical characteristics (assigned by the client)

Manufacturer's name	**TRIDELTA PARAFOUDRES S.A.**
Nominal discharge current – I_n [kA]	10
Rated voltage – U_r [kV]	1,035 x Uref
Continuous operating voltage - U_c [kV]	0,880 x Uref
Reference current - I_{ref} [mA]	1,0
Line discharge class	1
Standard rated frequency - [Hz]	50/60
year of manufacture	2011

ВЯРНО С ОРИГИНАЛА

439

Pictures of the sample

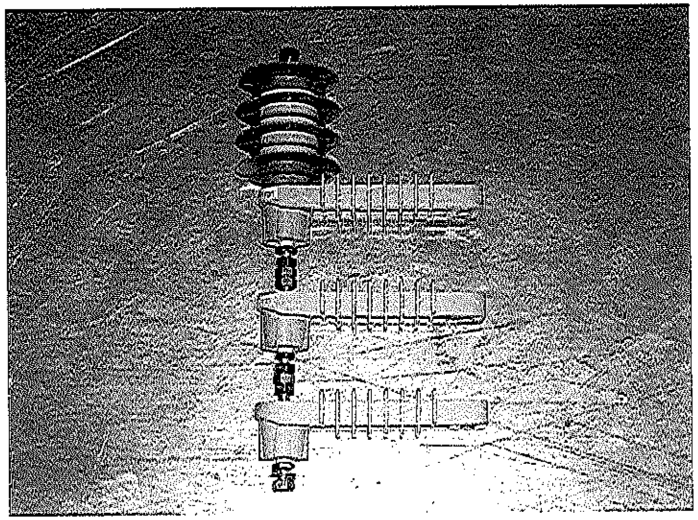


Photo no. 1

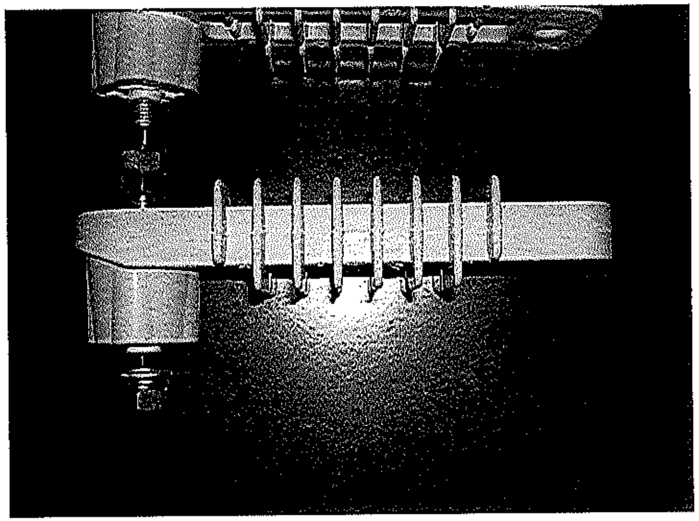


Photo no. 2

ВЯРНО С ОРИГИНАЛА

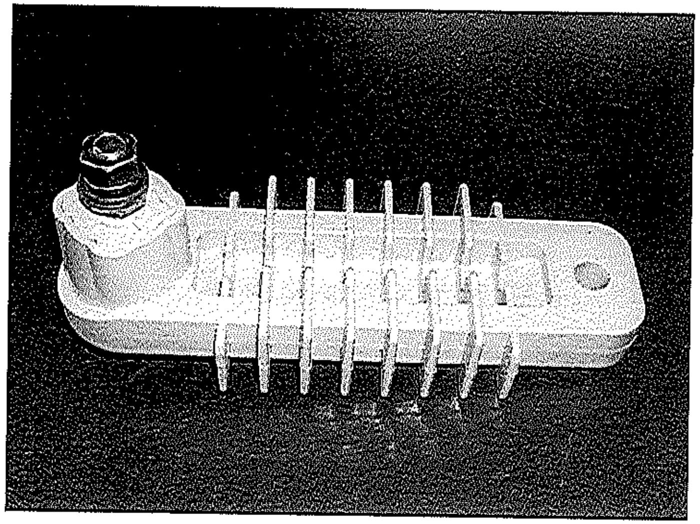


Photo no. 3

Photo no. 4

Reference Standard

IEC 60099-4 (2009/05) – Edition 2.2 - Clause 8.6.2
"Metal-oxide surge arresters without gaps for a.c. systems"

Test carried out	Number of samples tested
Operating duty test	3

Test object identification

Test object name	Identification of test sample (given by CESI)
Disconnector type S3D2 for metal oxide surge arrester	1OD - 2OD - 3OD

ВЯРНО С ОРИГИНАЛА

Test procedure

The test has been performed on three disconnectors connected in series.
A suitable surge arrester section was supplied by the Client.
It was used , as part of the circuit in this frame, connected in series with the test samples, to get proper impulse current waves and power frequency current flowing through the disconnectors.

The test procedure consisted of the following sequence:

a) Measurement of the power frequency reference voltage at the reference current

b) Measurement of the lightning impulse residual voltage at the nominal discharge current

c) Calculation of the voltage correction factors according to the reference standard

d) Conditioning 1: application of twenty impulses 8/20 µs at the nominal discharge current superimposed to the power frequency voltage at 1,2 times $U_c^{'}$ in four groups of five impulses
- interval between impulses of the same group: 50-60 seconds
- interval between groups: 30 minutes
- polarity of the impulses: same as that of the half cycle of power frequency voltage during which it occurred (positive)
- synchronization of the impulses: 60 electrical degrees before the peak of the power frequency.

e) Conditioning 2: application of one high current impulse 4/10 µs at 100 kA

f) Heating in an oven at the temperature of 60 °C till thermal equilibrium

g) Application of a second high current impulse 4/10 µs at 100 kA. A time shorter than 100 ms after the application of the second high current shot energization at U_r' for 10 sec. and then at U_c' for 30 min. to verify the thermal stability.

h) Measurement of the lightning impulse residual voltage at nominal discharge current for comparison with initial value with two impulses at 50 sec to 60 sec. time interval in between

The disconnectors did not operate.

The acceptance criteria are fulfilled. The test result is positive.

Visual inspection after the test

The disconnectors withstood the full procedure without operation and without showing any visible damage.

ВЯРНО С
ОРИГИНАЛА

494

Operating duty test.

Reference voltage test

Test circuit: A0019

Date: September 12, 2011

Oscillogram	voltage	current	current	current	power	3rd harmonic amplitude
	Sample No. 1OD-2OD-3OD					
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	µA
1	6,05	0,98	1,01	0,56	1,71	--

495

Operating duty test.

Lightning impulse residual voltage measurement before the test

Test circuit: A0120

Date: September 12, 2011

Sample	Requested current	Charging voltage	Oscillogram	Current waveshape	Discharge current	Residual Voltage
No.		kV	No.	µs	kA	kV
1OD-2OD-3OD	I_n	28,0	2	8,5/17,6	10,04	15,57

Notes:

ВЯРНО С
ОРИГИНАЛА

496

Operating duty test.

Voltage correction factor and energy calculations

Date: September 13, 2011

Sample	U_{ref} [1]	KU_r [2]	KU_C [3]	U_r' [4]	U_c' [5]	U_*' [6]
No.	kV			kV	kV	kV
1OD-2OD-3OD	6,05	1,035	0,880	6,262	5,324	6,389

[1] U_{ref} : measured reference voltage
[2] KU_r : factor claimbed by the manufacturer for calculation of U_r'
[3] KU_C : factor claimbed by the manufacturer for calculation of U_c'
[4] U_r' : corrected rated voltage [4] = [1] × [2]
[5] U_c' : corrected continuous operating voltage [5] = [1] × [3]
[6] U_*' : corrected voltage to be applied during the conditioning [6] = 1.2 × [5]

ВЯРНО С ОРИГИНАЛА

497

Operating duty test.

Conditioning

Test circuit: A0015

Date: September 13, 2011

Imp.	Osc.	Sample No. 1OD-2OD-3OD charging voltage	peak current	Note:
No.	No.	kV	kA	
1	4	36,6	10,0	
2		36,6	10,0	
3		36,6	10,0	
4		36,6	10,0	
5	5	36,6	10,0	
6		36,6	10,0	
7		36,6	10,0	
8		36,6	10,0	
9		36,6	10,0	
10	6	36,6	10,0	
11		36,6	10,0	
12		36,6	10,0	
13		36,6	10,0	
14		36,6	10,0	
15		36,6	10,0	
16		36,6	10,0	
17		36,6	10,0	
18		36,6	10,0	
19		36,6	10,0	
20	7	36,6	10,0	

Power frequency voltage applied to the test disconnectors	Sample No. 1OD-2OD-3OD
	6,389

Notes:

ВЯРНО С ОРИГИНАЛА

498

Operating duty test.

Conditioning: Application of two 100 kA 4/10 µs high current impulses (second part)

Test circuit: A0121

Date: September 13, 2011

Sample	Impulse	Charging voltage	Oscillogram	Discharge current	Current waveshape	Opposite polarity
No.	No.	kV	No.	kA	µs	%
1OD-2OD-3OD	1	83,1x2	8	100,3	4,5/9,9	5,0

Notes:

Operating duty test.

Application of the high current impulse, corrected rated voltage U_r' and corrected continuous operating U_c' for evaluation of the thermal stability.

Test circuit: A0123-A0020-A0131

Sample No.: 1OD-2OD-3OD

Ambient temperature 18 °C
Preheating temperature: 61 °C

Date: September 14, 2011

Second high current impulse application

Oscillogram	Charging voltage	Residual voltage	Discharge current	Current waveshape
No.	kV	kV	kA	µs
9	83,0x2	---	96,0	4,5/9,9

Corrected rated voltage U_r' application

Oscillogram	Time	Voltage	Current	Current	Power
No.	s	kV	+ mA_{cr}	- mA_{cr}	W
10	0	6,262	21,0	32,1	---
11	10		11,5	16,0	---

Corrected continuous operating voltage U_c' application to evaluate the thermal stability

Oscillogram	Time	Voltage	Current	Current	Power
No.	min	kV	+ mA_{cr}	- mA_{cr}	W
12	0	5,324	1,66	2,20	3,39
	5		0,83	0,81	1,30
	10		0,80	0,77	1,10
13	15		0,78	0,77	0,96
	20		0,77	0,75	0,87
	25		0,76	0,74	0,80
14	30		0,76	0,73	0,74

ВЯРНО С
ОРИГИНАЛА

500 1530

Operating duty test.

Lightning impulse residual voltage measurement after the test

Test circuit: A0120

Date: September 14, 2011

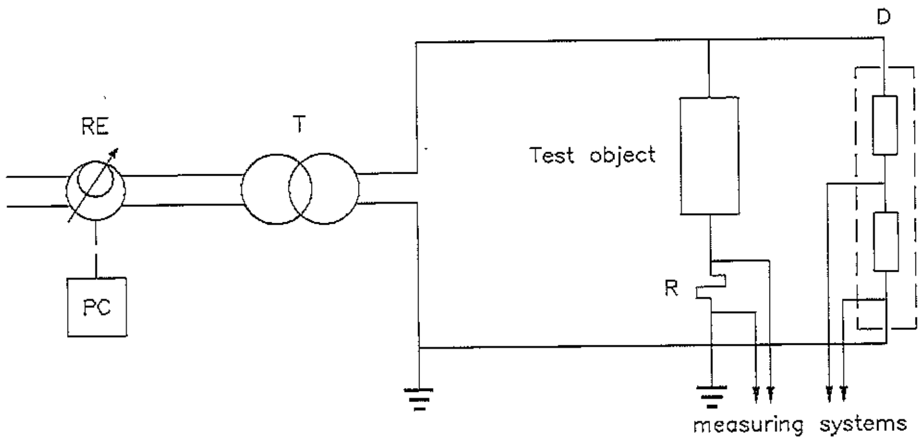
Sample	Requested current	Charging voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage
No.		kV	No.	µs	kA	kV
1OD-2OD-3OD	I_n	28,0	15	8,5/17,6	10,18	15,74
		28,0	16		10,16	15,73

Notes:

ВЯРНО С ОРИГИНАЛА

1501 501

Circuit A0019



Power frequency supply

RE - programmable supply type PACIFIC A.C. Power Source 140 ASX.; CESI no. 0560408
PC - personal computer
T - voltage transformer type SPECIALTRASFO; power 30 kVA; voltage 200 V/15-30 kV

Current measuring system

R - Current shunt CESI No.31120; R= 941,4 Ω
- Electro optical system CESI No.11517/518
OSC - Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122;
- CESI No 056227- 0562226 (on channel No.1)

Voltage measuring system

D - Voltage divider SAGI; CESI No.11120
- Electro optical system CESI No.11521/522
OSC - Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122;
- CESI No 056227- 0562226 (on channel No.2)

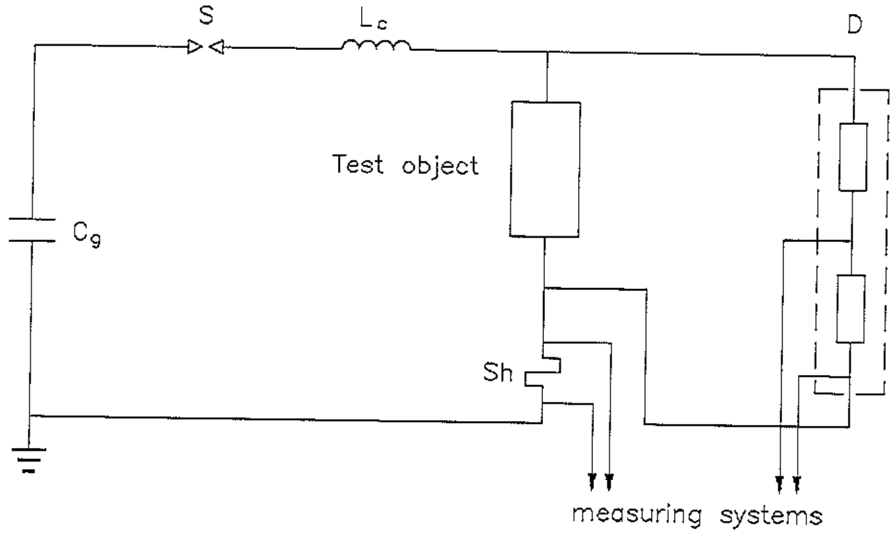
Software system:

SW - S.A.D. Surge arrester version 1.0

ВЯРНО С ОРИГИНАЛА

592 15088

Circuit A0120



Impulse generator

No. of stages	1
Cg	4,98 μF
Lc	10 μH
S	- Spark-gap

Voltage measuring system.

D	- Voltage divider SAGI; CESI No.13027
	- Electro optical system CESI No.11521/522;
OSC	- Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122;
	- CESI No 056227- 0562226 (on channel No.2)

Current measuring system

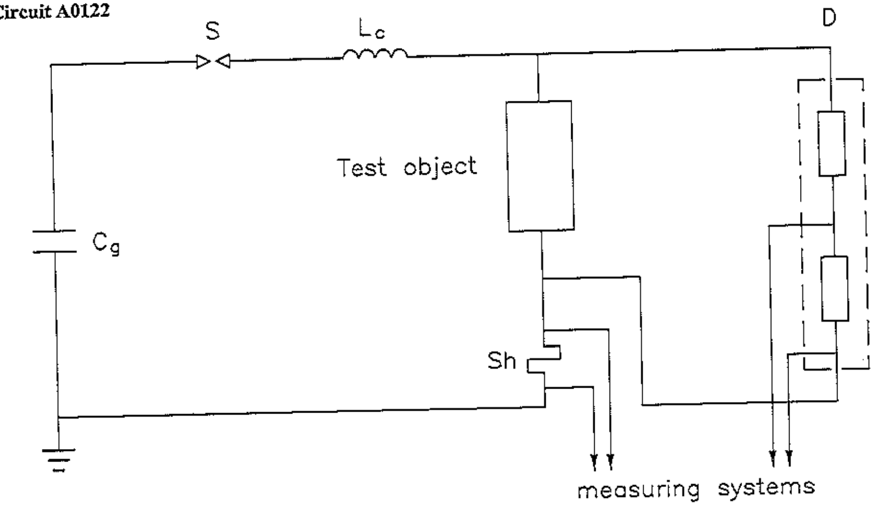
Sh	- Current shunt CESI No.6042; R= 2 mΩ; peak current= 250 kA
	- Electro optical system CESI No.11517/518;
OSC	- Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122;
	- CESI No 056227- 0562226 (on channel No.1)

Software system:

SW - S.A.D. Surge arrester version 1.0

503

Circuit A0122



Impulse generator

No. of stages	1
Cg	1,66 µF
Lc	120 µH
S	- Spark-gap

Voltage measuring system.

D - Voltage divider SAGI; CESI No.11120
- Electro optical system CESI No 11521/522

OSC - Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122;
- CESI No 056227- 0562226 (on channel No.2)

Current measuring system

Sh - Current shunt CESI No.6037; R= 20 mΩ; peak current= 250 kA
- Electro optical system CESI No 11517/519

OSC - Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122;
- CESI No 056227- 0562226 (on channel No.1)

Software system:

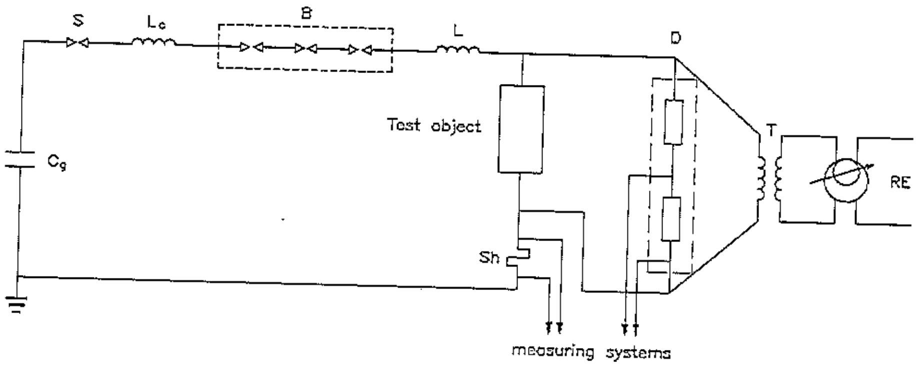
SW - S.A.D. Surge arrester version 1.0

A014IG

ВЯРНО С ОРИГИНАЛА

534

Circuit A0015



Impulse generator

No. of stages: 1
C_g - Capacitor 4,98 µF
L - Inductance of the circuit
L_c - Inductor 10 µH
S - Spark gap
One resistor block has been added
Power frequency supply
RE - Regulator type specicialtrasfo; power 20 kVA; voltage 380 V/ 220 V
T - Transformer type Pivi; power 30 kVA; voltage 220 V/ 15 kV
B - Blocking gap

Current measuring system
Sh - Current shunt CESI No.6037; R= 20 mΩ; peak current= 250 kA
- Electro optical system CESI No 11517/519
OSC - Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122/ NI-PXI 5152;
- CESI No 056227- 0562226 (on channel No.1)

Voltage measuring system.
D - Voltage divider SAGI; CESI No.11120
- Electro optical system CESI No 11521/522
OSC - Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122/ NI-PXI 5152;
- CESI No 056227- 0562226 (on channel No.2)

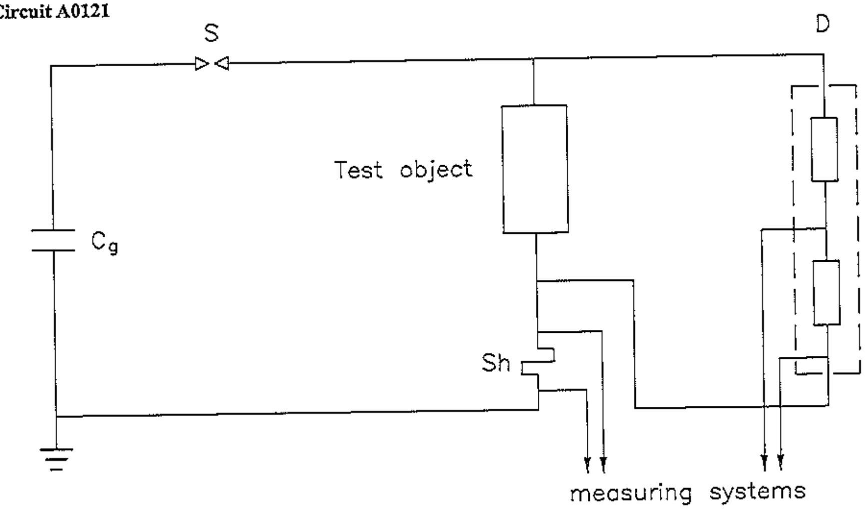
Software system:
SW - S.A.D. Surge arrester version 1.0

A0015IG

ВЯРНО С ОРИГИНАЛА

5?5

Circuit A0121



Impulse generator

No. of stages 2
Cg 3,32 μF

S - Spark-gap

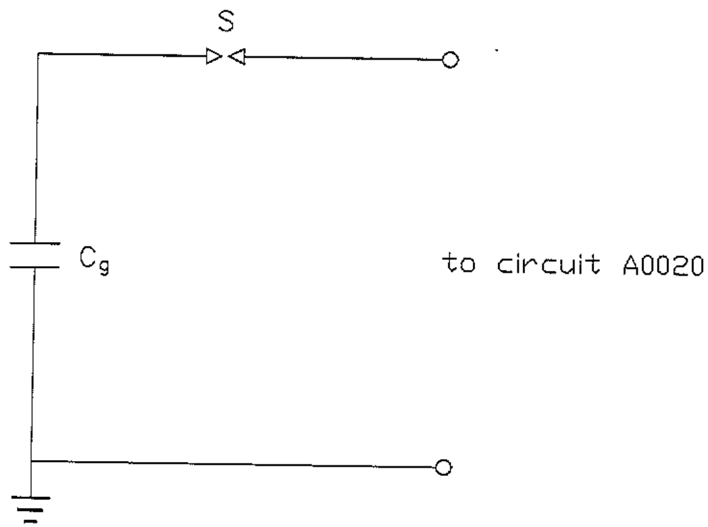
Three blocks in series have been added
Voltage measuring system.
D - Voltage divider SAGI; CESI No.11120
- Electro optical system CESI No11517/518
OSC - Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122;
- CESI No 056227- 0562226 (on channel No.2)

Current measuring system
Sh - Current shunt CESI No.6042; R= 2 mΩ; peak current= 250 kA
- Electro optical system CESI No11521/522
OSC - Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122;
- CESI No 056227- 0562226 (on channel No.1)

Software system:
SW - S.A.D. Surge arrester version 1.0

ВЯРНО С ОРИГИНАЛА
506

Circuit A0123



Impulse generator circuit

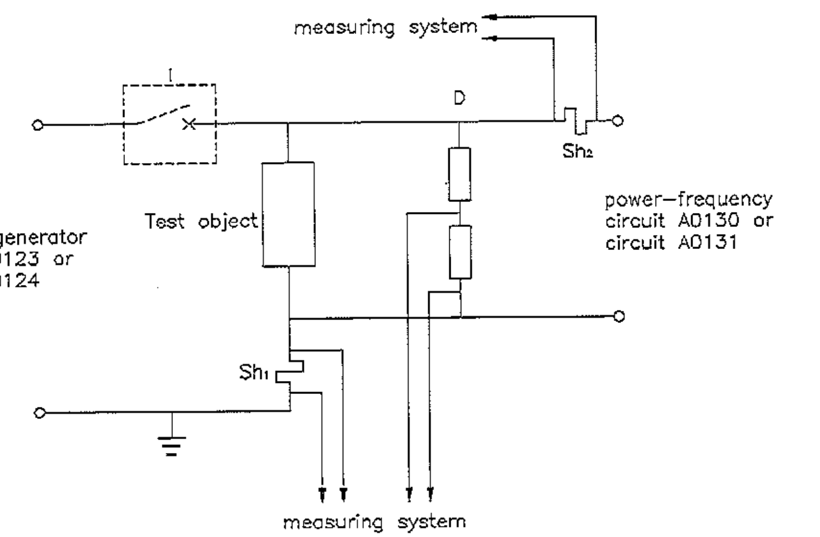
No. of stages 2
Cg 3,32 µF

S - spark-gap

A0123IG

507

Circuit A0020



Impulse generator circuit A0123

I - Circuit-breaker

Impulsive current measuring system

Sh_1 - Current shunt CESI No.6042; R= 2 m Ω
- Electro optical system CESI No.11517/518

OSC_1 - Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.1)

Power frequency circuit A0130

Voltage measuring system.

D - Voltage divider SAGI; CESI No.11120
- Electro optical system CESI No.8009/8015

OSC - Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122;
- CESI No 056227- 0562226 (on channel No.2)

Power frequency current measuring system

Sh_2 (MCOV) - Current shunt CESI R= 1000 Ω - Electro optical system CESI No.11519/11520

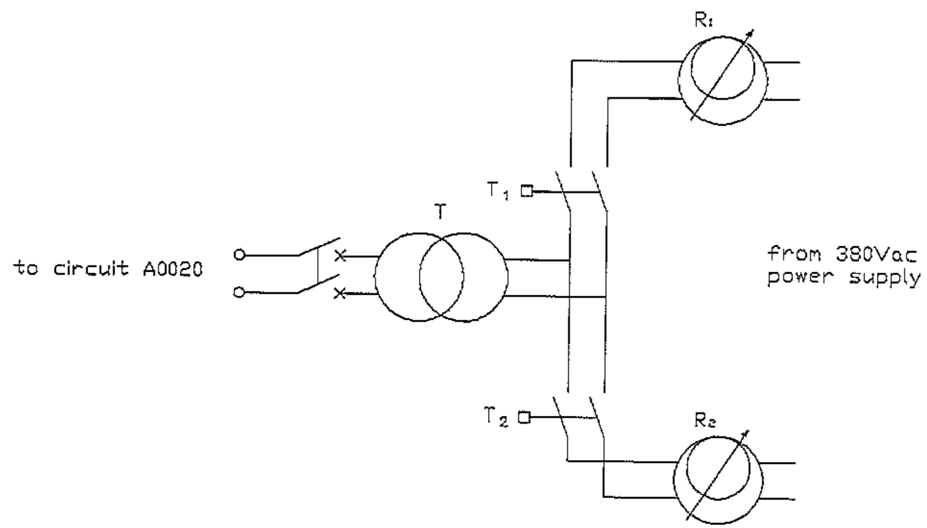
OSC - Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122;
- CESI No 056227- 0562226 (on channel No.1)

Software system:

SW - S.A.D. Surge arrester version 1.0

538

Circuit A0131

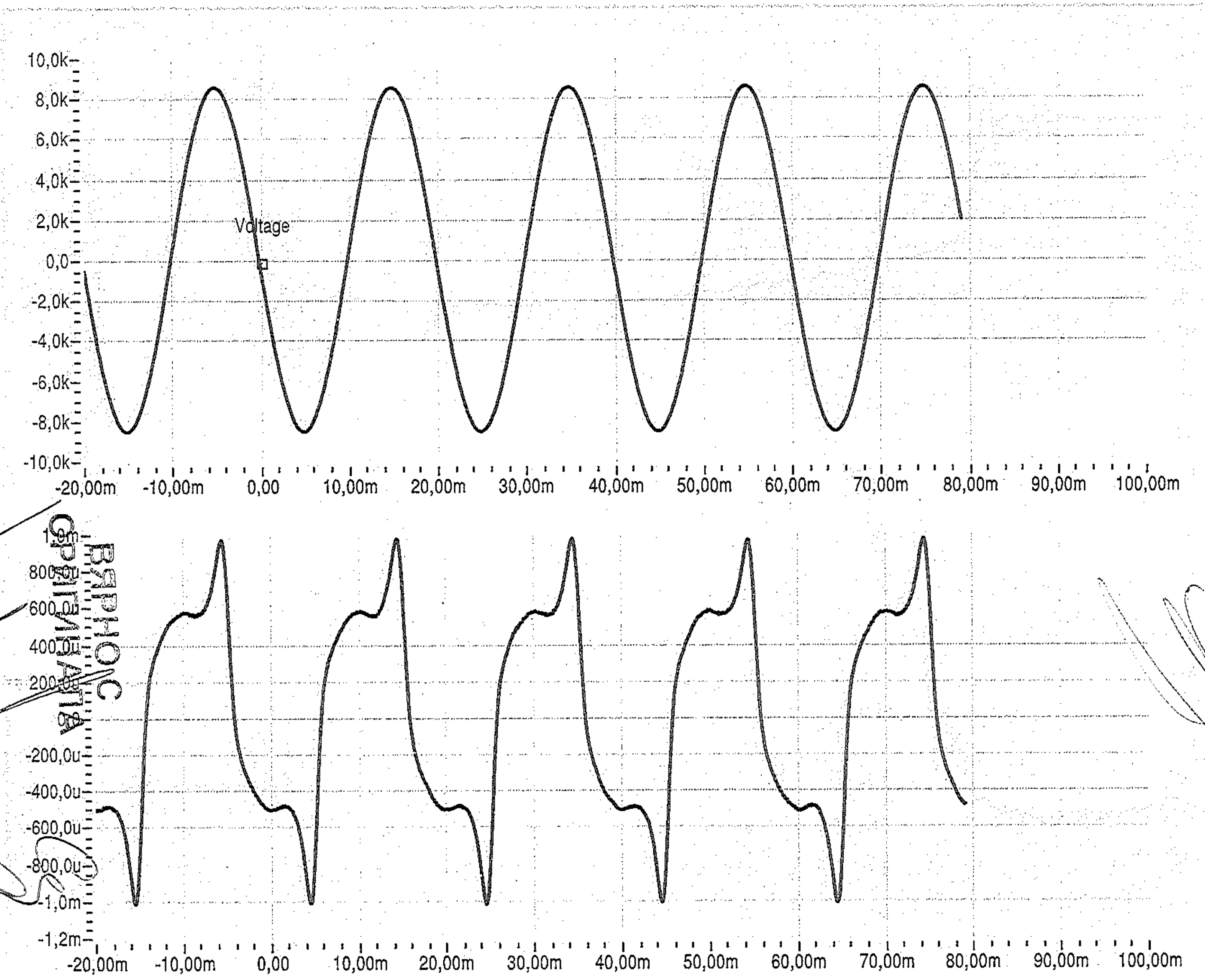


Power-frequancy circuit

from 380Vac power supply

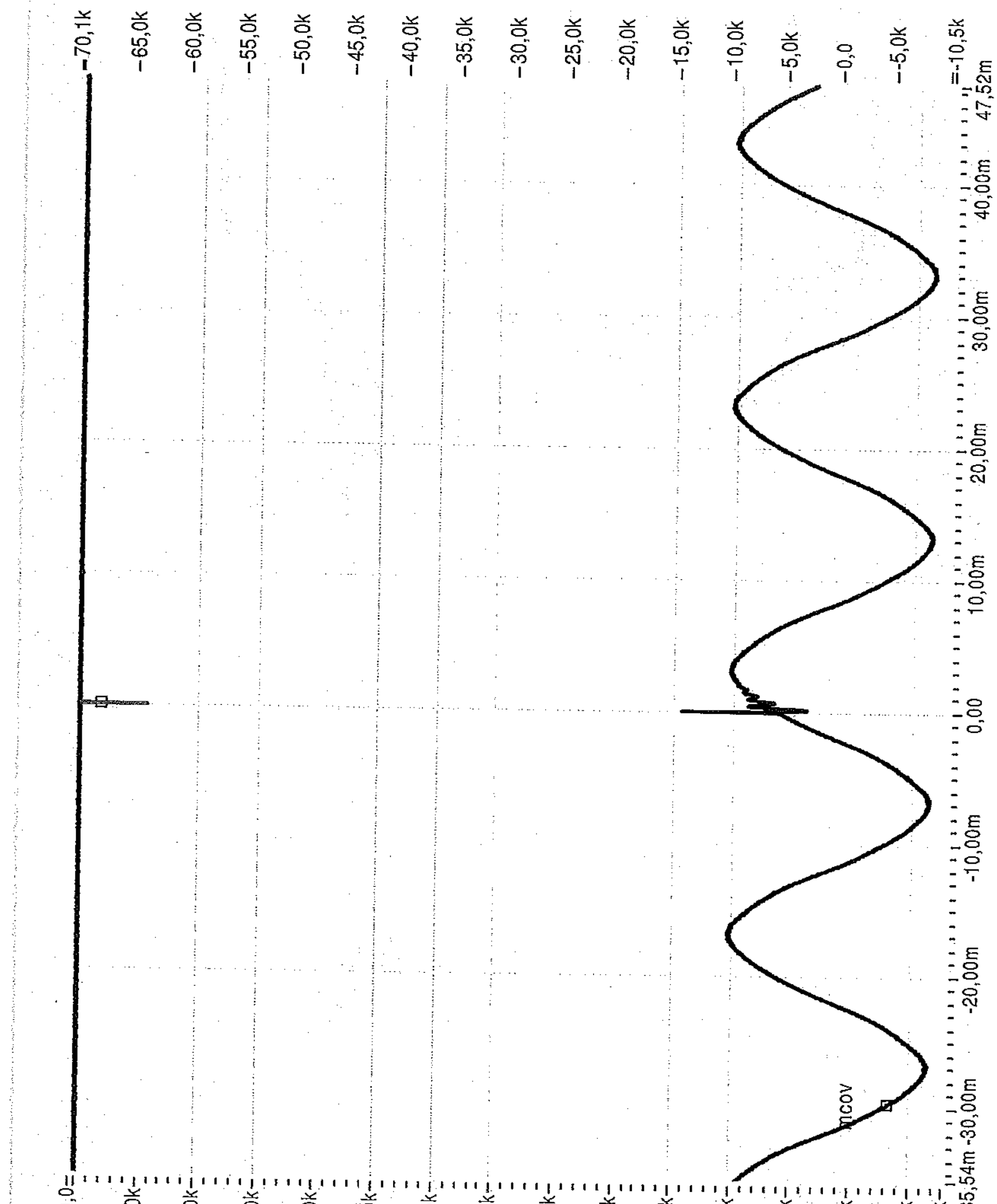
R_1 single-phase voltage regulator CORMES; power 20 kVA; voltage 380/04220 Vac
R_2 single-phase voltage regulator CORMES; power 10 kVA; voltage 380/04220 Vac
T_1 voltage transformer type SPECIALTRASFO; power 30 kVA; voltage 200-400 V/15-30 kV

509



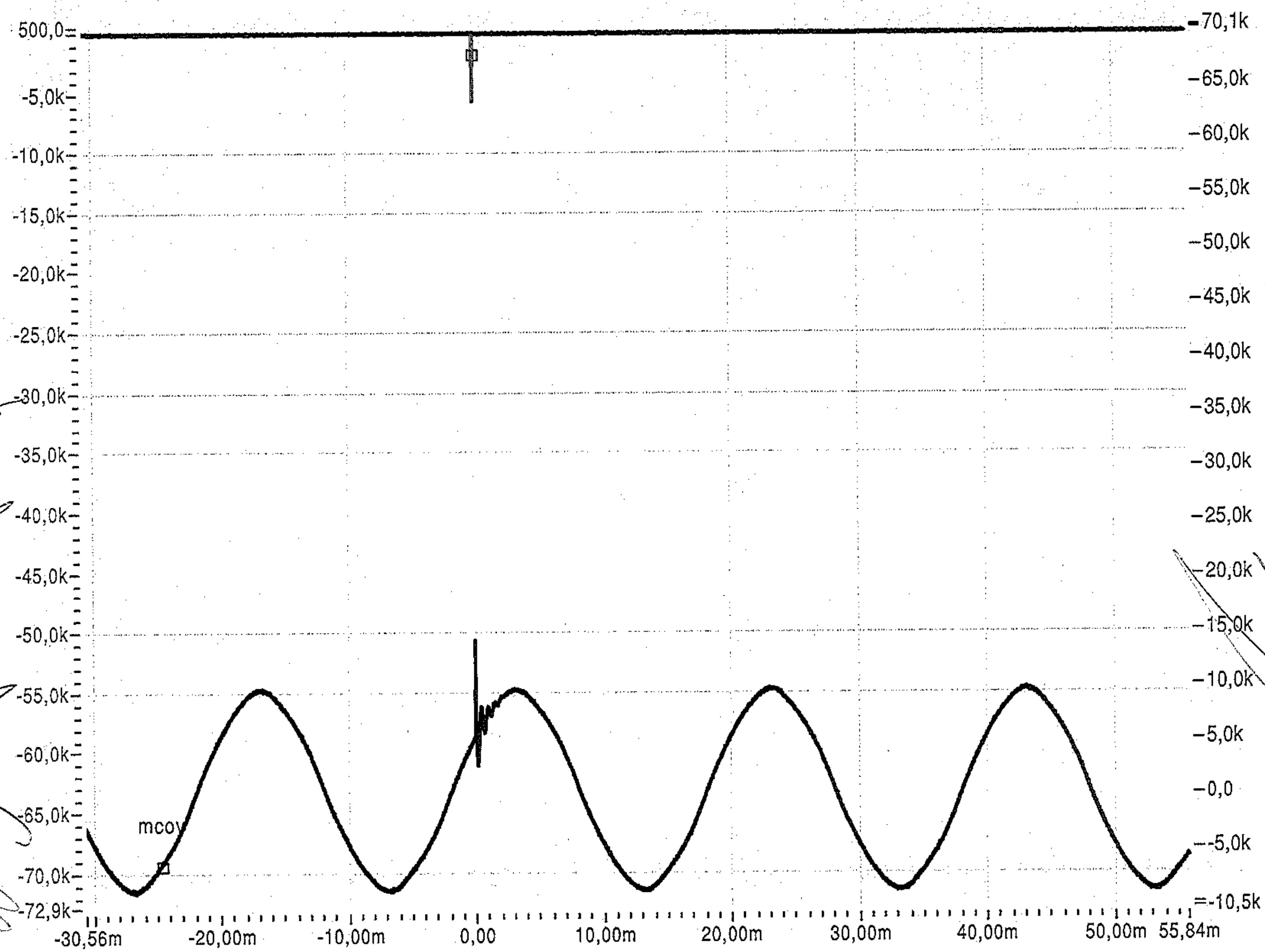
CESI B1027448 Oscillogram n. 1

ВЯРНО С ОРИГИНАЛА



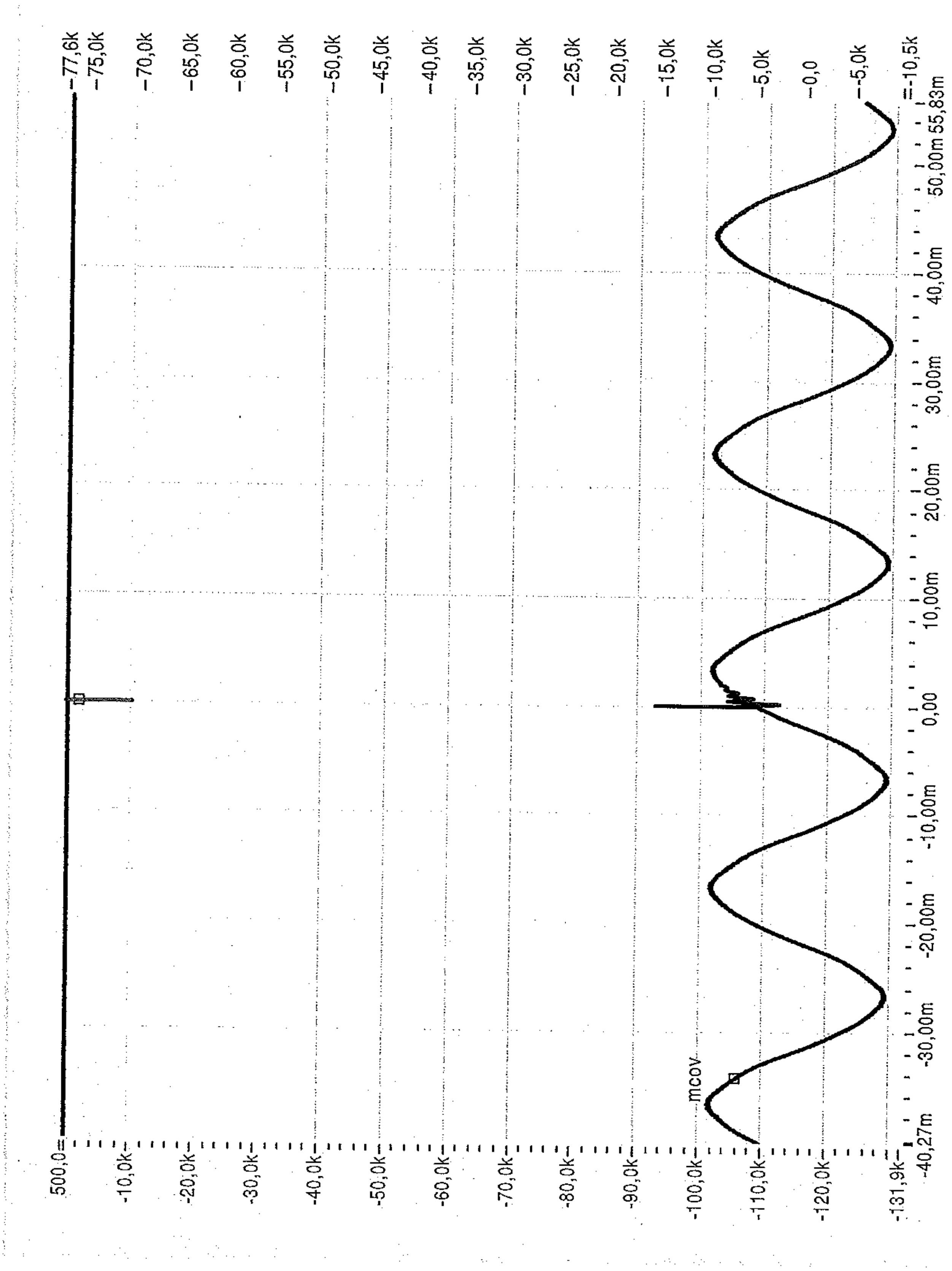
ВЯРНО С
ОРИГИНАЛА

CESI B1027448 Oscillogram n. 5



CESI B1027448 Oscillogram n. 6

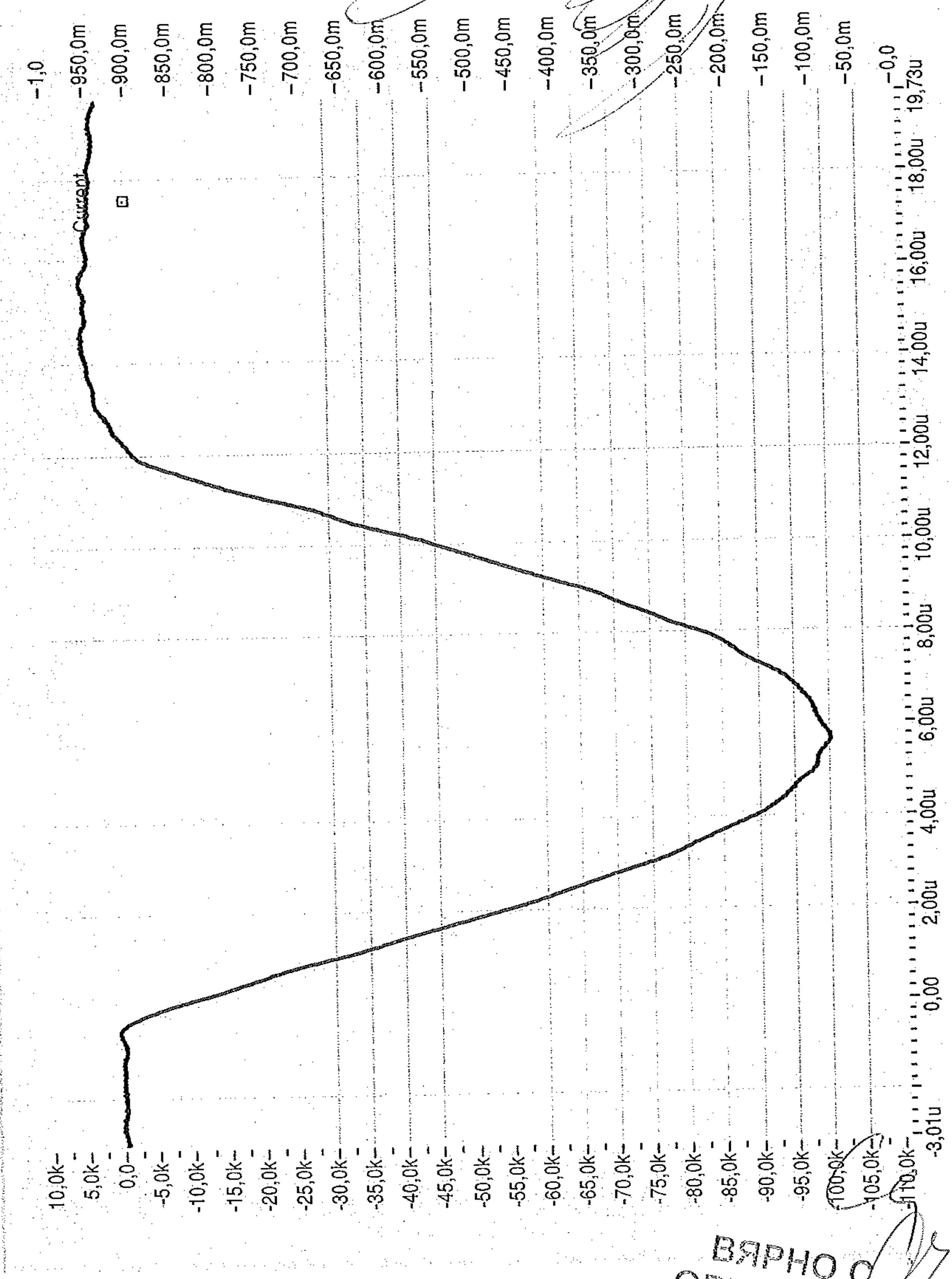
ВЯРНО С ОРИГИНАЛА



ВЯРНО С ОРИГИНАЛА

\CESI B1027448\Oscillogram n. 7

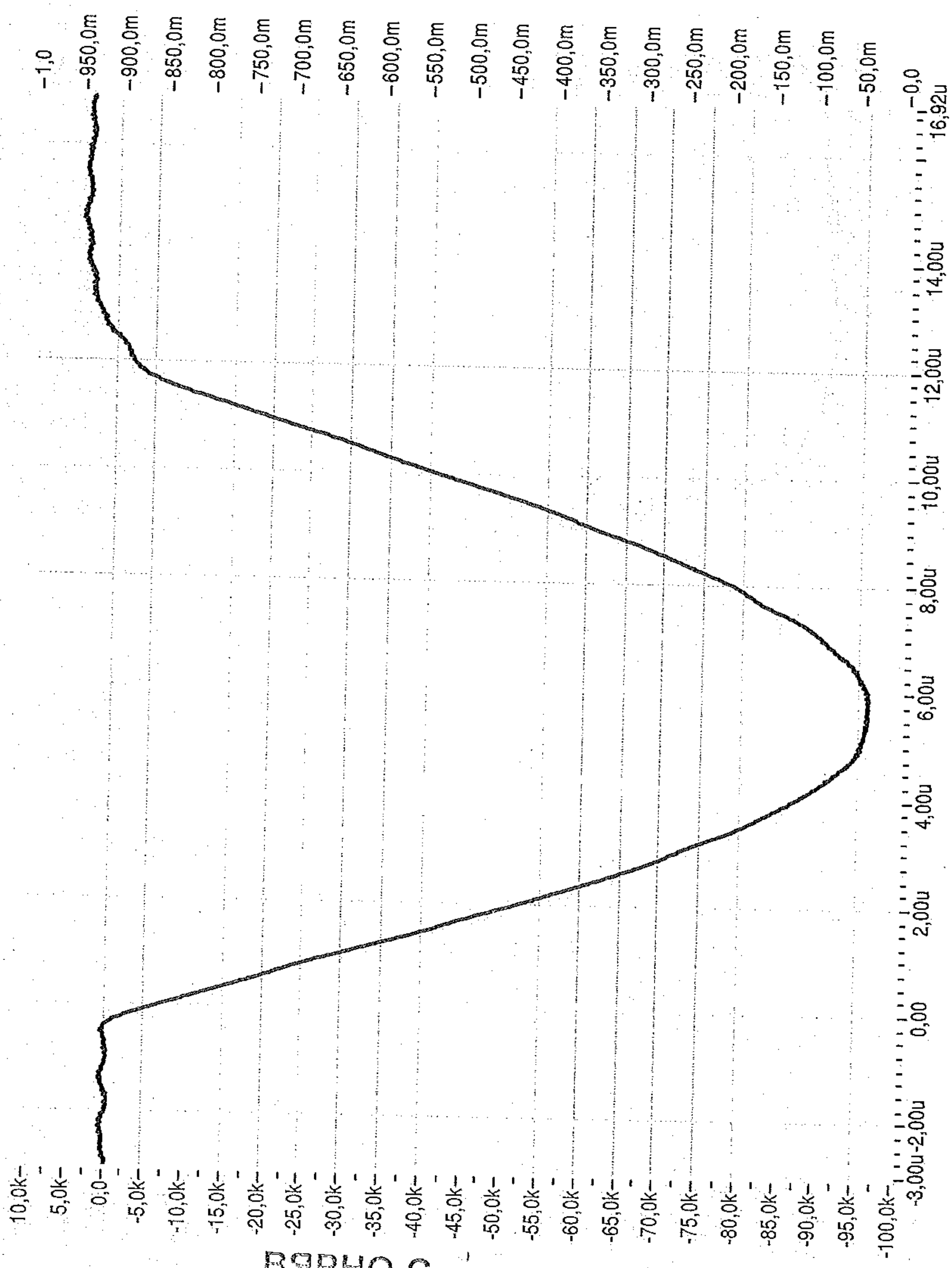
515



ВЯРНО С ОРИГИНАЛА

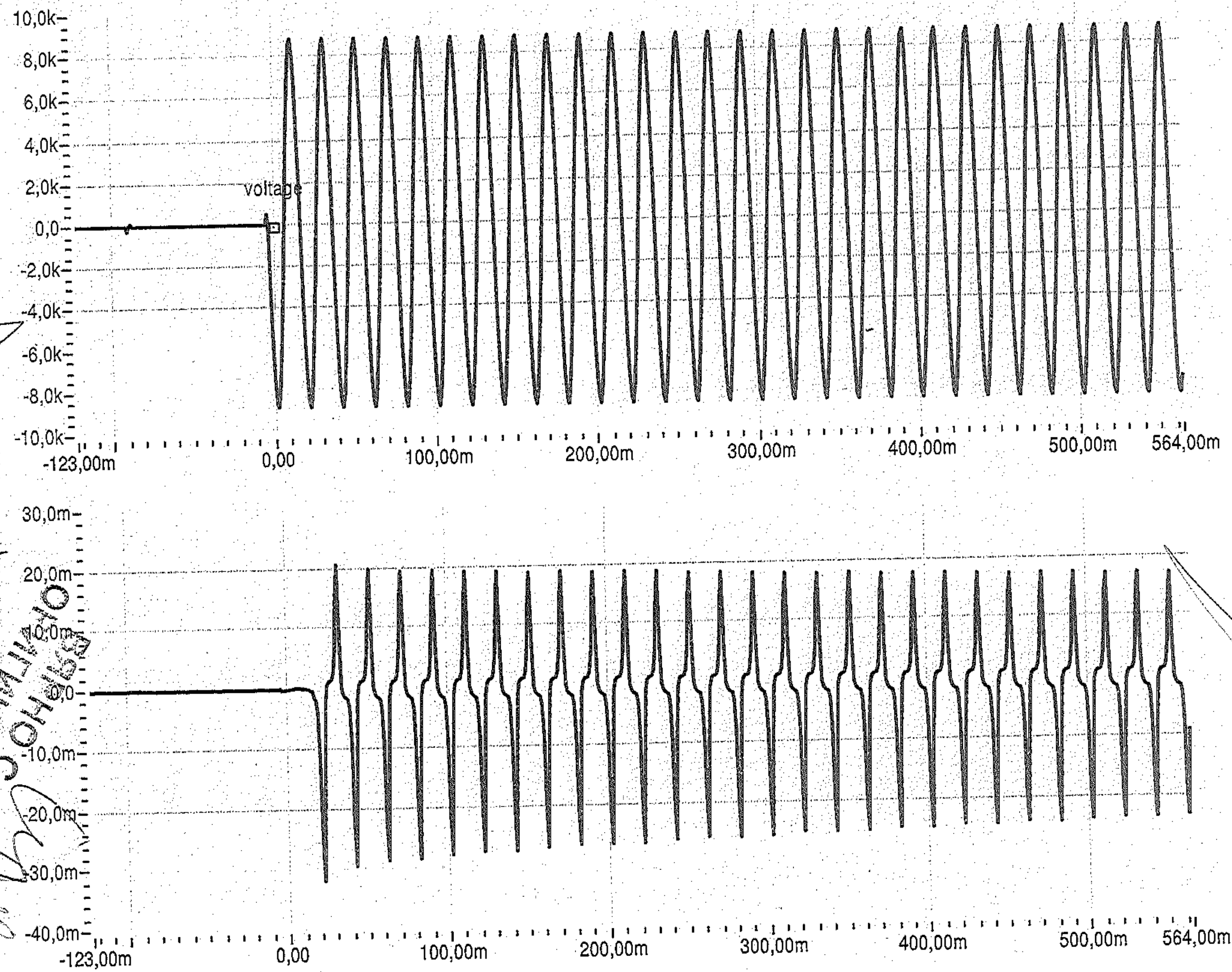
CESI B1027448 Oscillogram n. 8

516



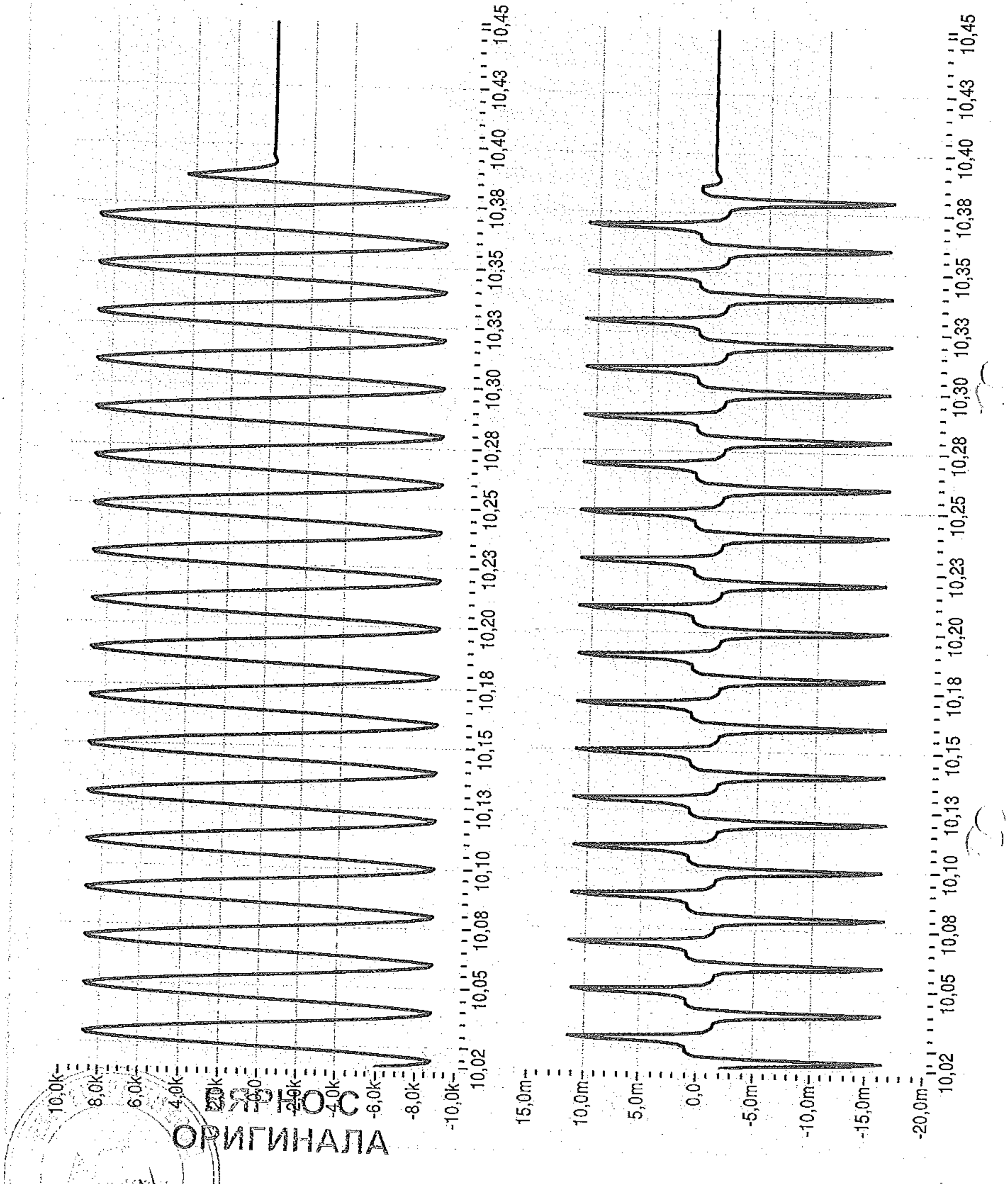
ВЯРНО С
ОРИГИНАЛА

CESI B1027448 Oscillogram n. 9



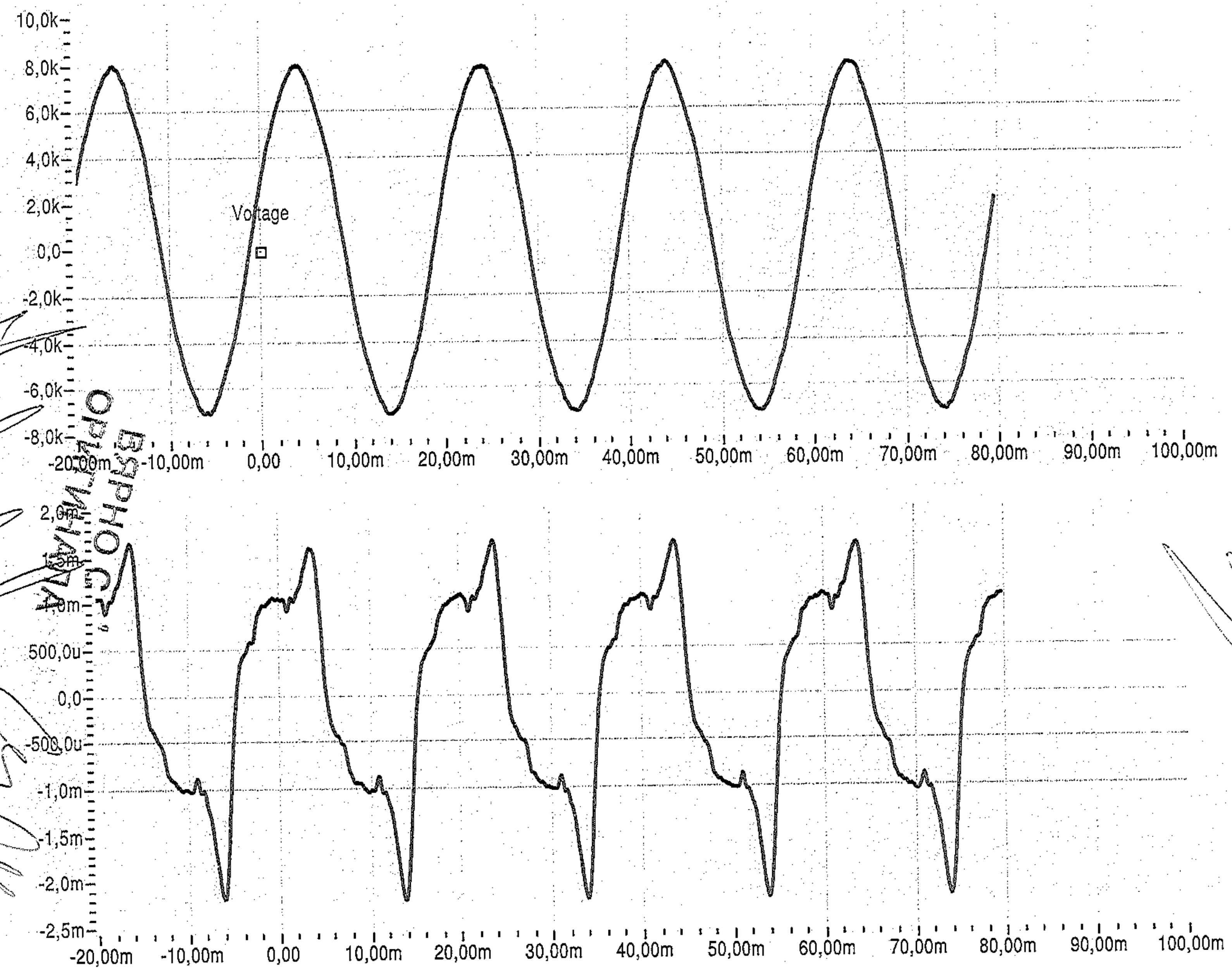
CESI B1027448 Oscillogram n. 10

ВЯРНО С ОРИГИНАЛА



ВЯРНО С
ОРИГИНАЛА

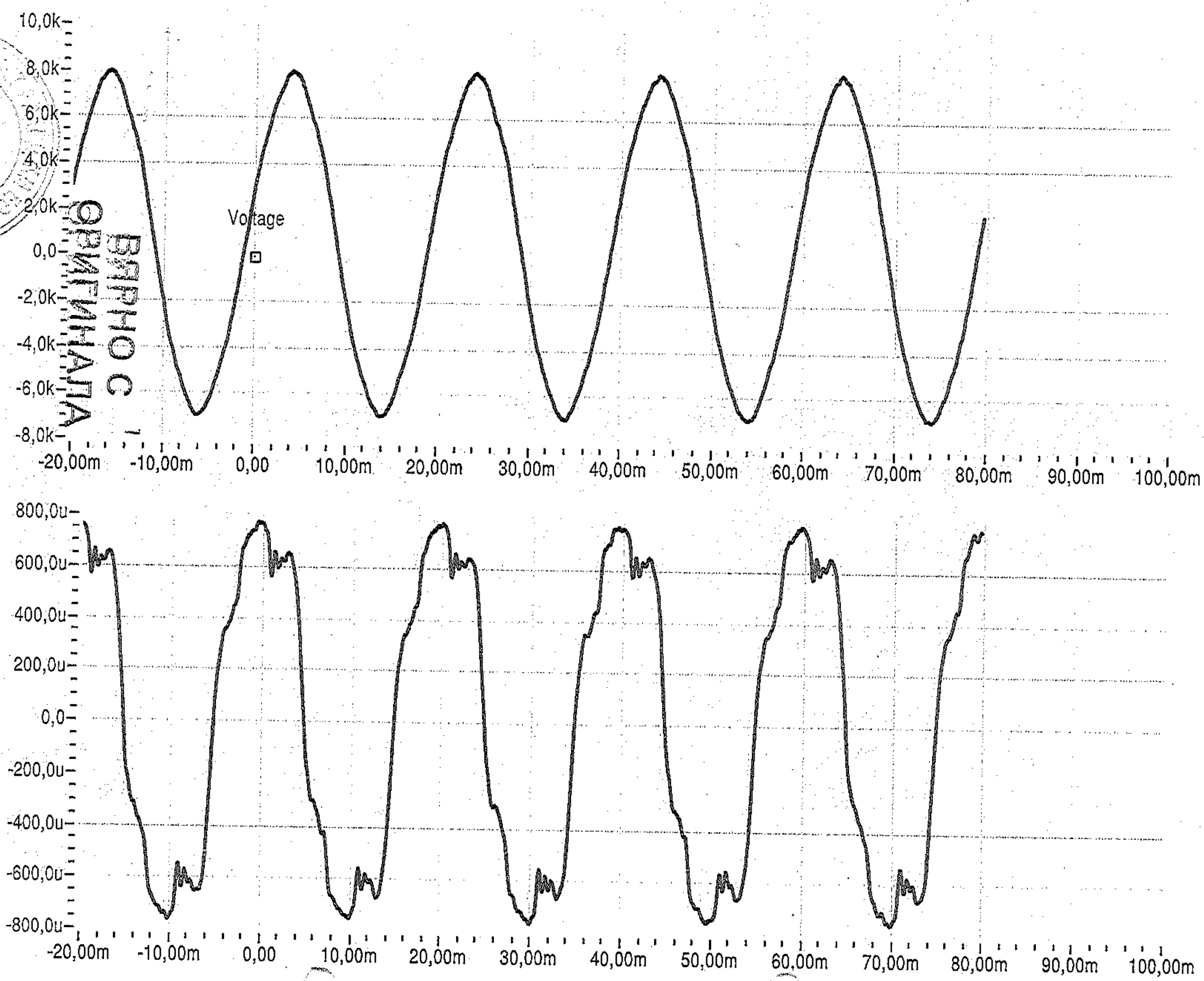
CESI B1027448 Oscillogram n. 11



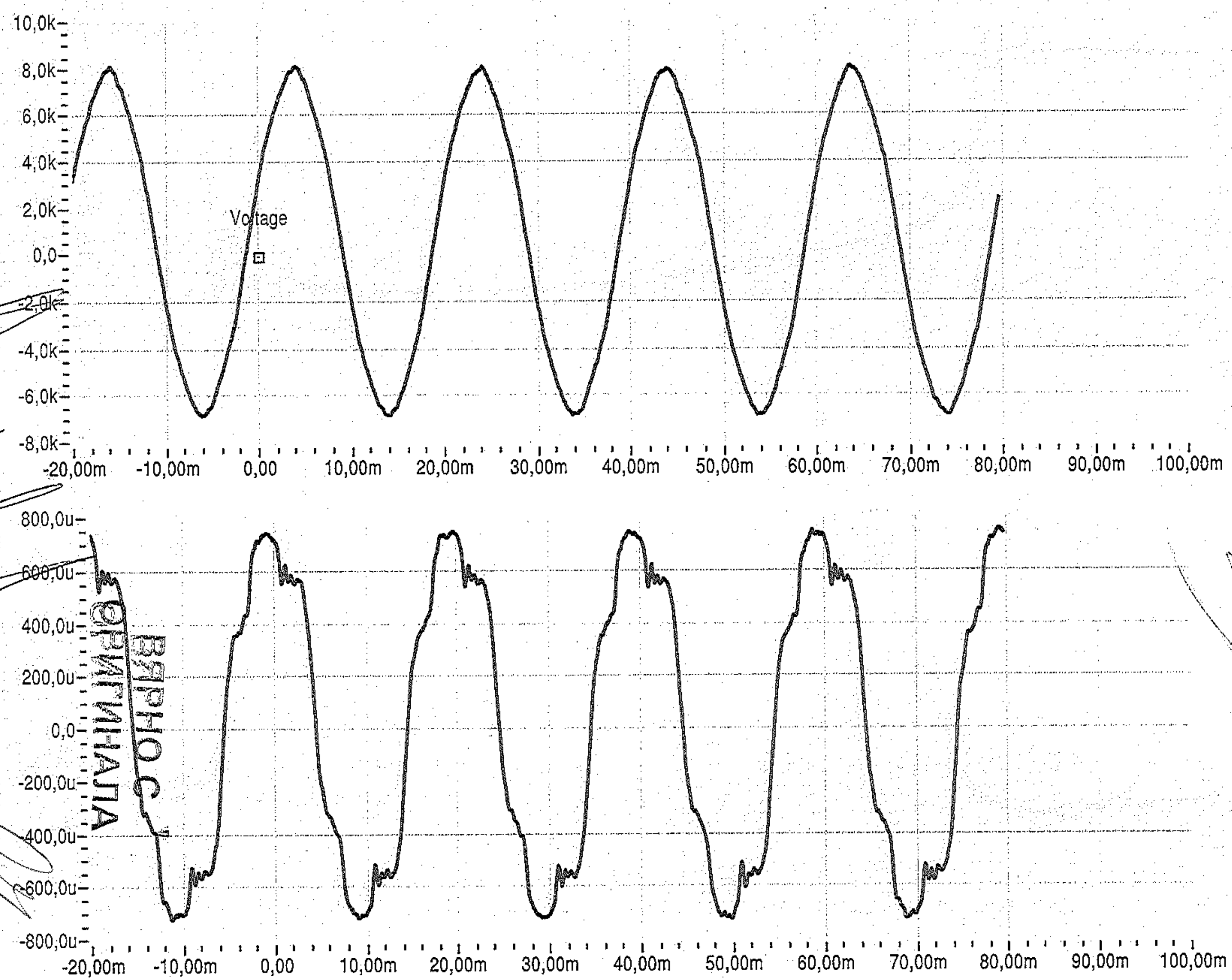
ВЯРНО С ОРИГИНАЛА

CESI B1027448 Oscillogram n. 12

CESI B1027448 Oscillogram n. 13

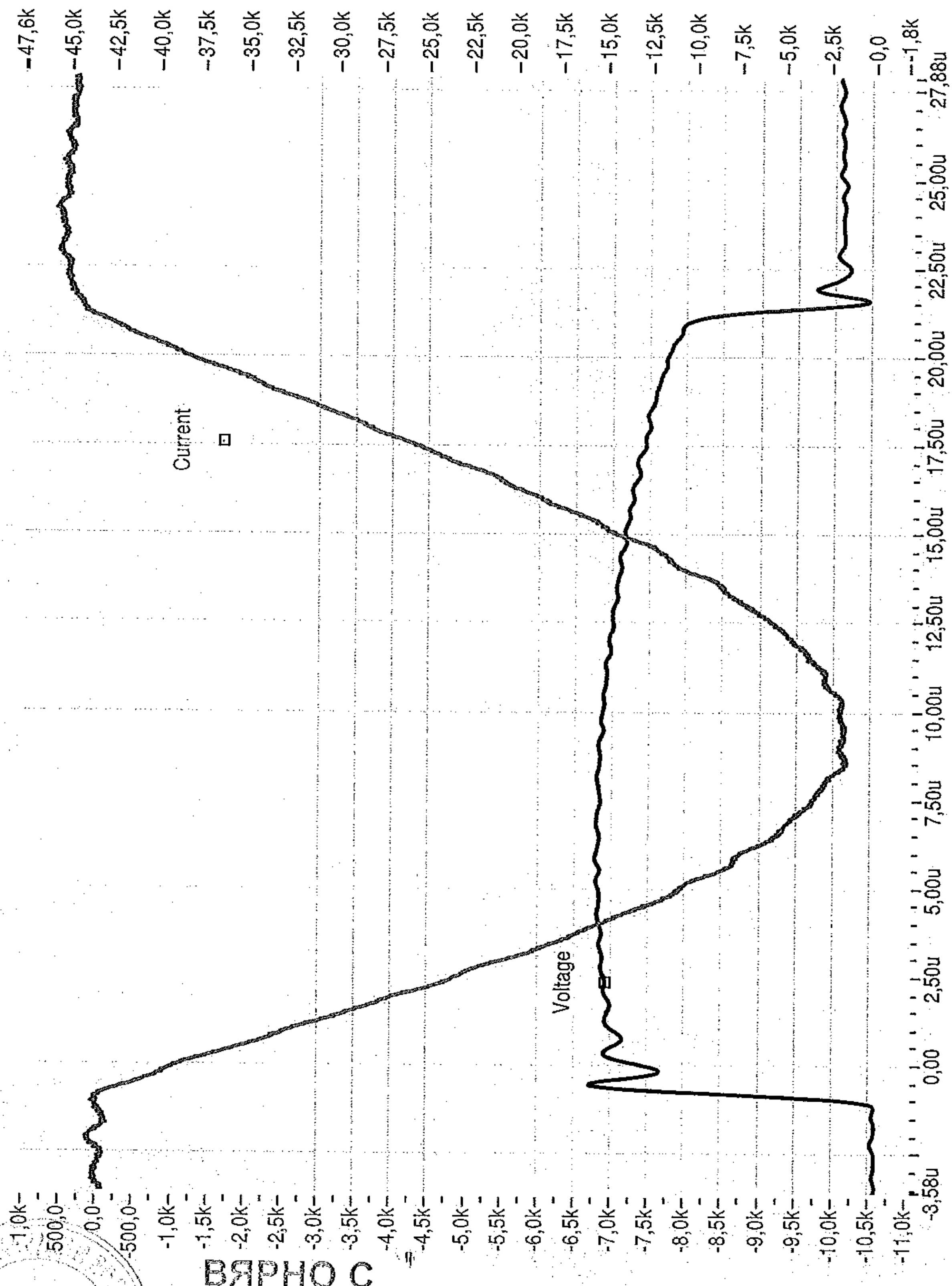


ВЯРНО С ОРИГИНАЛА



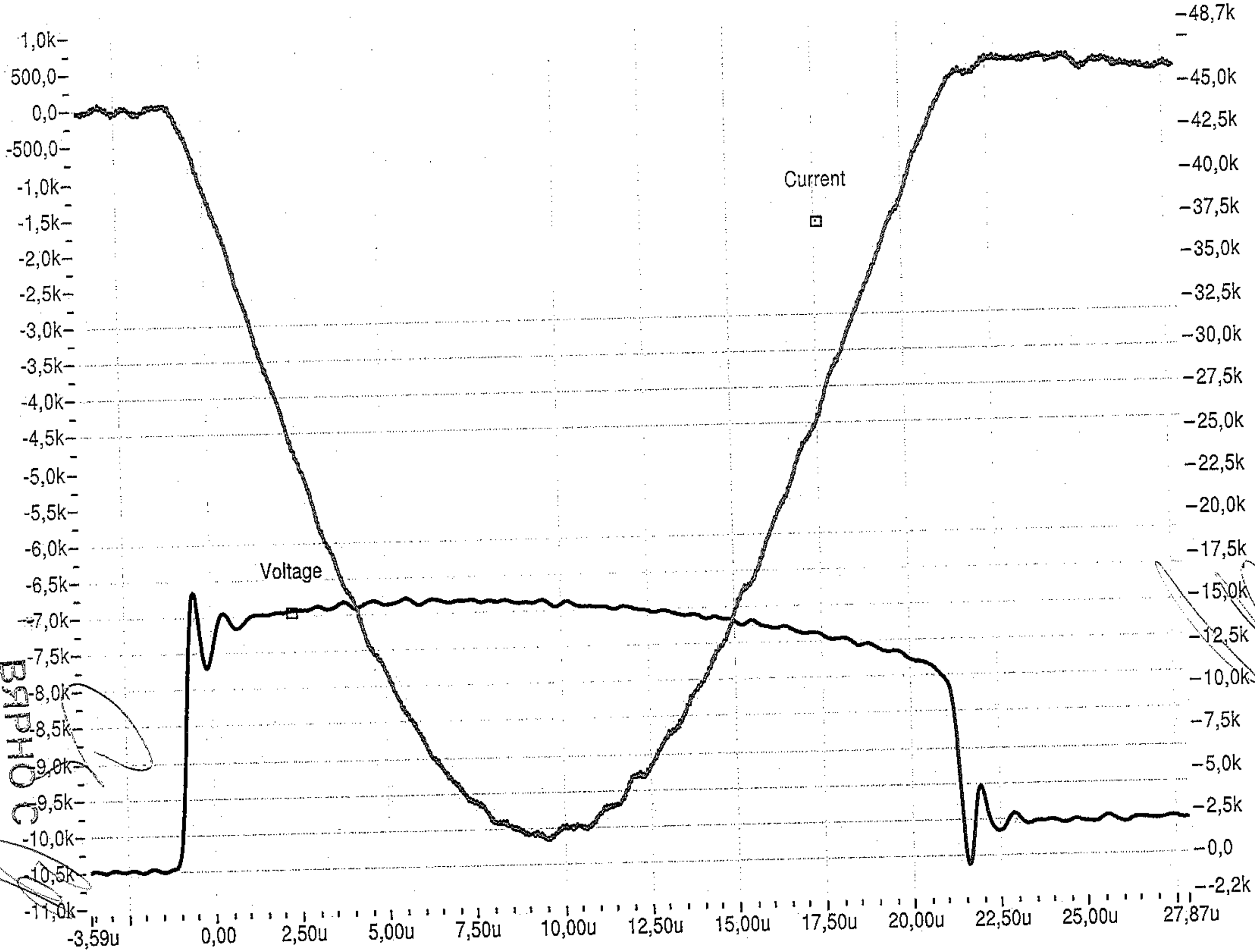
CESI B1027448 Oscillogram n. 14

ВЯРНО С ОРИГИНАЛА



ВЯРНО С
ОРИГИНАЛА

CESI B1027448 Oscillogram n. 15



CESI B1027448 Oscillogram n. 16

ВЯРНО С ОРИГИНАЛА

Test Report

CESI

Client	Tridelta Parafoudres S.A.
Address of the Client	Boulevard de l'Adour 65202 Bagnères de Bigorre Cedex – France
Manufacturer	Tridelta Parafoudres S.A.
Tested samples/items	Disconnectors for polymer housed metal-oxide surge arresters
Tests carried out	Disconnector operation test
Standards/Specifications	IEC 60099-4 – Edition 2.2 (2009-05) at clause 8.6.3
Tests date	from September 13, 2011 to September 13, 2011

No. of pages	16	No. of pages annexed	33
Issue date	September 13, 2011		
Prepared	PPR - Assolari Mauro		
Verified	PPR - Vidori Mauro, TPI - Sironi Alberto		
Approved	PMI - The Manager - Arcidiaco Lorenzo		

CESI S.p.A.
Testing & Certification Division
Testing Operations Area
"Milan Platform"
Manager
Lorenzo Arcidiaco

ВЯРНО С ОРИГИНАЛА

515

CESI
Centro Elettrotecnico Sperimentale Italiano Giacinto Motta spa
Via R. Rubattino 54
20134 Milano - Italia
Telefono +39 022125.1
Fax +39 0221255440
http://www.cesi.it

Capitale sociale 8 550 000 Euro interamente versato
Codice fiscale e numero
Iscrizione CCIAA 00793580150
Registro Imprese di Milano
Sezione Ordinaria
N. R.E.A. 429222
P.I. IT00793580150

Tests witnessed by

Mr. Malpiece	Tridelta Parafoudres S.A.
Mr. Athanasas	Public Power Corporation S.A.

Identification of the object not requested

Only for laboratory requirement, in order to reproduce the test conditions, all the laboratory data are contained in the document marked: ---

The measurement uncertainties of the main test results reported in this document comply with the following limits:

- **voltage:** ± 5,0 % (budgetary estimation)
- **current:** ± 3,5 % (document A9027618)
- **time:** ± 1,4 % (document A9030312)

The measurement uncertainties are estimated at the level of twice the standard deviation corresponding, in the case of normal distribution, to a confidence level of about 95 %.

Laboratory information

Receipt date of the sample	September, 2011
Test location	CESI – Via Rubattino 54 – Milan
CESI testing team	S. Neri C. Signorini A. Carboni
Test laboratory	P102 / MP1
Activity code	AE11PMI018

ВЯРНО С
ОРИГИНАЛА

516

ВЯРНО С ОРИГИНАЛА

517

Rated characteristics of the surge arresters for which the disconnectors are designed to be used

Manufacturer	TRIDELTA Parafoudres
Rated voltage	5 – 42 kV
nominal discharge current	10 kA
line discharge class	1
samples number	800A 1 DO – 800A 2 DO – 800A 3 DO – 800A 4 DO – 800A 5 DO 200A 1 DO – 200A 2 DO – 200A 3 DO – 200A 4 DO – 200A 5 DO 20A 1 DO – 20A 2 DO – 20A 3 DO – 20A 4 DO – 20A 5 DO
Type	S3D2
Frequency	50-60 Hz

Name and signature of Client's witness:

Disconnector operation test

Arrangements and test modalities

The disconnectors were tested alone, without the surge arrester.

The applied prospective voltage was about 4850 V.

The equipment was hang up to a copper support placed in horizontal position as shown in the photos no.1 and no.2.

Five samples of disconnectors were tested for each of the three current values stated by the Standard that are 800 A, 200 A and 20 A.

Test result

For all the samples tested a correct operation occurred with a permanent and effective disconnection.

<u>The test result is positive.</u>

ВЯРНО С
ОРИГИНАЛА

529

Single-phase current tests

Test circuit: M0015
Reference number of the oscillograms: B1027905

Oscillogram	Calibration of the test circuit: Prospective current	Power factor	Voltage	Frequency
No./sheets	A	-	kV	Hz
5/1	809	0,05	4,88	50
16/1	205	0,05	4,82	50
23/1	20,3	0,04	4,88	50

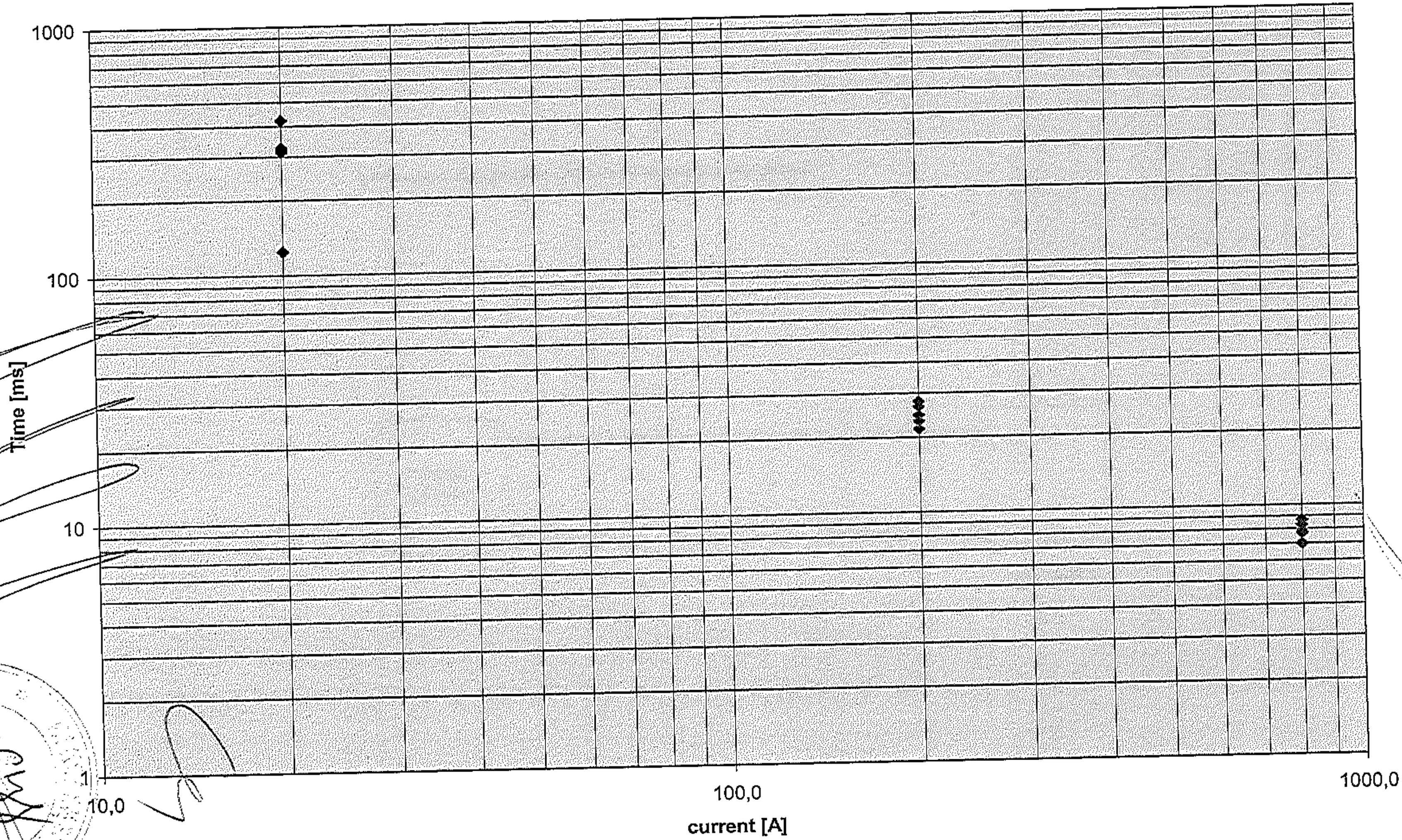
Conditions of the apparatus before the tests: new, as supplied by the Customers

Date: September 13, 2011

Test	Oscillogram	sample tested	test voltage	test current	time to first movement	current duration	photo after the test	permanent disconnection	Notes
No.	No./sheets	-	kV	A	ms	ms	no.	-	-
1	8/2	800A 1 DO	4,86	800	8,3	98,8	6	yes	-
2	10/2	800A 2 DO	4,85	800	7,8	99,1	-	yes	-
3	11/2	800A 3 DO	4,87	800	7,7	98,6	-	yes	-
4	12/2	800A 4 DO	4,87	800	8,7	98,6	-	yes	-
5	13/2	800A 5 DO	4,86	800	7,0	99,0	-	yes	-
6	17/2	200A 1 DO	4,81	200	27,8	199	7-8	yes	-
7	18/2	200A 2 DO	4,82	200	26,5	199	-	yes	-
8	19/2	200A 3 DO	4,83	200	23,2	198	-	yes	-
9	20/2	200A 4 DO	4,82	200	21,6	199	-	yes	-
10	21/2	200A 5 DO	4,82	200	24,5	198	-	yes	-
11	24/2	20A 1 DO	4,87	20	423	625	9-10	yes	-
12	25/2	20A 2 DO	4,86	20	124	265	-	yes	-
13	26/2	20A 3 DO	4,84	20	320	493	-	yes	-
14	27/2	20A 4 DO	4,84	20	327	476	-	yes	-
15	28/2	20A 5 DO	4,84	20	314	492	-	yes	-

Condition of the apparatus after the tests: see photos

Time current versus curve

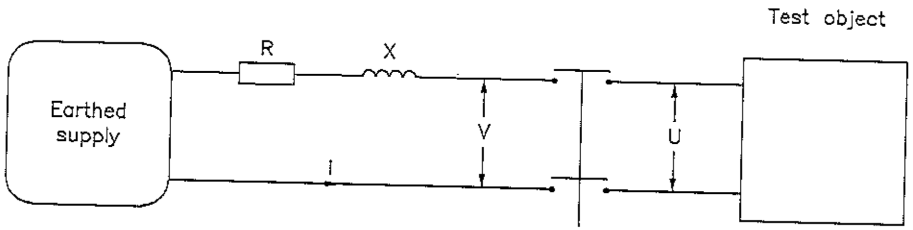


531

ВЯРНО С ОРИГИНАЛА

532

Test circuit M0015



The symbols used in this diagram are the same as those on the oscillograms.

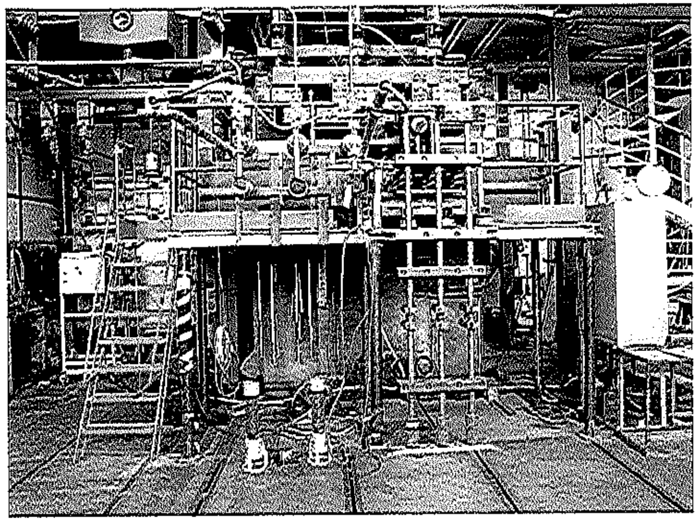


Photo no. 1

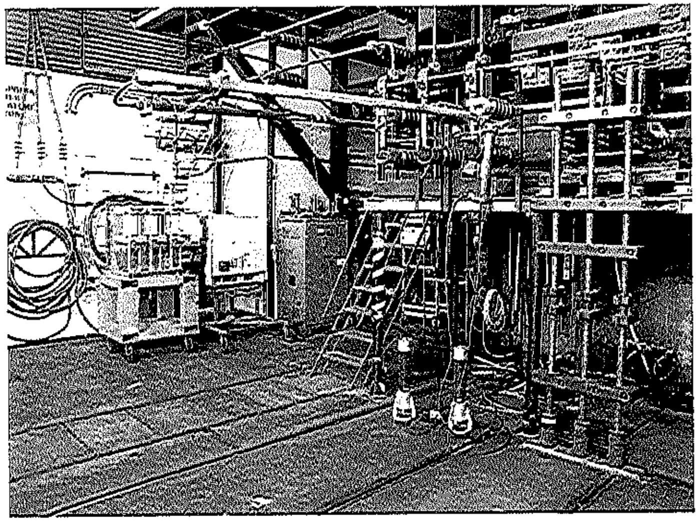


Photo no. 2

M2009IG

ВЯРНО С ОРИГИНАЛА

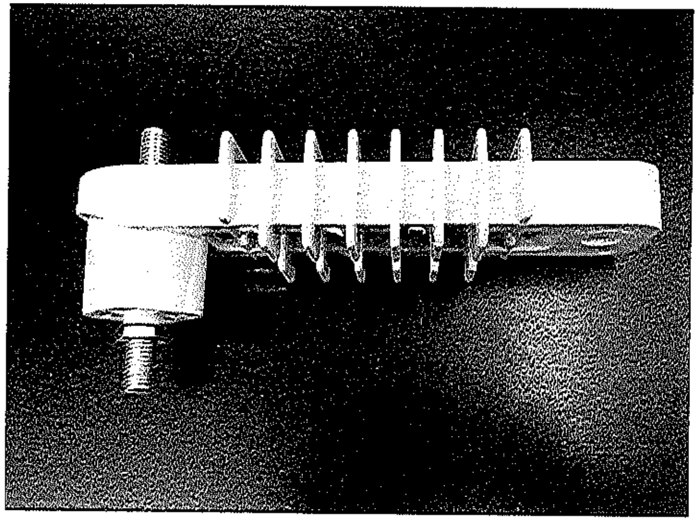


Photo no. 3
sample new

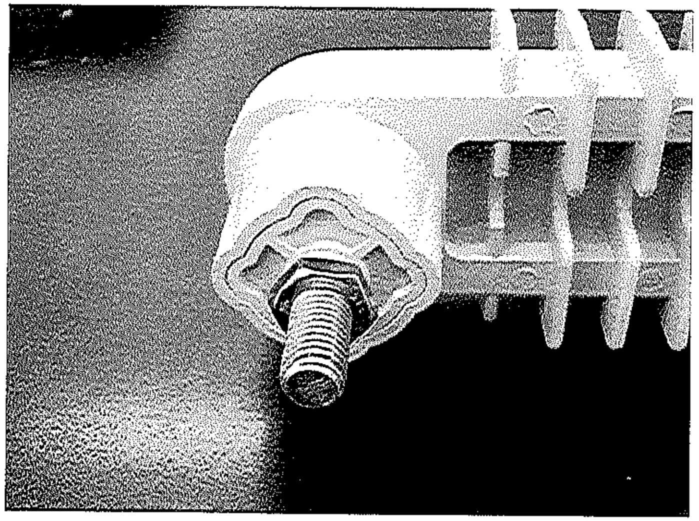


Photo no. 4
sample new

534

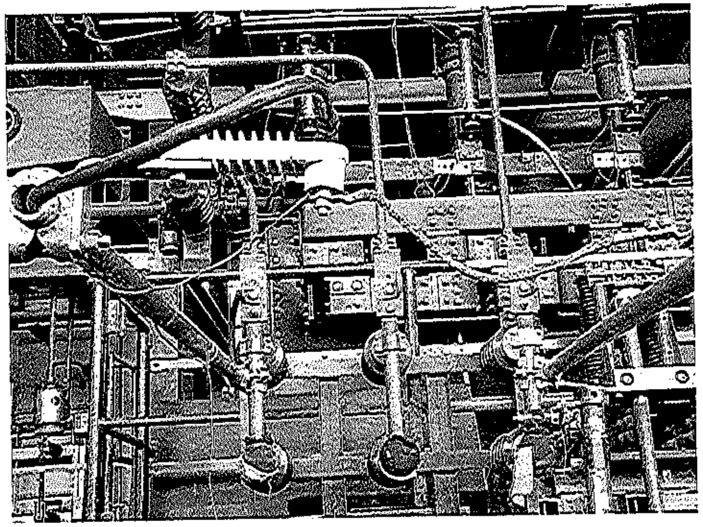


Photo no. 5
sample new before the test

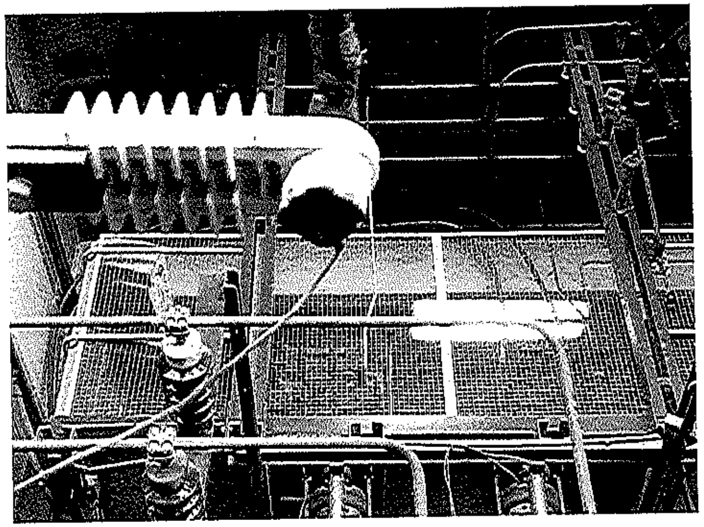


Photo no. 6
sample no.800A 1 DO after the test

ВЯРНО С ОРИГИНАЛА

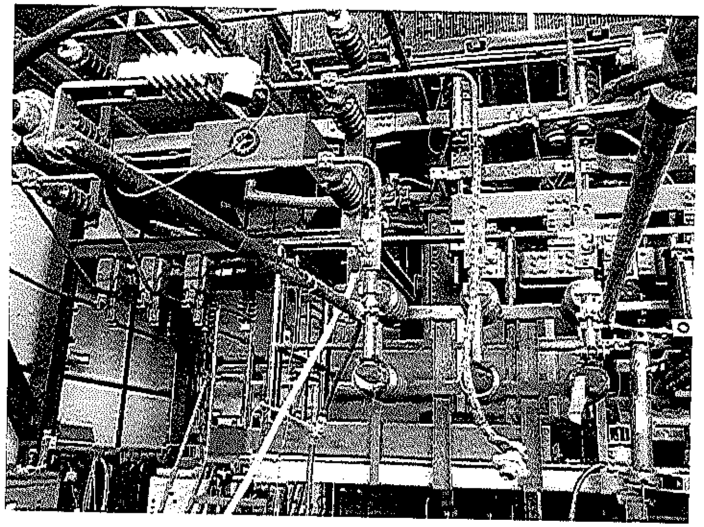


Photo no. 7
sample no.200A 1 DO after the test

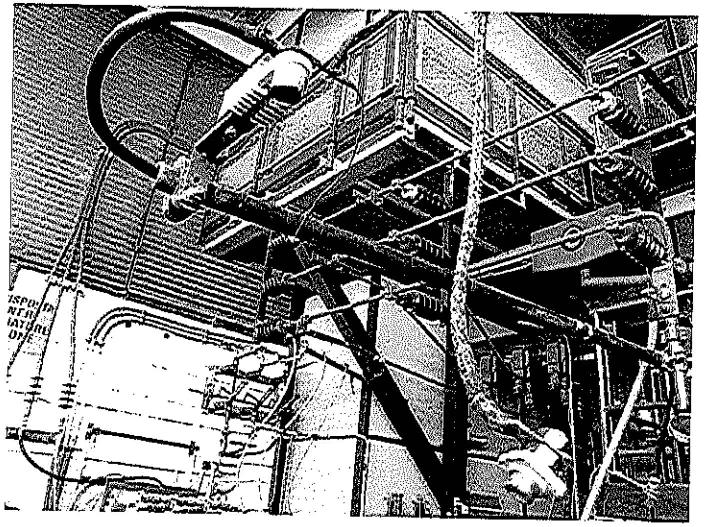


Photo no. 8
sample no.200A 1 DO after the test

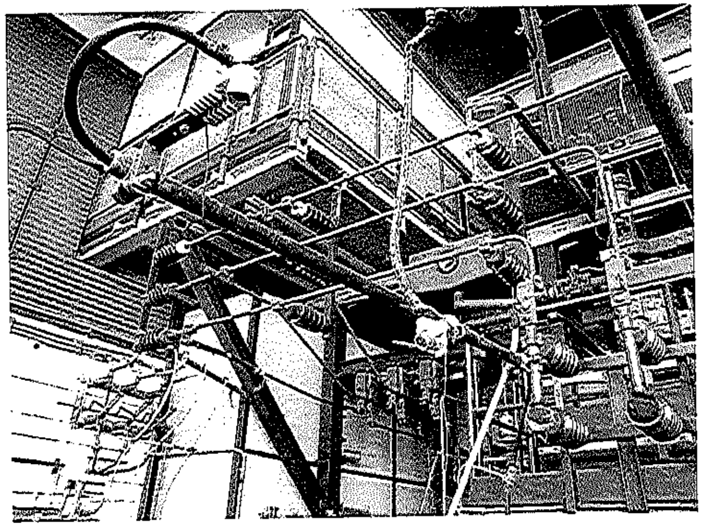


Photo no. 9
sample no.20A 1 DO after the test

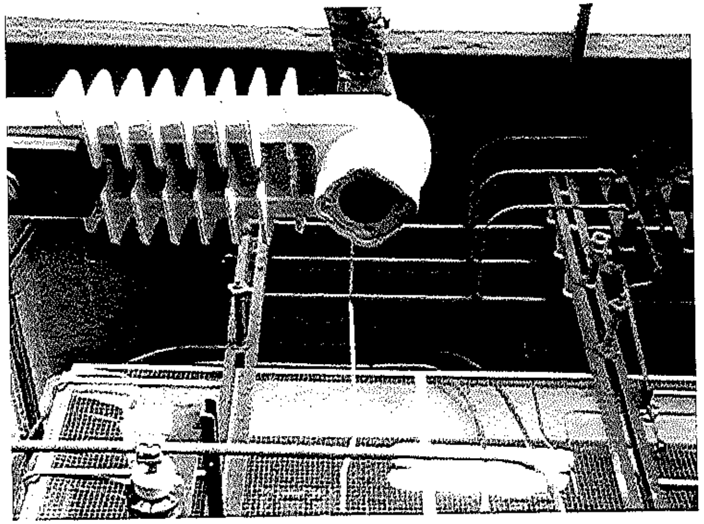


Photo no. 10
sample no.20A 1 DO after the test

ВЯРНО С ОРИГИНАЛА

527

538

Laboratory information

Requested values and test circuit parameters

Test	Requested values								Synchronizer	Time
	voltage	r.m.s. current	peak current	I^2t	duration	X_{AT}	X_{bt}		position	of the test
No.	V	A	A	MA^2s	s	Ω	Ω		°	-
T1	4800	800	-	-	0,1	61,2 + 63,5	-		128	10.20am
1 to 5	"	800	-	-	0,1	"	-		35	10.50am
T2	"	200	-	-	0,1	240,8 x 2	0,6 x 3		128	11.40am
6 to 10	"	200	-	-	0,2	"	-		35	11.50am
T3	"	20	-	-	0,1	103,0 x 2	77,12 x 3		128	1.35pm
11 to 15	"	20	-	-	1,5	"	"		35	1.45pm

Laboratory information

Date: September 13, 2011

Characteristics of supply circuit

Tests		Supply	OTE MV		OTE LV	
from	to		K	position	K	position
T1	15	23 kV Lambrate	4,667	-	-	-

Characteristics of measuring system

Measure	Transducer		National Instrument		Krenz channel
			SCXI	PXI	
-	ref.	position	No.	No.	No.
I	G2		1	1	
U	N1 - N2		2	2	
V	A1 - A3		3	3	

Symbols assigned in "ref." column refer to the measuring equipment listed in page "Laboratory P102 – MP1. Measuring system characteristics."

Other measuring equipment:
Ohmmeter CESI number: -

ВЯРНО С ОРИГИНАЛА

Laboratory P102 – MP1
Measuring system characteristics

Ref.	Type	CESI No.
A1	Voltage transformer TV2 – R-S	9032
A2	Voltage transformer TV2 – S-T	9033
A3	Resistive dividers for TV2	14142
B1	Resistive divider K= 206,5	11465
B2	Resistive divider K= 206,5	11466
B3	Resistive divider K= 206,5	11467
B4	Resistive divider K= 206,5	11468
C1	Current transformer TA2 – R	17060
C2	Current transformer TA2 – S	17061
C3	Current transformer TA2 – T	17059
C4	Resistive burden for TA2	5562
D1	Current transformer 4000 A / 5 A	14466
D2	Resistive burden for TA3	17072
E1	Shunt 40 μΩ – 100 kA – R	8231
E2	Shunt 40 μΩ – 100 kA – S	8232
E3	Shunt 40 μΩ – 100 kA – T	8230
F1	Shunt 1,33 mΩ – 5 kA – R	7965
F2	Shunt 1,33 mΩ – 5 kA – S	7966
F3	Shunt 1,33 mΩ – 5 kA – T	7968
G1	Shunt 1,6 mΩ – 5 kA – additional	7964
G2	Shunt 1,6 mΩ – 5 kA – additional	7963
G3	Shunt 1,6 mΩ – 5 kA – additional	7967
H1	Shunt 80 μΩ – 100 kA	5524
H2	Shunt 80 μΩ – 100 kA	5525
H3	Shunt 80 μΩ – 100 kA	5526
J1	Electro-optical link for thermocouple T	13372
J2	Electro-optical link for thermocouple T	14556
J3	Electro-optical link for thermocouple J	17074
J4	Electro-optical link for thermocouple J	17076
J5	Electro-optical link for thermocouple J	17078
J6	Electro-optical link for thermocouple K	22463
J7	Electro-optical link for thermocouple K	22465
J8	Electro-optical link for thermocouple K	22467
J9	Electro-optical link for thermocouple K	22469

Ref.	Type	CESI No.
K1	Shunt 160 μΩ – 30 kA	5559
K2	Shunt 160 μΩ – 30 kA	5560
K3	Shunt 160 μΩ – 30 kA	5561
L1	Shunt 111 mΩ	9754
L2	Shunt 111 mΩ	9758
L3	Shunt 111 mΩ	9759
=	KRENZ TRC1	13119
=	KRENZ TRC2	13120
M1	Voltage transformer 24 kV / 100 V	3387
N1	Divider RC 30 kV	14677
N2	Divider RC 30 kV	14678
N3	Divider RC 30 kV	14679
N4	Divider RC 30 kV	11990
N5	Divider RC 30 kV	11991
N6	Divider RC 30 kV	11992
P1	Schering bridge	696
P2	Resistive box	8451
R1	Micro-ohmmeter MOM600A	14204
S1	Micro-ohmmeter OM21	14643
T1	Megger METRISO	13139
U1	Thermocouples calibrator CALIS 5	23138
V1	Digital multimeter FLUKE 8060A	17519
Z1	Temperature probe FLUKE 80T-150U	3831
Z2	Shunt 150A/80mV	3477
Z3	Digital multimeter FLUKE 8060A	9893

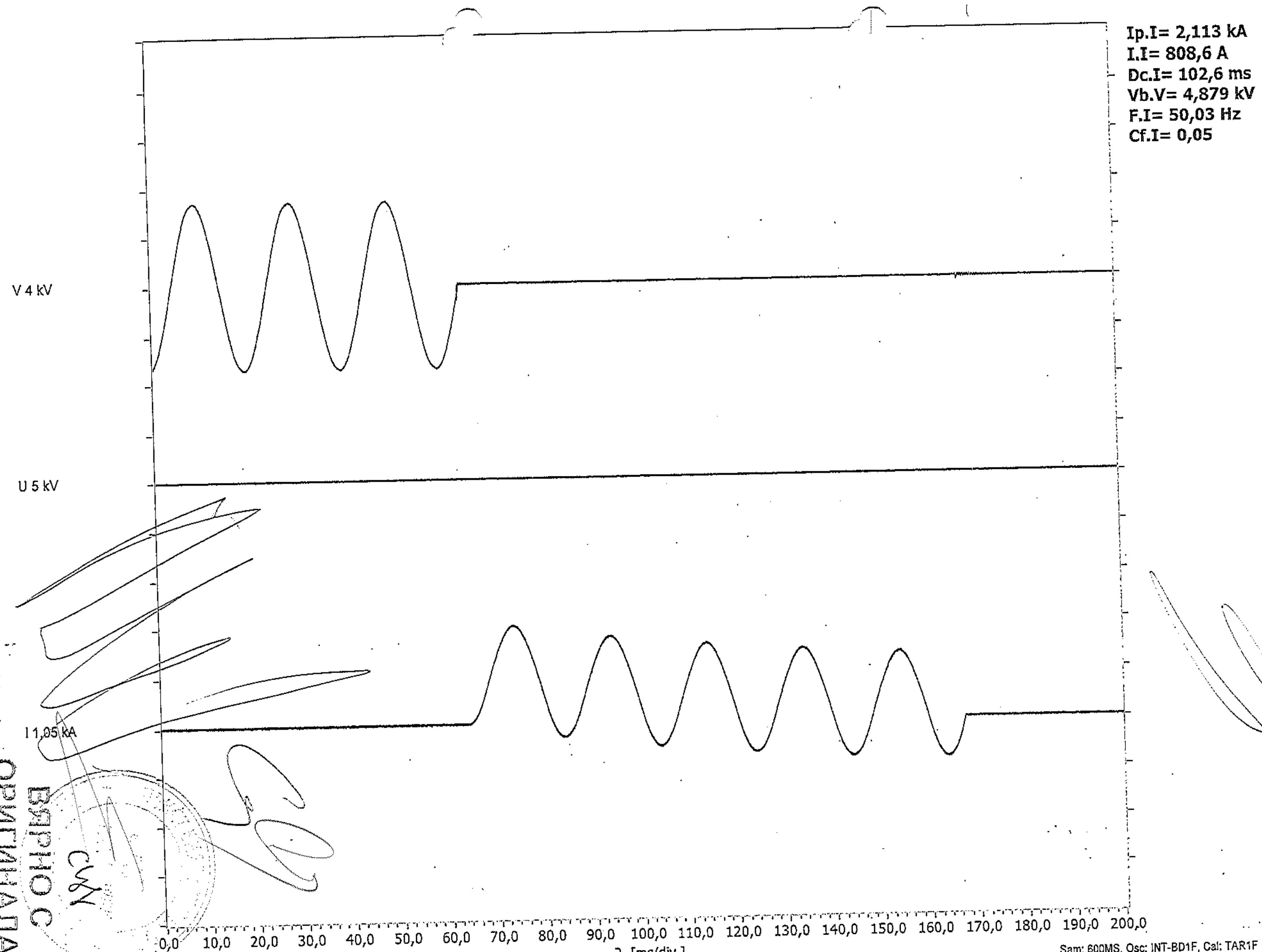
Measuring software: SAD – P102	Software release: 4.2 – 31/12/2002	Hardware: VAX 4200 with VMS 5.4

Prepared by: C. Del Giorgio

Date: 11/03/2010

ВЯРНО С ОРИГИНАЛА

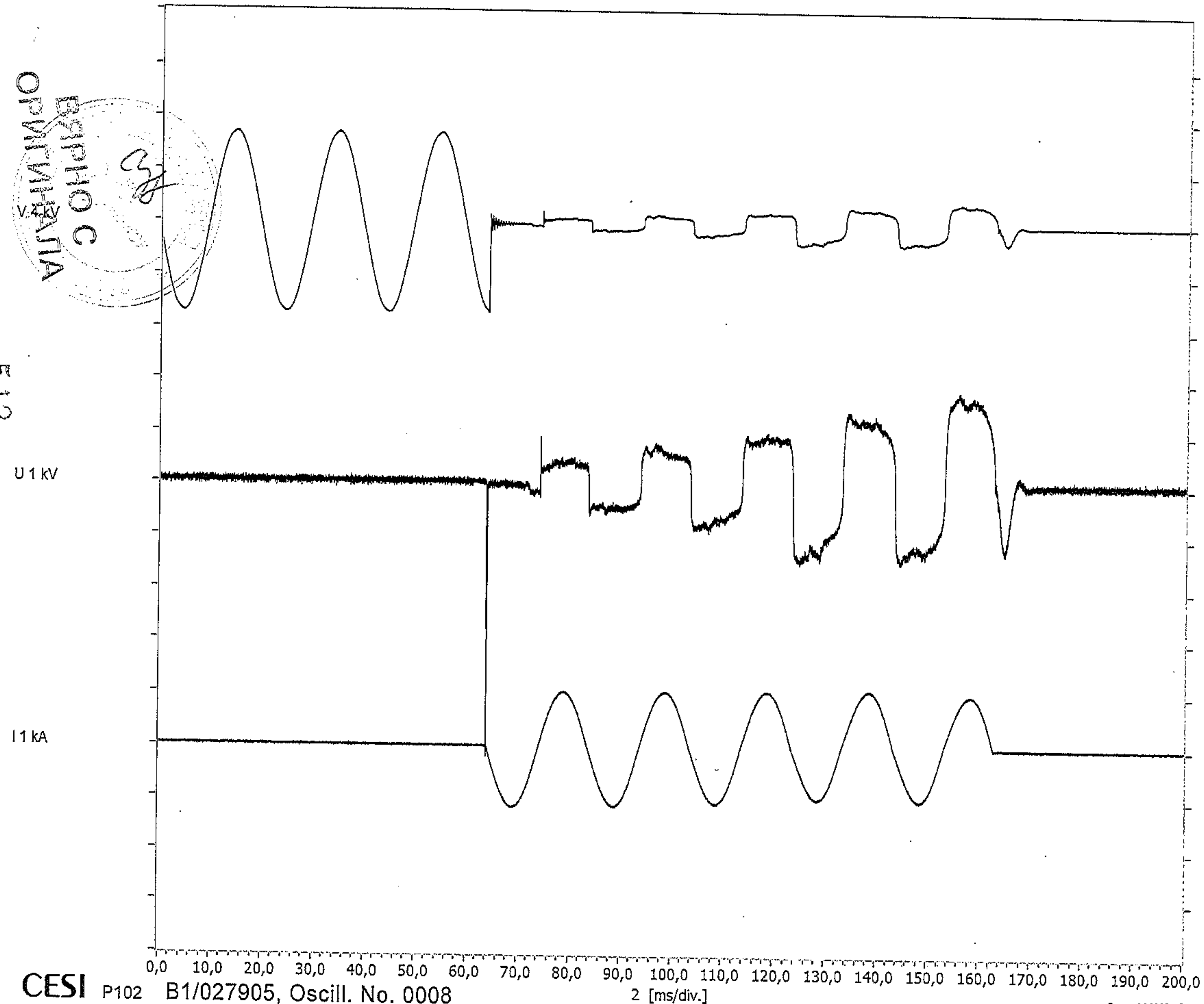
510



CESI P102 B1/027905, Oscill. No. 0005

ВЯРНО С ОРИГИНАЛА

511



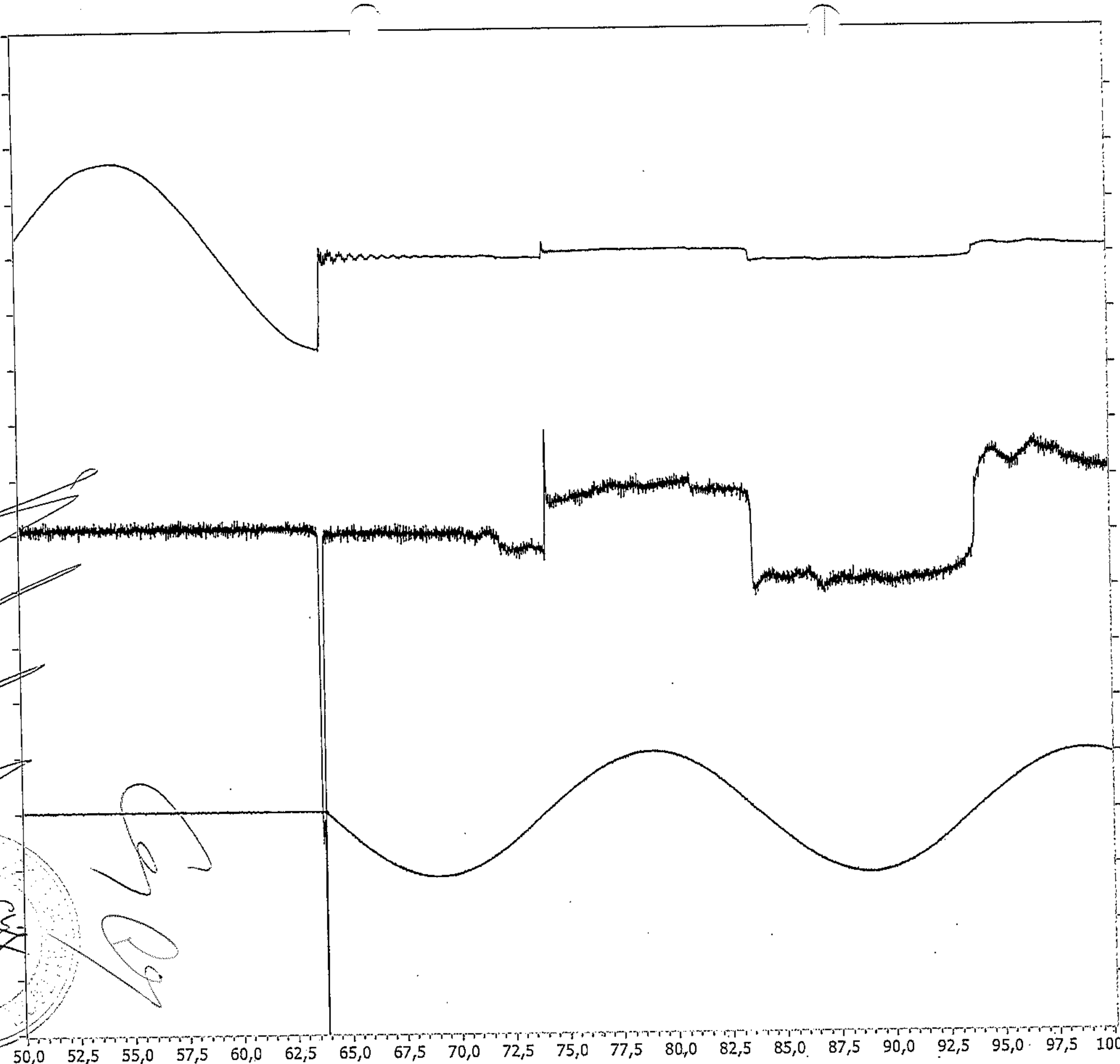
Ip.I= 1,179 kA
I.I= 754,2 A
Dc.I= 98,81 ms
I2t.I= 55,49 kA2s
Vb.V= 4,859 kV
Da.I= 90,92 ms
E.I= 53 kJ
P.I= 1,796 MW
F.I= 49,95 Hz

CESI P102 B1/027905, Oscill. No. 0008

Sam: 600MS, Osc: INT-BD1F, Cal: INT1F

ВЯРНО С ОРИГИНАЛА

512



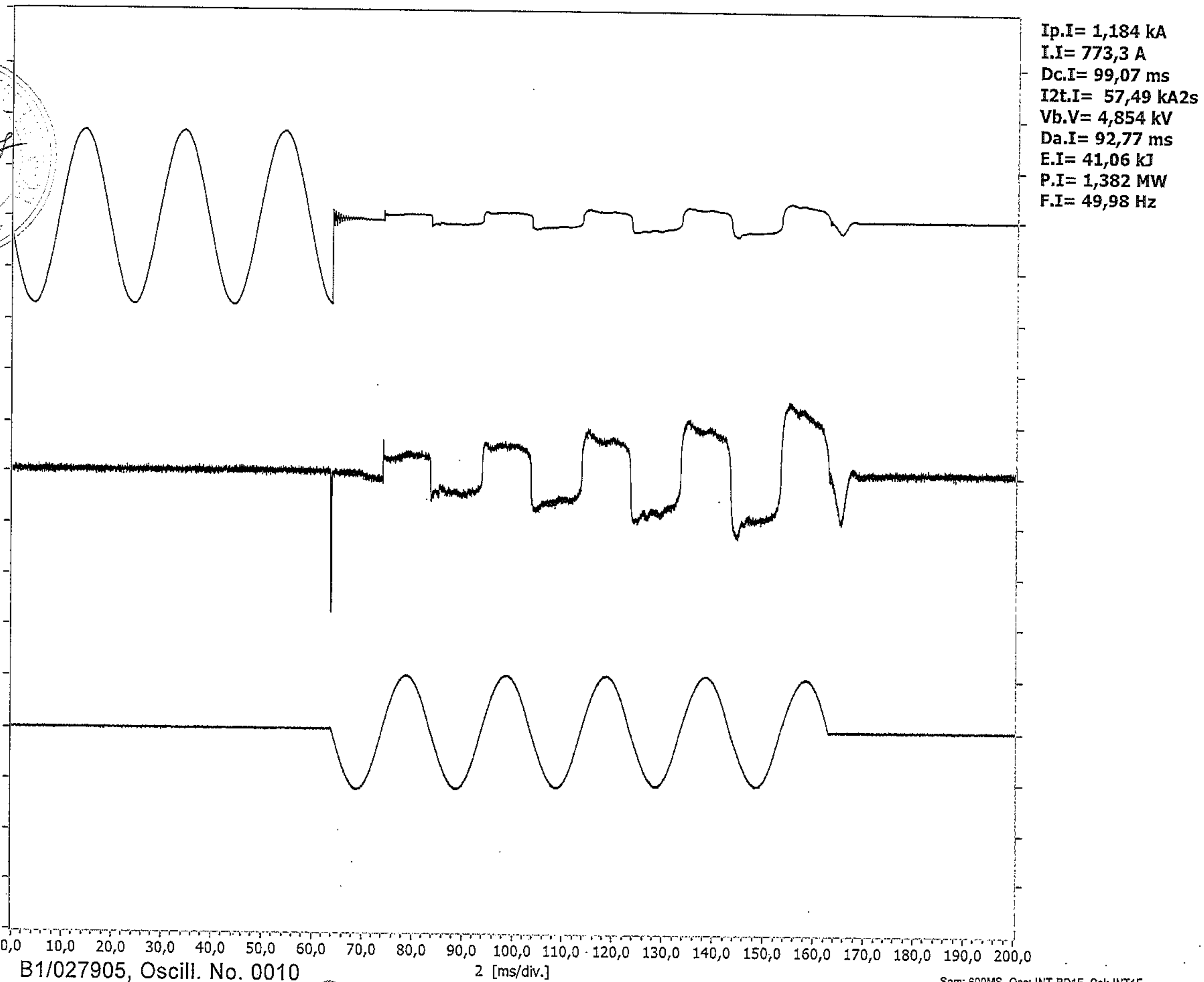
Ip.I= 1,179 kA
I.I= 754,2 A
Dc.I= 98,81 ms
I2t.I= 55,49 kA2s
Vb.V= 4,859 kV
Da.I= 90,92 ms
E.I= 53 kJ
P.I= 1,796 MW
F.I= 49,95 Hz
dT= 8,306 ms

Sam: 600MS, Osc: INT-BD1F, Cal: INT1F

CESI P102 B1/027905, Oscill. No. 0008

ВЯРНО С ОРИГИНАЛА

513

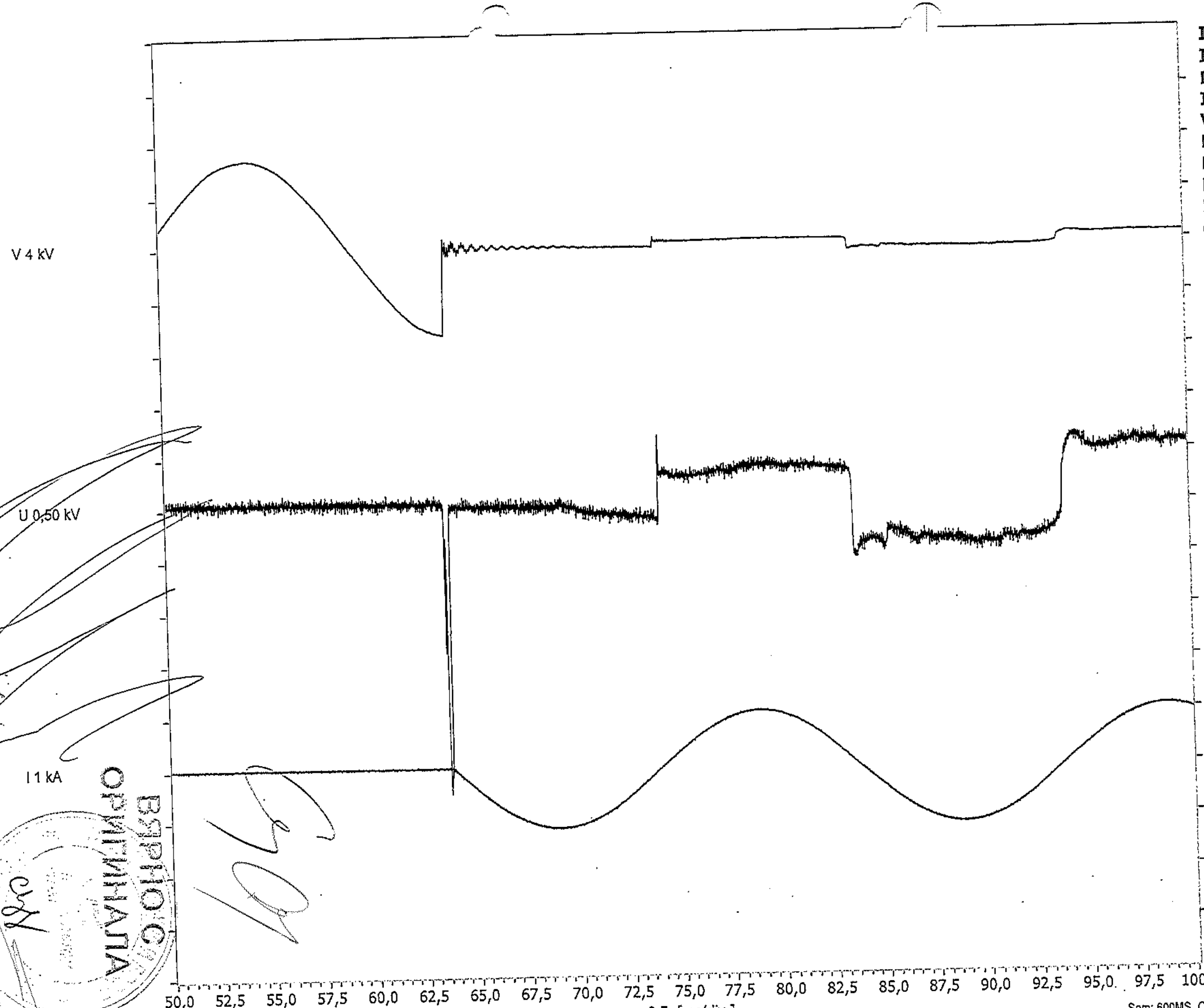


CESI P102 B1/027905, Oscill. No. 0010

Sam: 600MS, Osc: INT-BD1F, Cal: INT1F

ВЯРНО С ОРИГИНАЛА

514

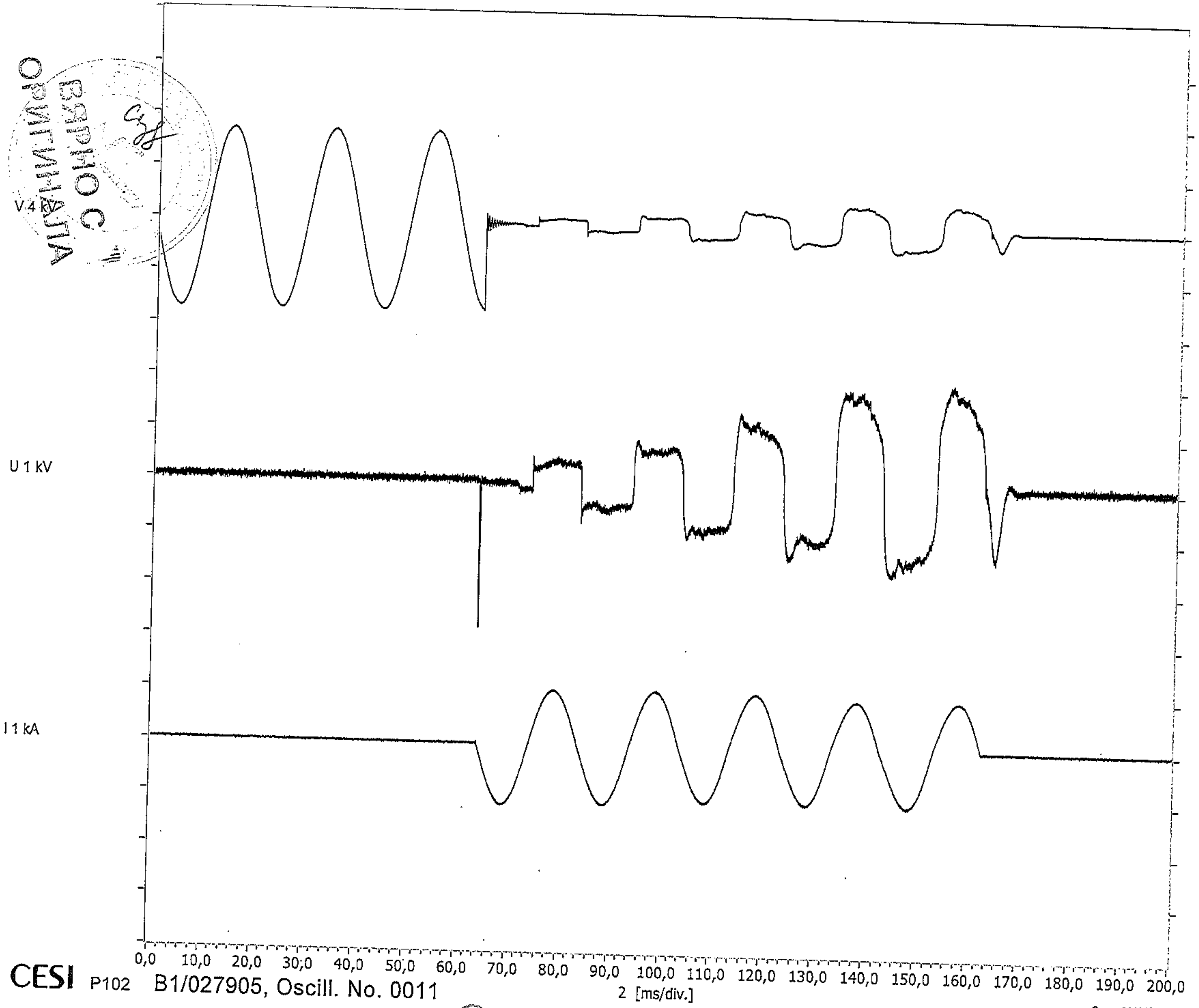


Ip.I= 1,184 kA
I.I= 773,3 A
Dc.I= 99,07 ms
I2t.I= 57,49 kA2s
Vb.V= 4,854 kV
Da.I= 92,77 ms
E.I= 41,06 kJ
P.I= 1,382 MW
F.I= 49,98 Hz
dT= 7,825 ms

Sam: 600MS, Osc: INT-BD1F, Cal: INT1F

CESI P102 B1/027905, Oscill. No. 0010

ВЯРНО С ОРИГИНАЛА



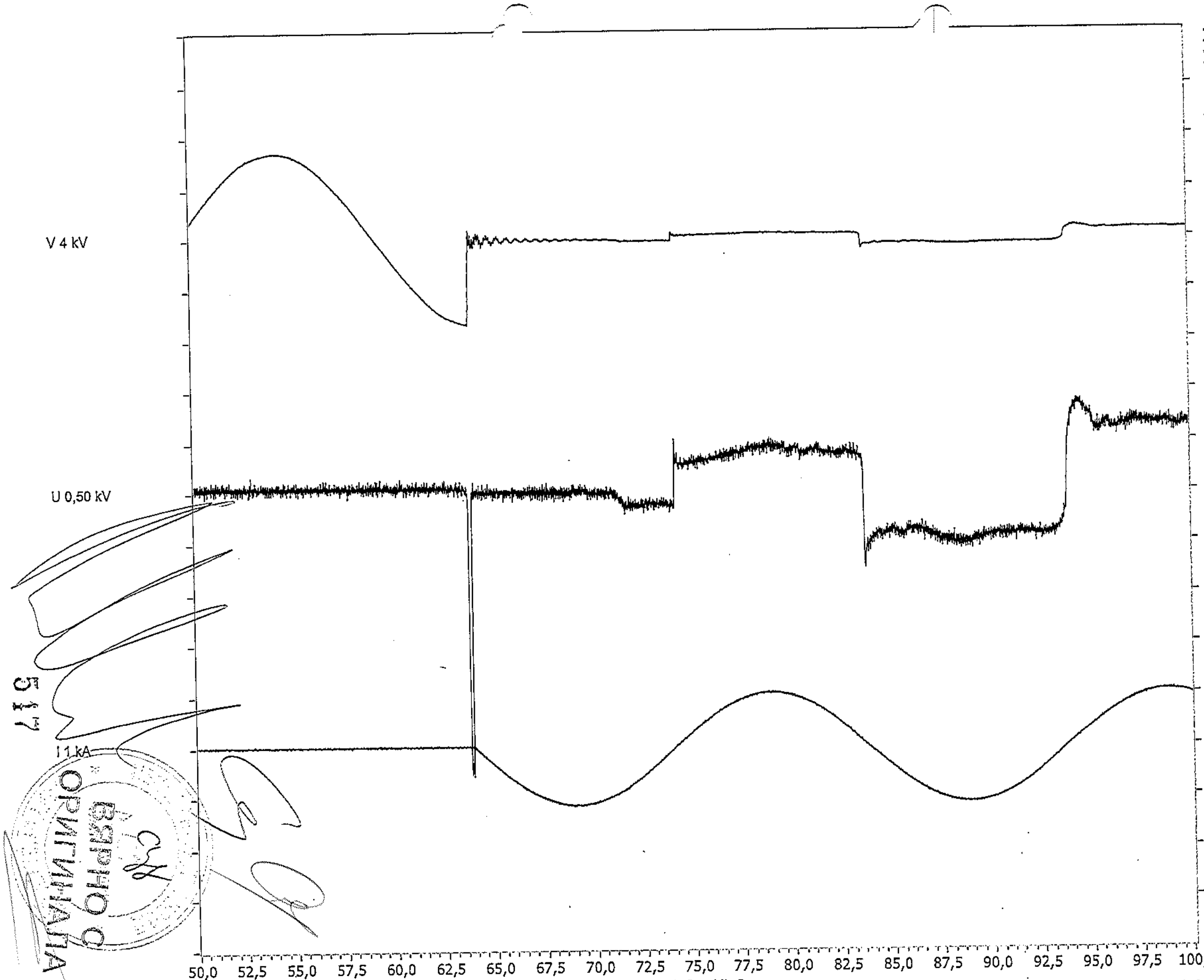
Ip.I= 1,187 kA
I.I= 757,6 A
Dc.I= 98,61 ms
I2t.I= 54,63 kA2s
Vb.V= 4,867 kV
Da.I= 91,44 ms
E.I= 58,78 kJ
P.I= 1,814 MW
F.I= 49,98 Hz

CESI P102 B1/027905, Oscill. No. 0011

Sam: 600MS, Osc: INT-BD1F, Cal: INT1F

ВЯРНО С ОРИГИНАЛА

516



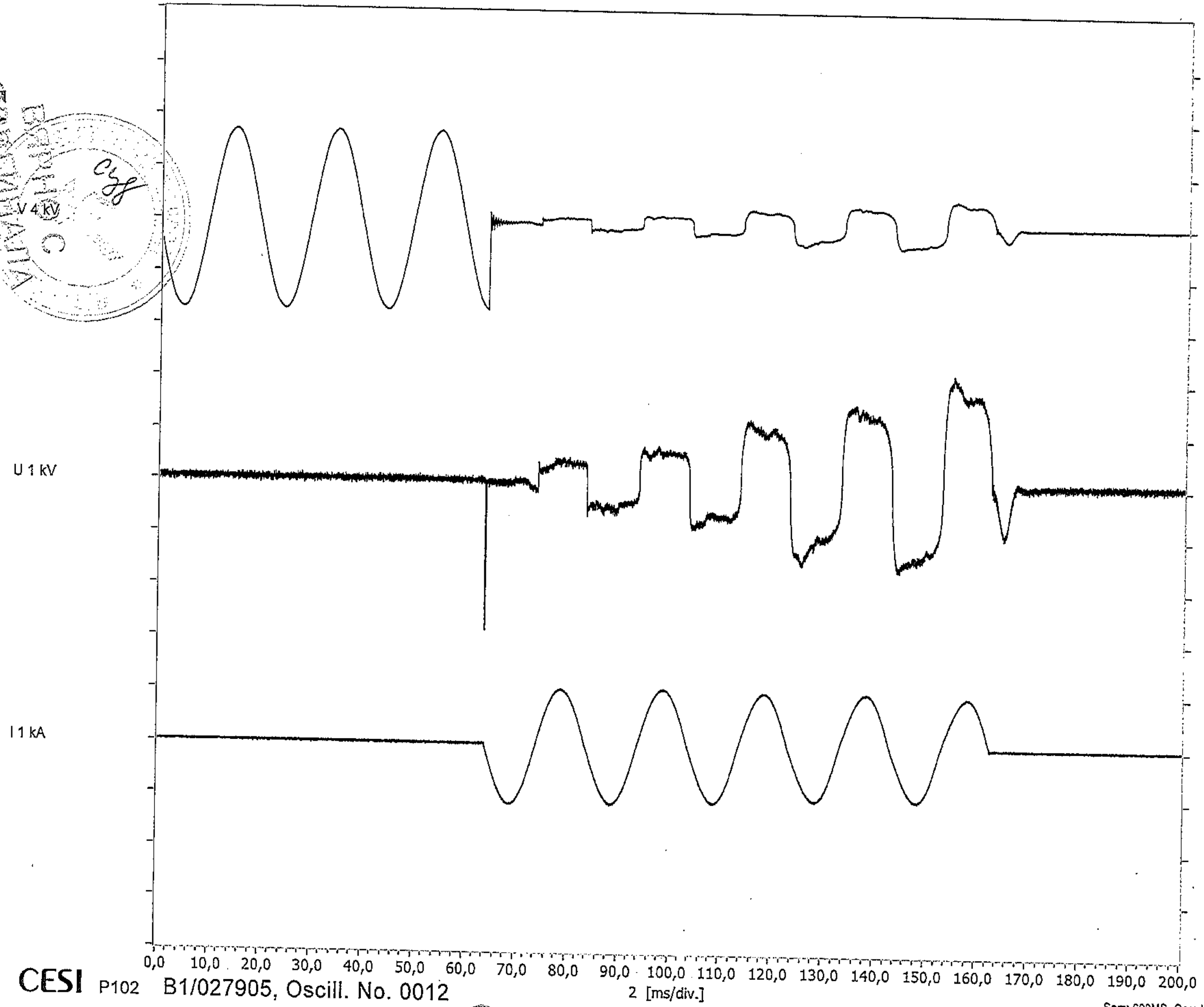
Ip.I= 1,187 kA
I.I= 757,6 A
Dc.I= 98,61 ms
I2t.I= 54,63 kA2s
Vb.V= 4,867 kV
Da.I= 91,44 ms
E.I= 58,78 kJ
P.I= 1,814 MW
F.I= 49,98 Hz
dT= 7,669 ms

Sam: 600MS, Osc: INT-BD1F, Cal: INT1F

CESI P102 B1/027905, Oscill. No. 0011

ВЯРНО С ОРИГИНАЛА

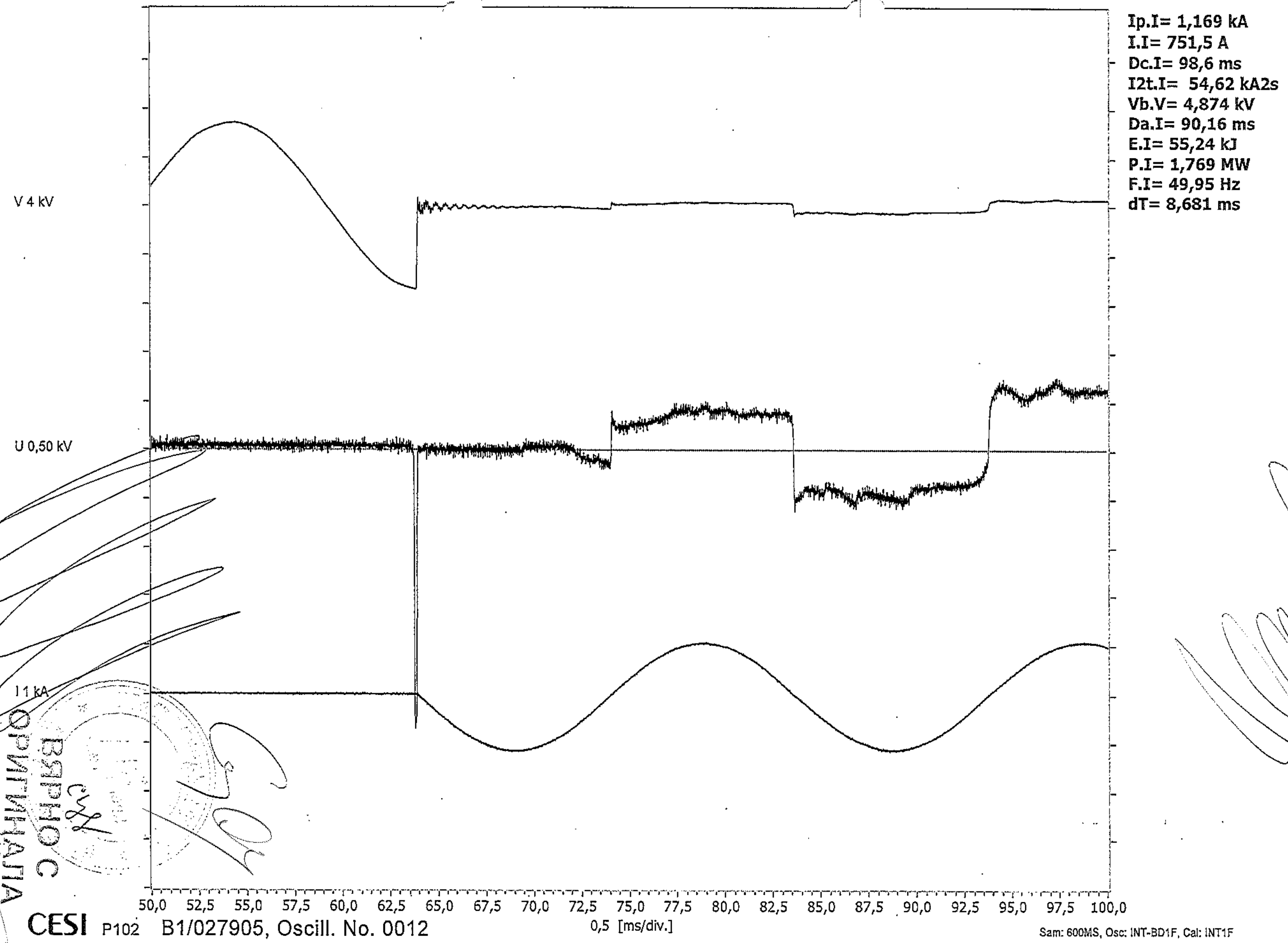
517



Ip.I= 1,169 kA
I.I= 751,5 A
Dc.I= 98,6 ms
I2t.I= 54,62 kA2s
Vb.V= 4,874 kV
Da.I= 90,16 ms
E.I= 55,24 kJ
P.I= 1,769 MW
F.I= 49,95 Hz

CESI P102 B1/027905, Oscill. No. 0012

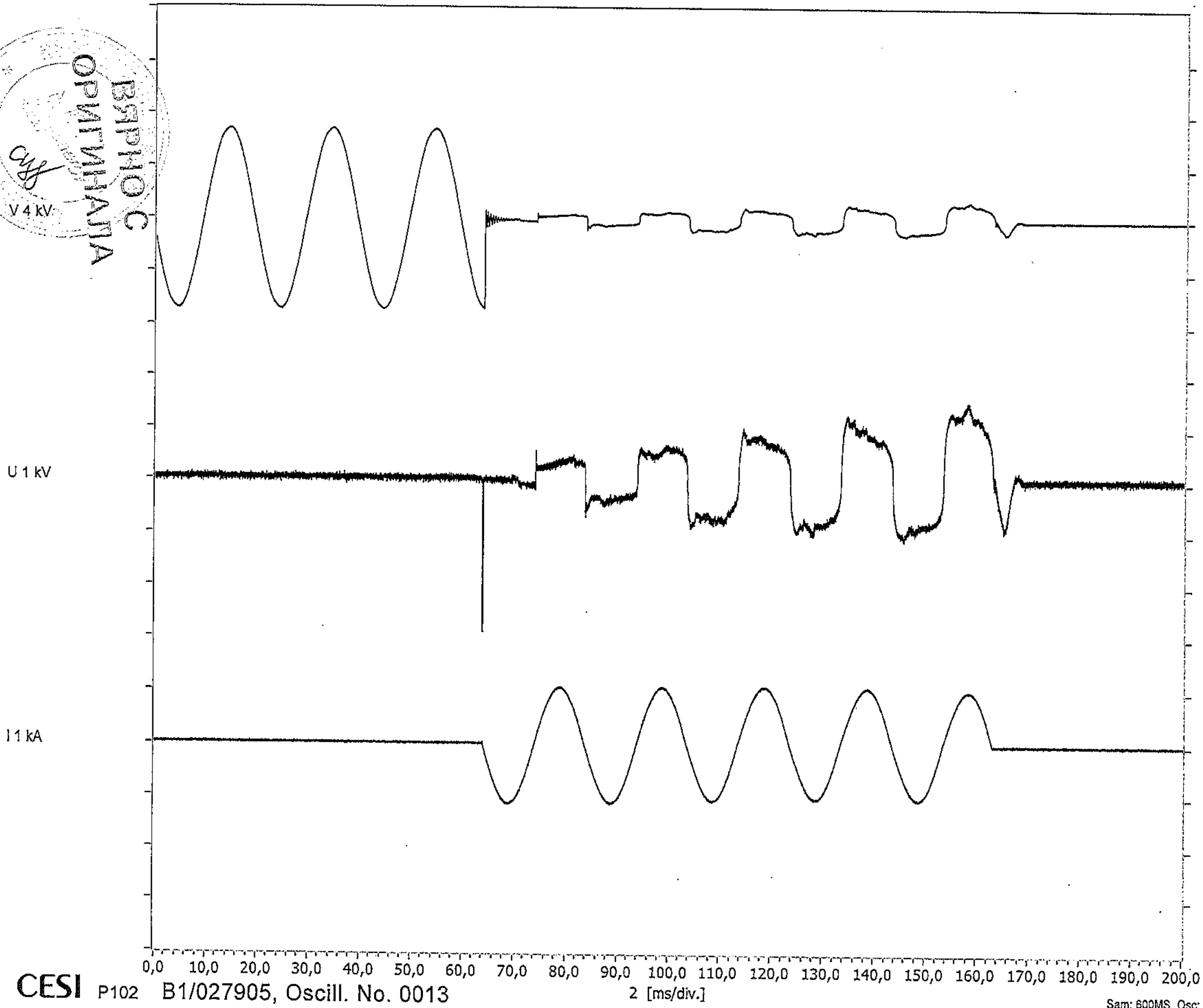
Sam: 600MS, Osc: INT-BD1F, Cal: INT1F



CESI P102 B1/027905, Oscill. No. 0012

ВЯРНО С
ОРИГИНАЛА

519



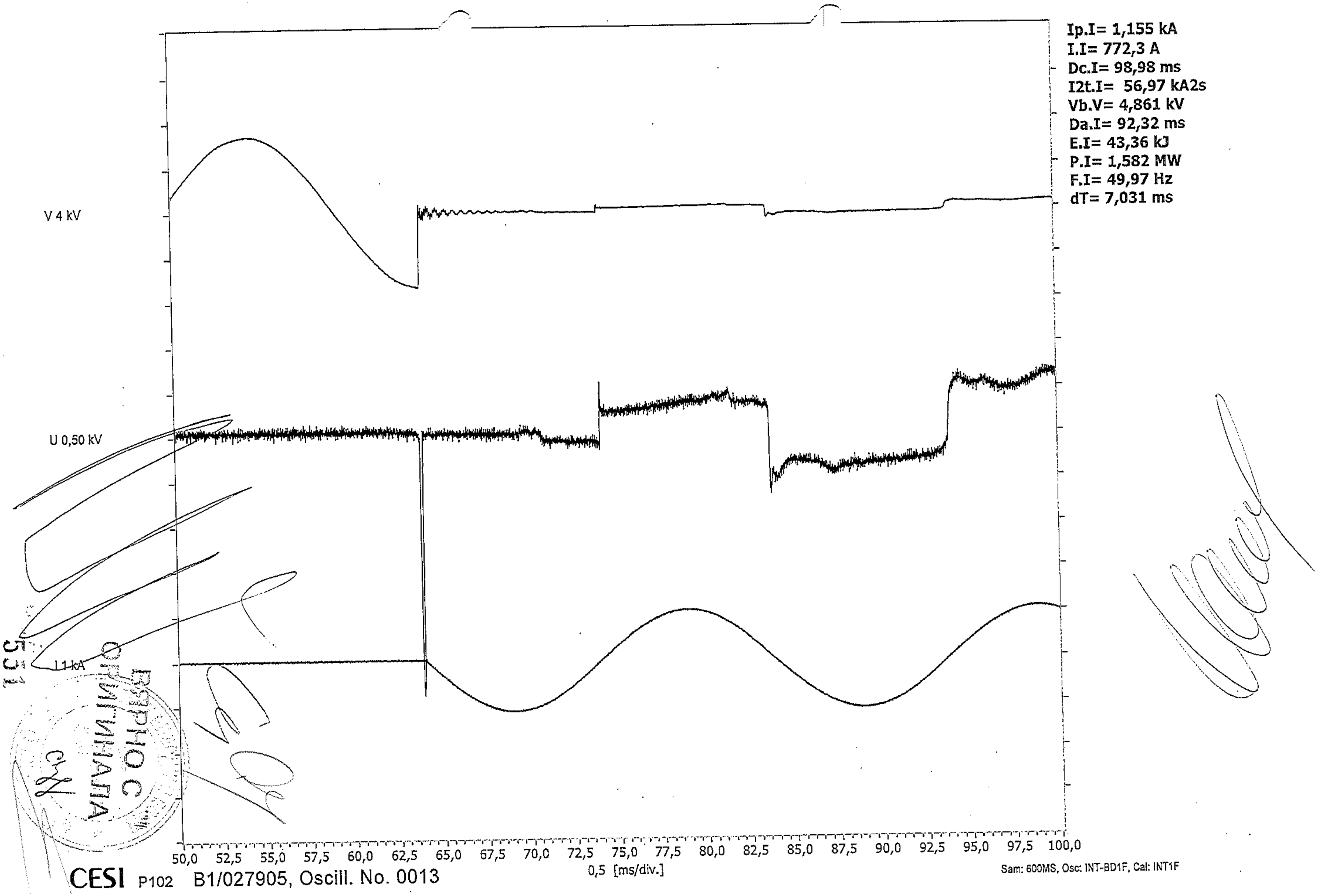
Ip.I= 1,155 kA
I.I= 772,3 A
Dc.I= 98,98 ms
I2t.I= 56,97 kA2s
Vb.V= 4,861 kV
Da.I= 92,32 ms
E.I= 43,36 kJ
P.I= 1,582 MW
F.I= 49,97 Hz

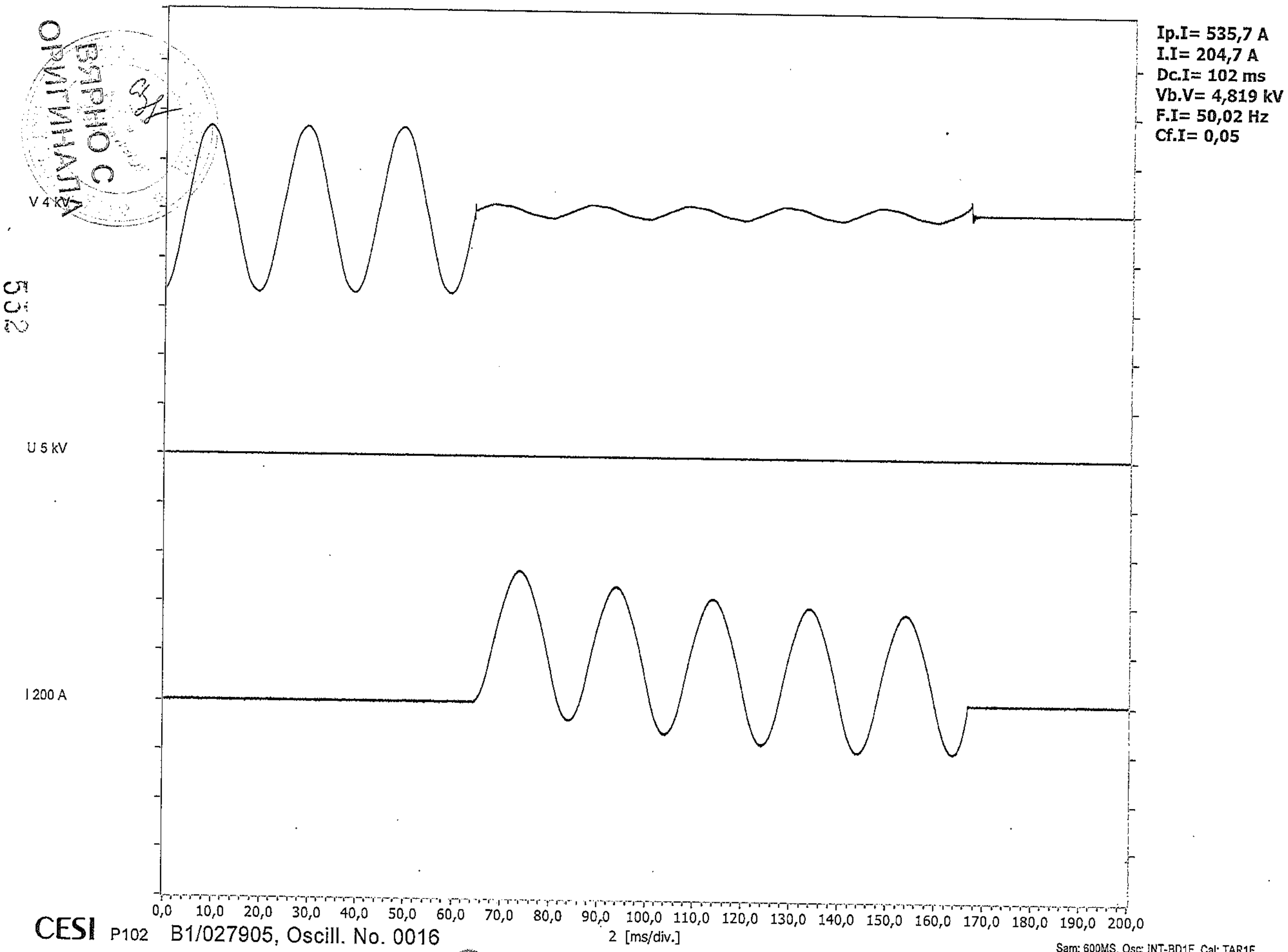
CESI P102 B1/027905, Oscill. No. 0013

Sam: 600MS, Osc: INT-BD1F, Cal: INT1F

ВЯРНО С ОРИГИНАЛА

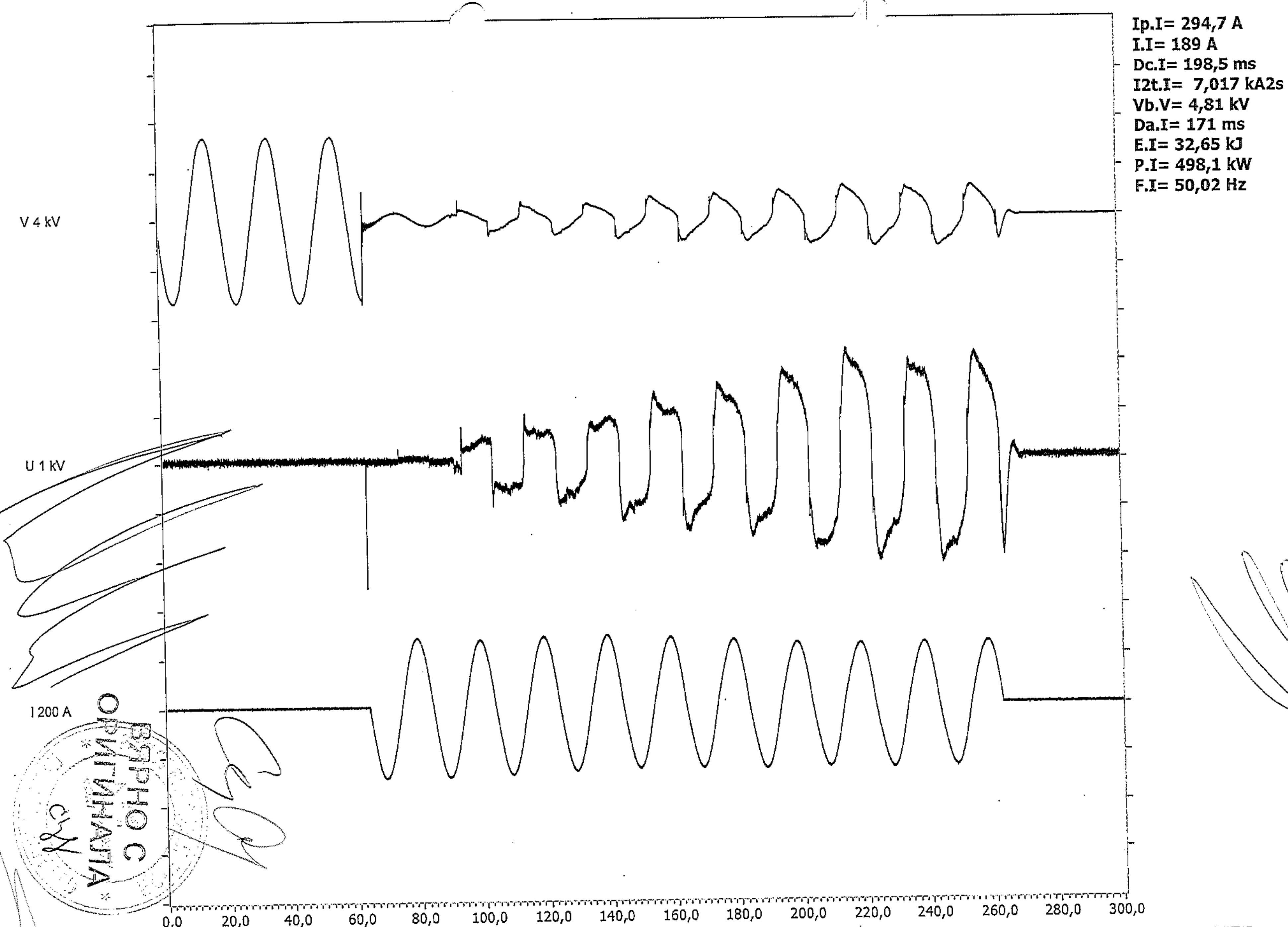
530


Ip.I= 1,155 kA
I.I= 772,3 A
Dc.I= 98,98 ms
I2t.I= 56,97 kA2s
Vb.V= 4,861 kV
Da.I= 92,32 ms
E.I= 43,36 kJ
P.I= 1,582 MW
F.I= 49,97 Hz
dT= 7,031 ms
V 4 kV
U 0,50 kV
I 1 kA
50,0 52,5 55,0 57,5 60,0 62,5 65,0 67,5 70,0 72,5 75,0 77,5 80,0 82,5 85,0 87,5 90,0 92,5 95,0 97,5 100,0
0,5 [ms/div.]
Sam: 600MS, Osc: INT-BD1F, Cal: INT1F
CESI P102 B1/027905, Oscill. No. 0013
ВЯРНО С ОРИГИНАЛА
551



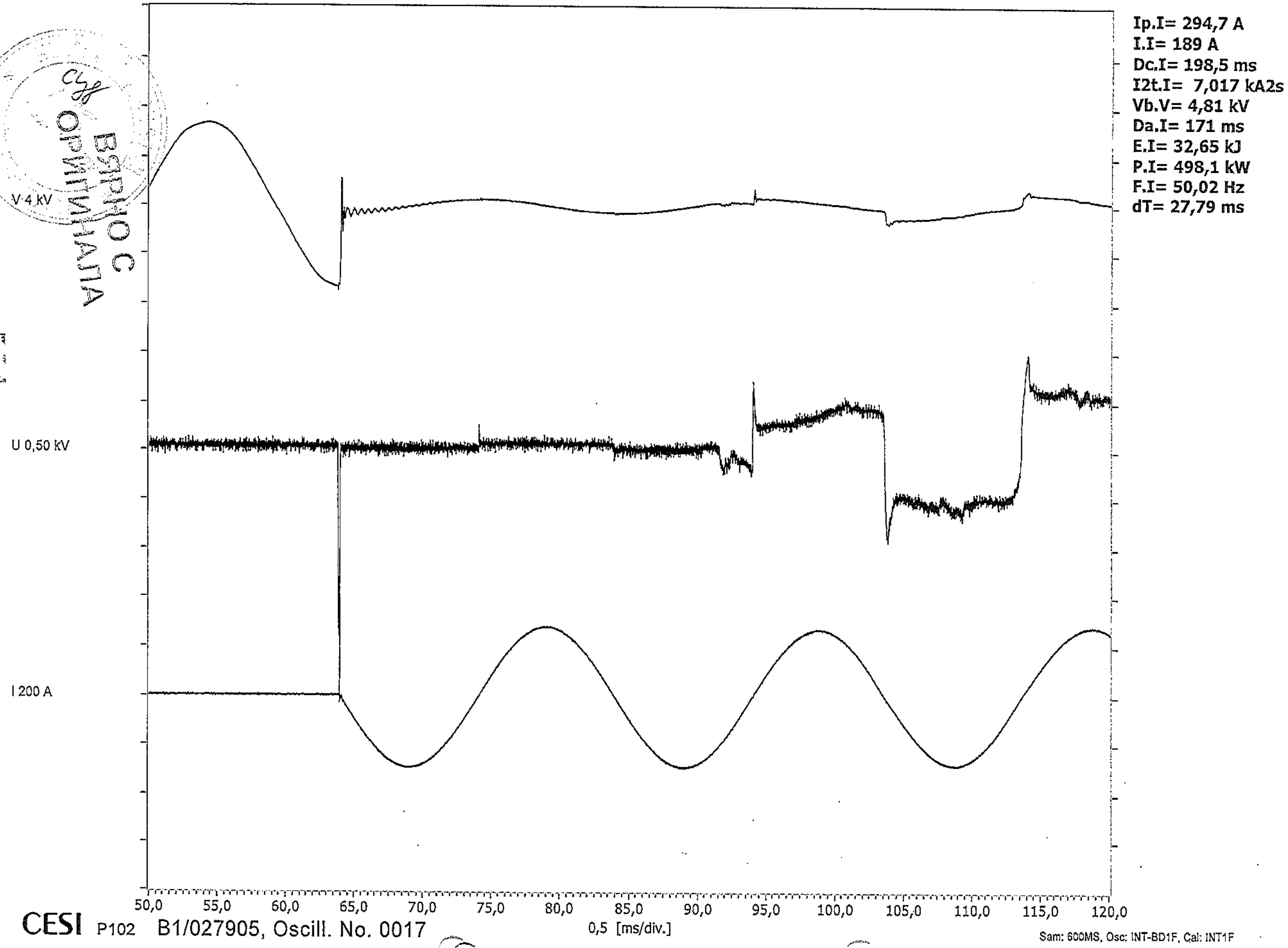
ВЯРНО С ОРИГИНАЛА

552



CESI P102 B1/027905, Oscill. No. 0017

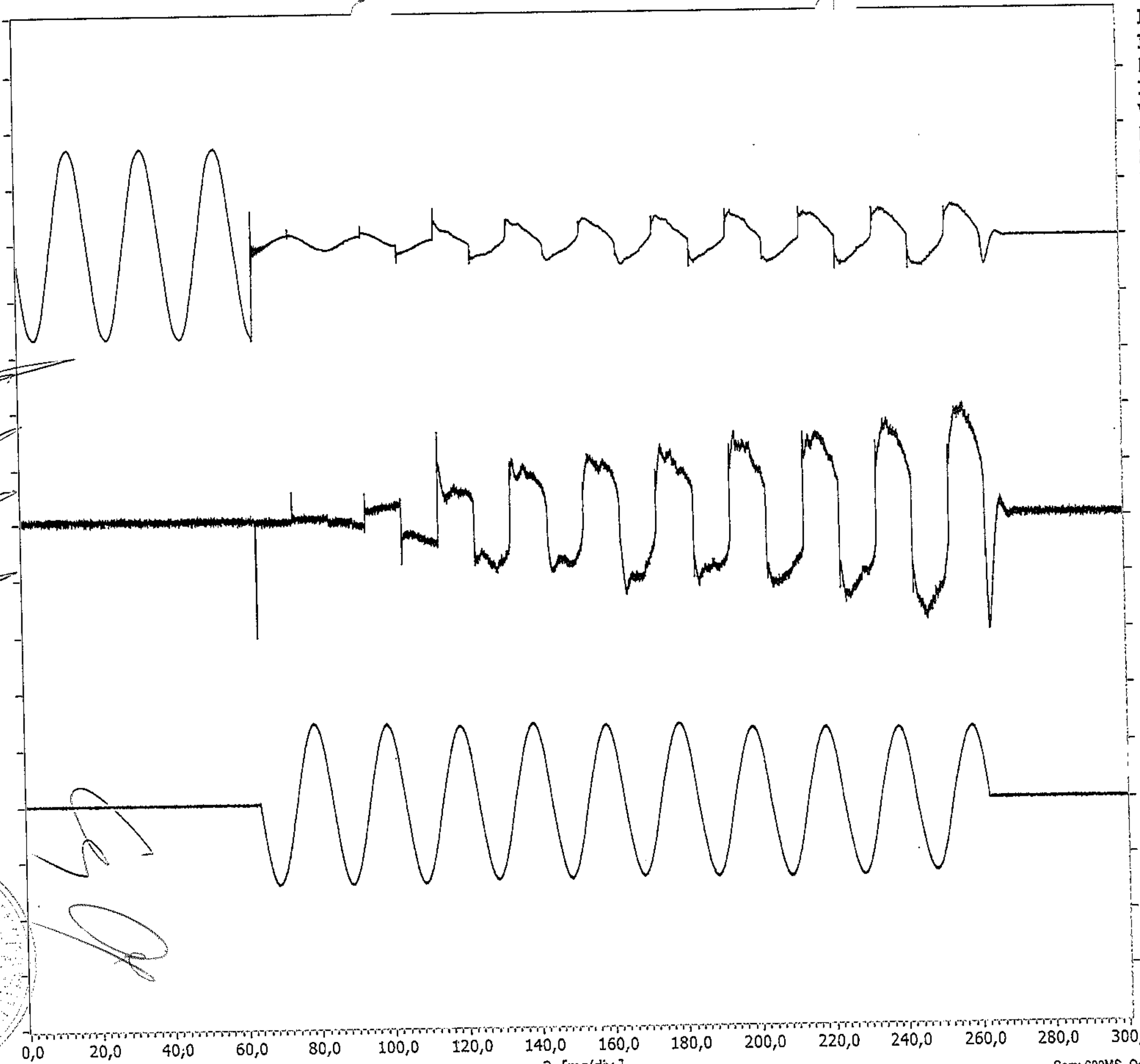
ВЯРНО С ОРИГИНАЛА



CESI P102 B1/027905, Oscill. No. 0017

ВЯРНО С ОРИГИНАЛА

554

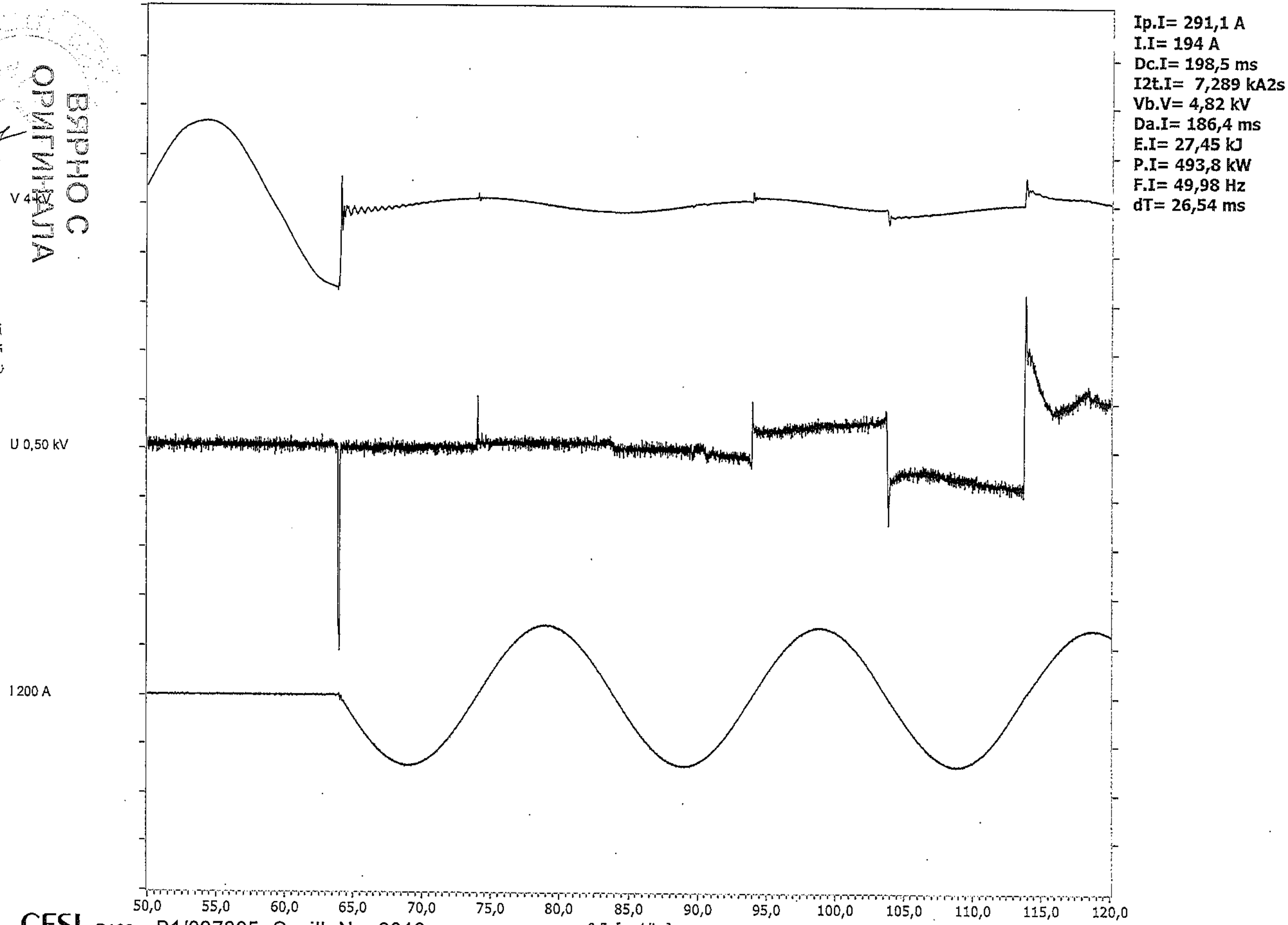


Ip.I= 291,1 A
I.I= 194 A
Dc.I= 198,5 ms
I2t.I= 7,289 kA2s
Vb.V= 4,82 kV
Da.I= 186,4 ms
E.I= 27,45 kJ
P.I= 493,8 kW
F.I= 49,98 Hz

CESI P102 B1/027905, Oscill. No. 0018

Sam: 600MS, Osc: INT-BD1F, Cal: INT1F

ВЯРНО С ОРИГИНАЛА

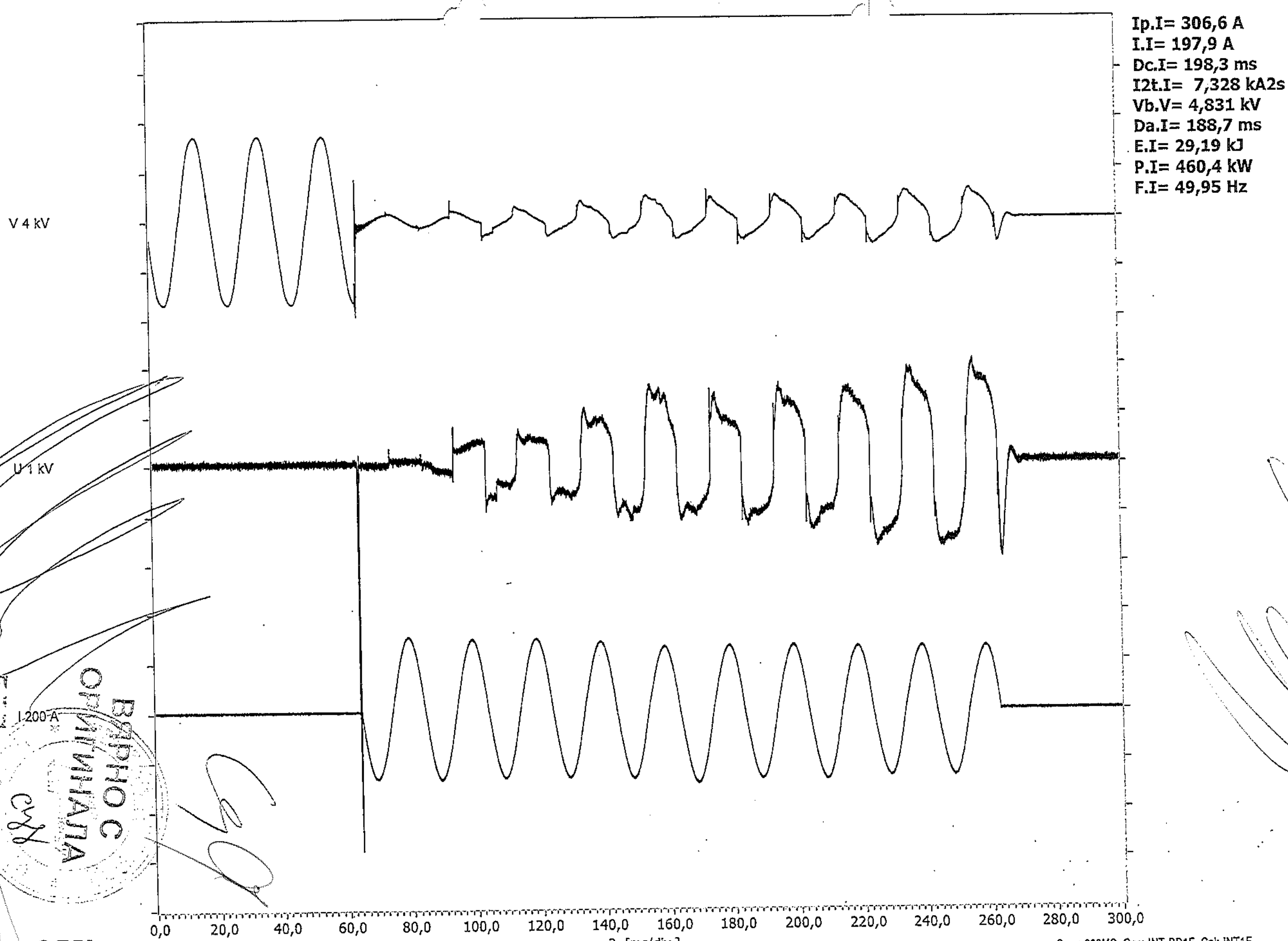


CESI P102 B1/027905, Oscill. No. 0018

Sam: 600MS, Osc: INT-BD1F, Cal: INT1F

ВЯРНО С ОРИГИНАЛА

558

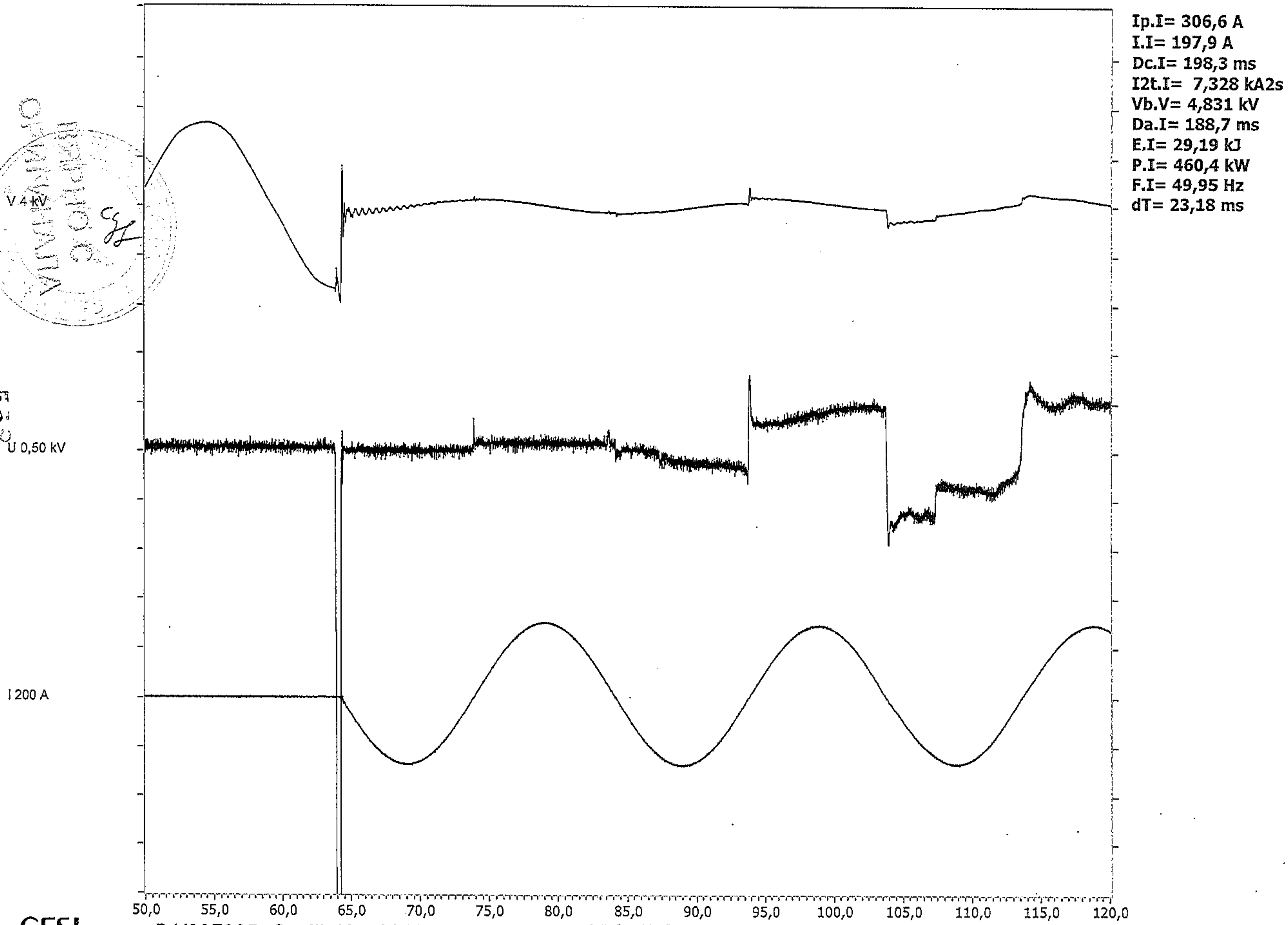


CESI P102 B1/027905, Oscill. No. 0019

ВЯРНО С ОРИГИНАЛА

557

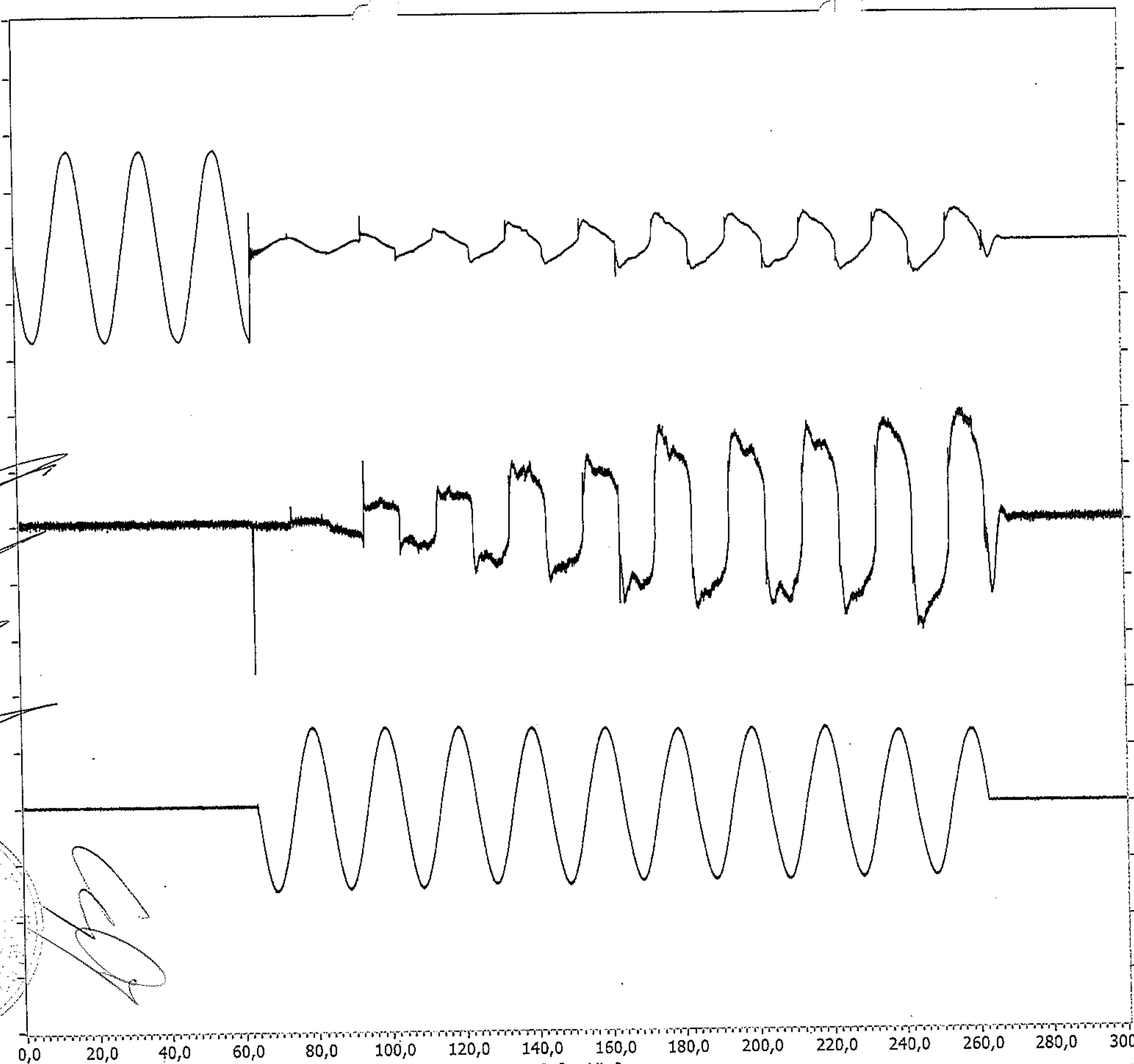
538



CESI P102 B1/027905, Oscill. No. 0019

Sam: 600MS, Osc: INT-BD1F, Cal: INT1F

ВЯРНО С ОРИГИНАЛА



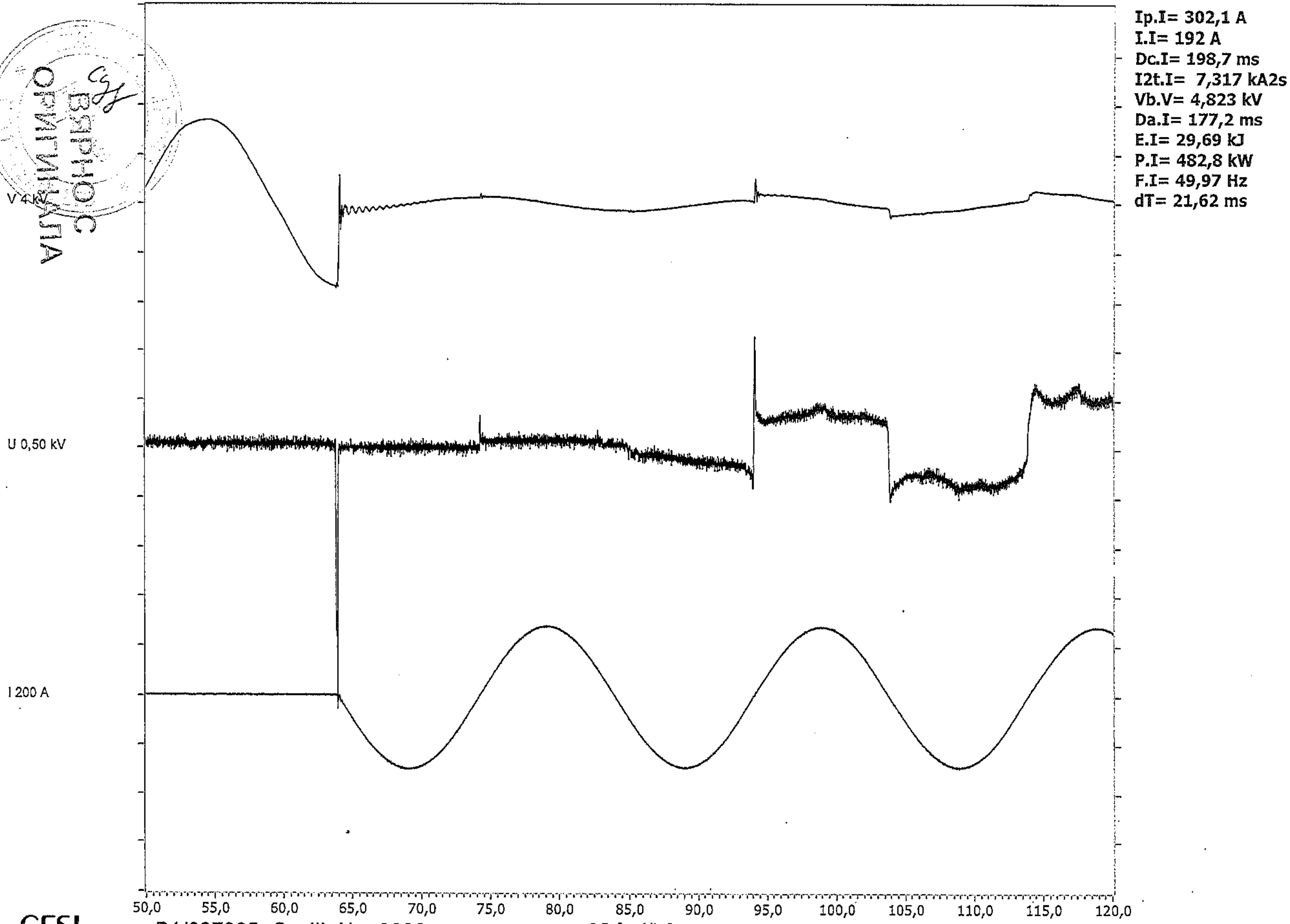
Ip.I= 302,1 A
I.I= 192 A
Dc.I= 198,7 ms
I2t.I= 7,317 kA2s
Vb.V= 4,823 kV
Da.I= 177,2 ms
E.I= 29,69 kJ
P.I= 482,8 kW
F.I= 49,97 Hz

CESI P102 B1/027905, Oscill. No. 0020

Sam: 600MS, Osc: INT-BD1F, Cal: INT1F

ВЯРНО С ОРИГИНАЛА

559

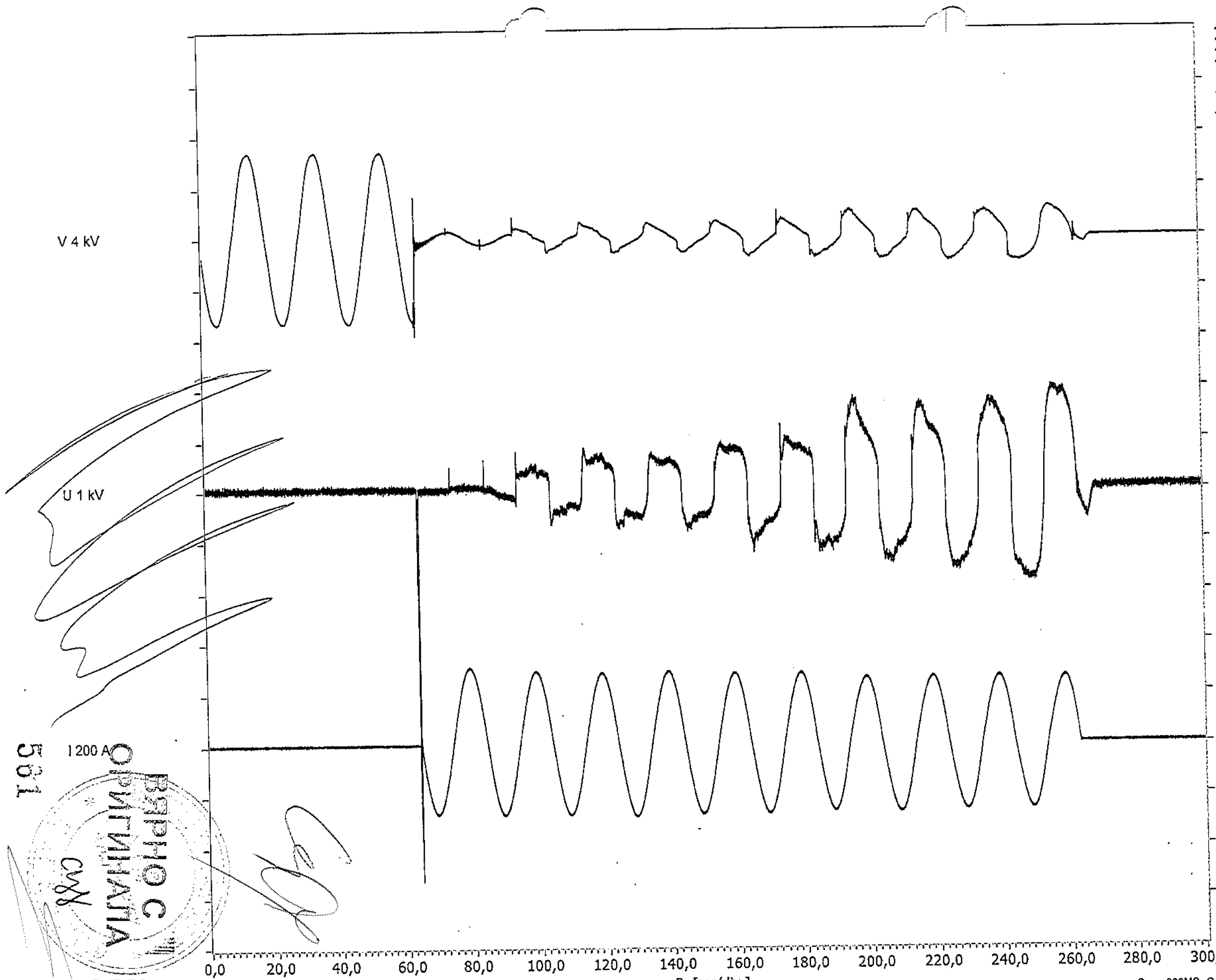


CESI P102 B1/027905, Oscill. No. 0020

Sam: 600MS, Osc: INT-BD1F, Cal: INT1F

560

Ip.I= 307,9 A
I.I= 196,9 A
Dc.I= 198,3 ms
I2t.I= 7,329 kA2s
Vb.V= 4,821 kV
Da.I= 174,6 ms
E.I= 27,54 kJ
P.I= 523 kW
F.I= 49,94 Hz

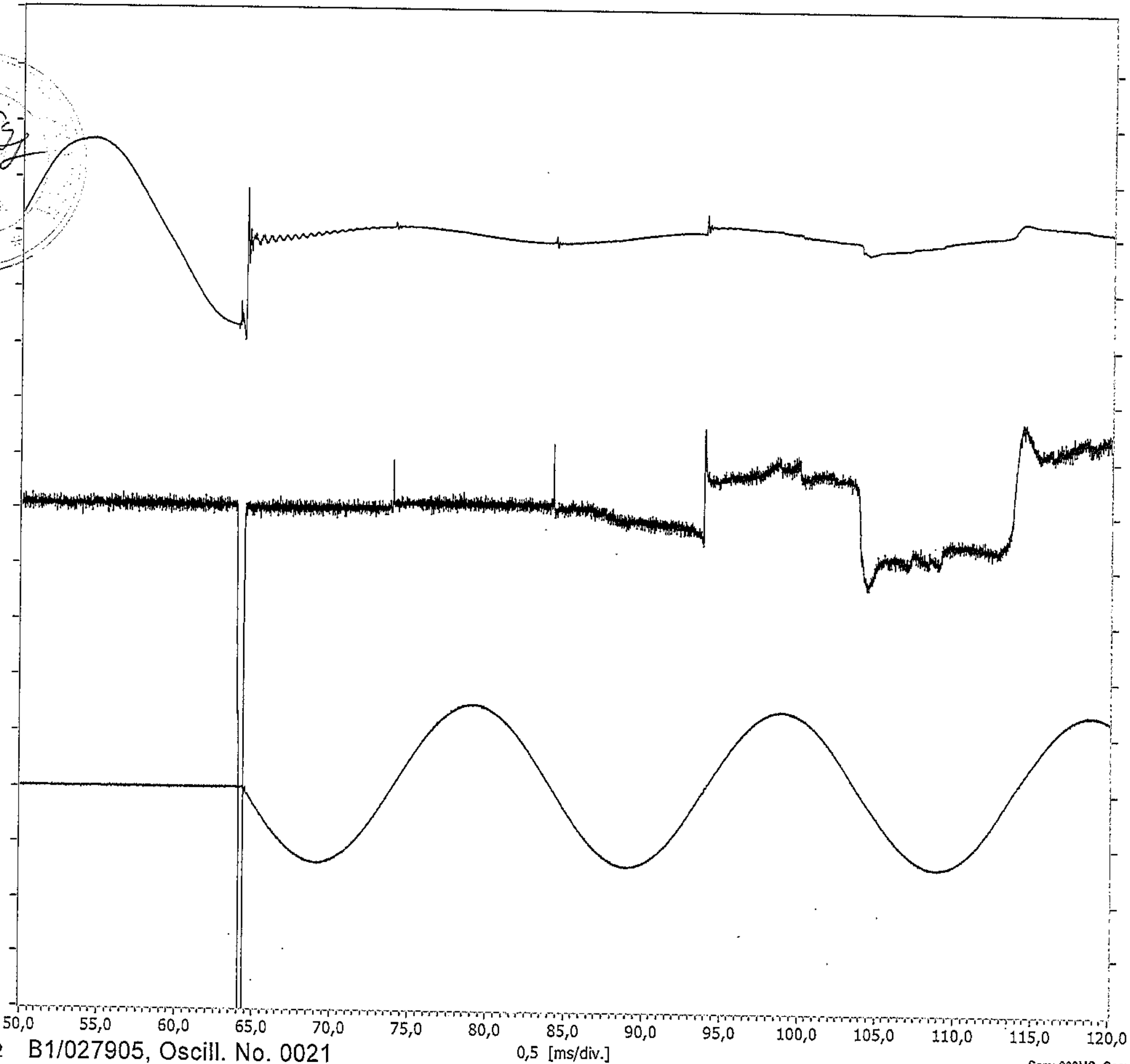


CESI P102 B1/027905, Oscill. No. 0021

Sam: 600MS, Osc: INT-BD1F, Cal: INT1F

ВЯРНО С ОРИГИНАЛА

561



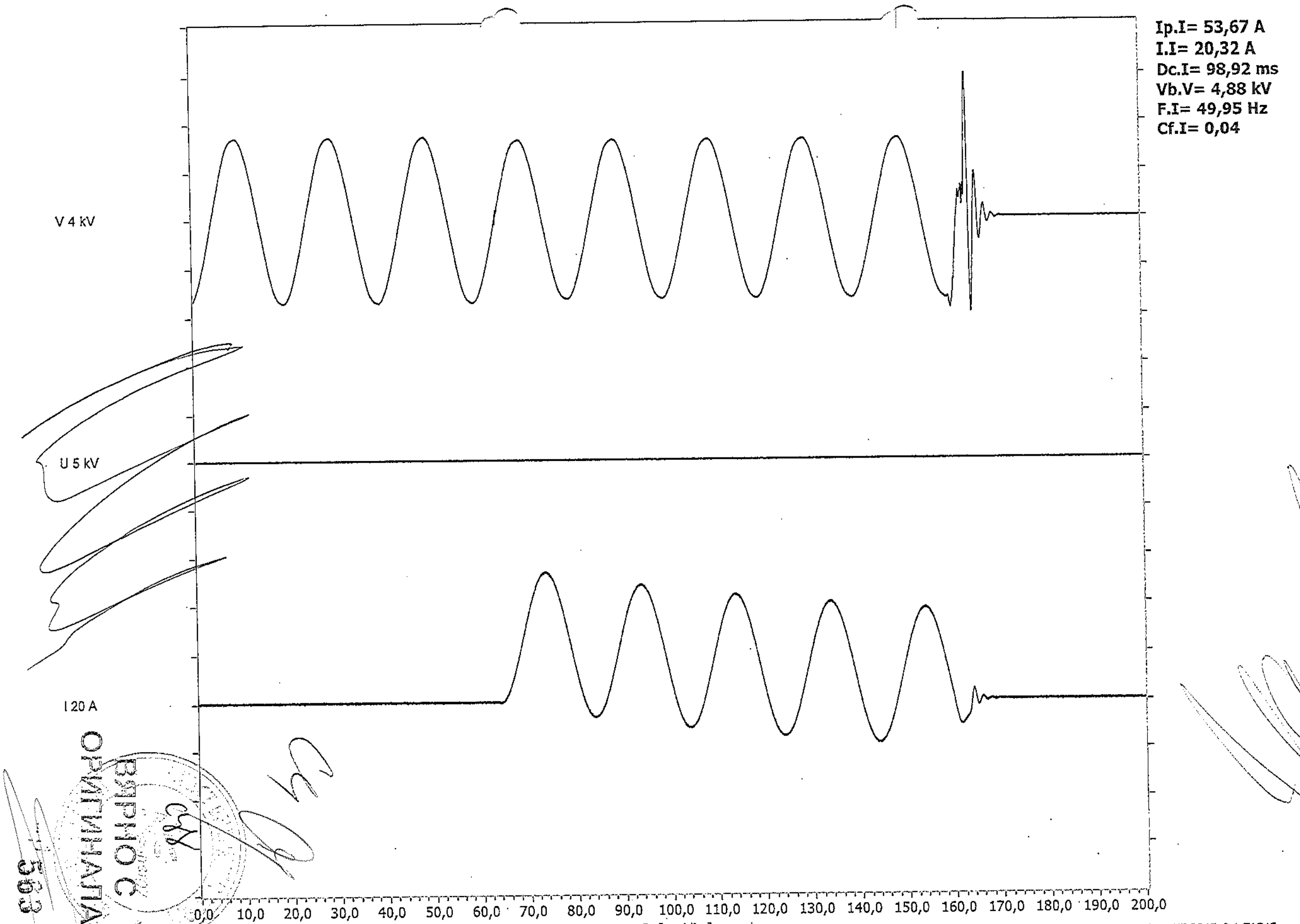
Ip.I= 307,9 A
I.I= 196,9 A
Dc.I= 198,3 ms
I2t.I= 7,329 kA2s
Vb.V= 4,821 kV
Da.I= 174,6 ms
E.I= 27,54 kJ
P.I= 523 kW
F.I= 49,94 Hz
dT= 24,53 ms

CESI P102 B1/027905, Oscill. No. 0021

Sam: 600MS, Osc: INT-BD1F, Cal: INT1F

ВЯРНО С ОРИГИНАЛА

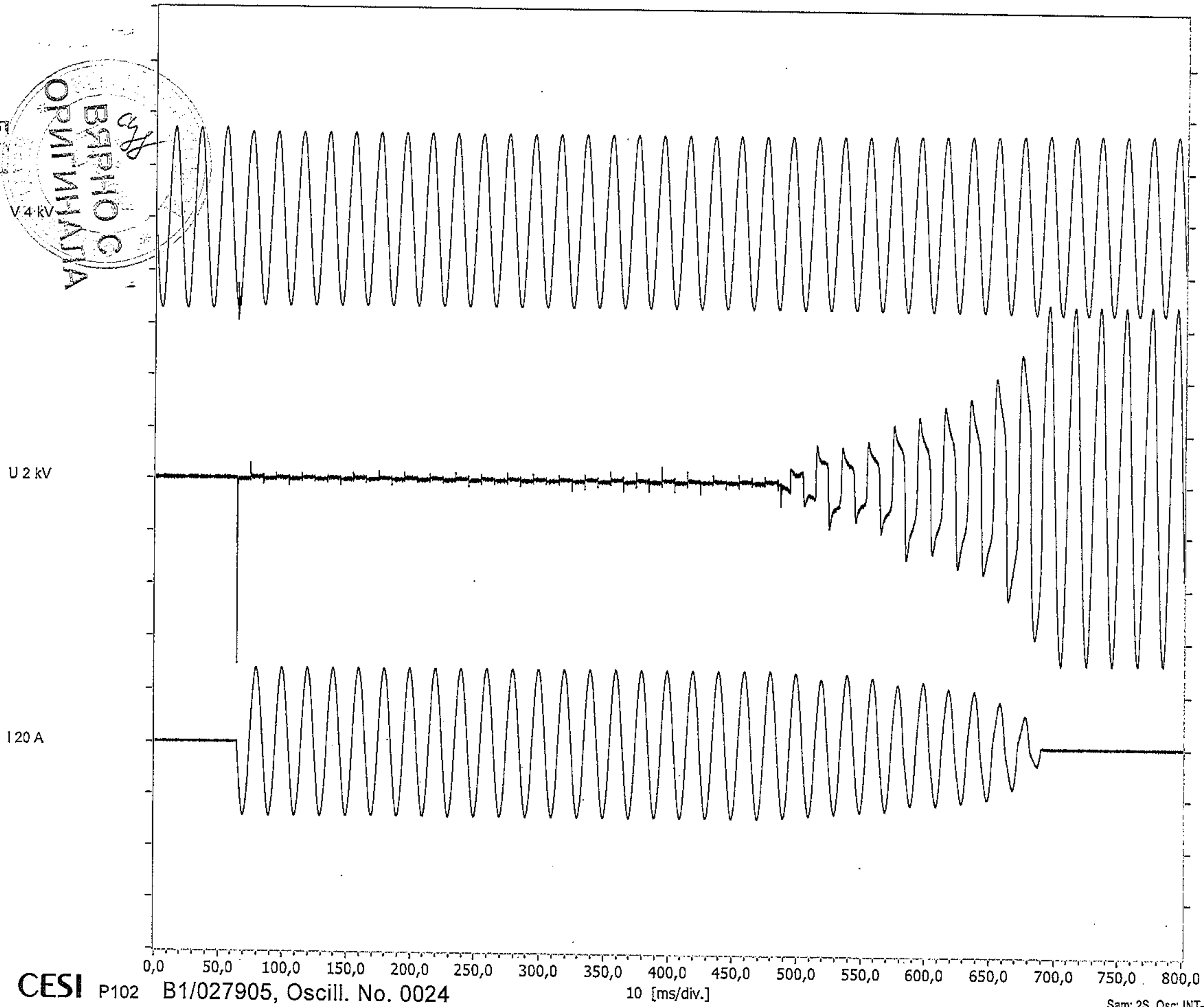
562



CESI P102 B1/027905, Oscill. No. 0023

Sam: 600MS, Osc: INT-BD1F, Cal: TAR1F

ВЯРНО С ОРИГИНАЛА



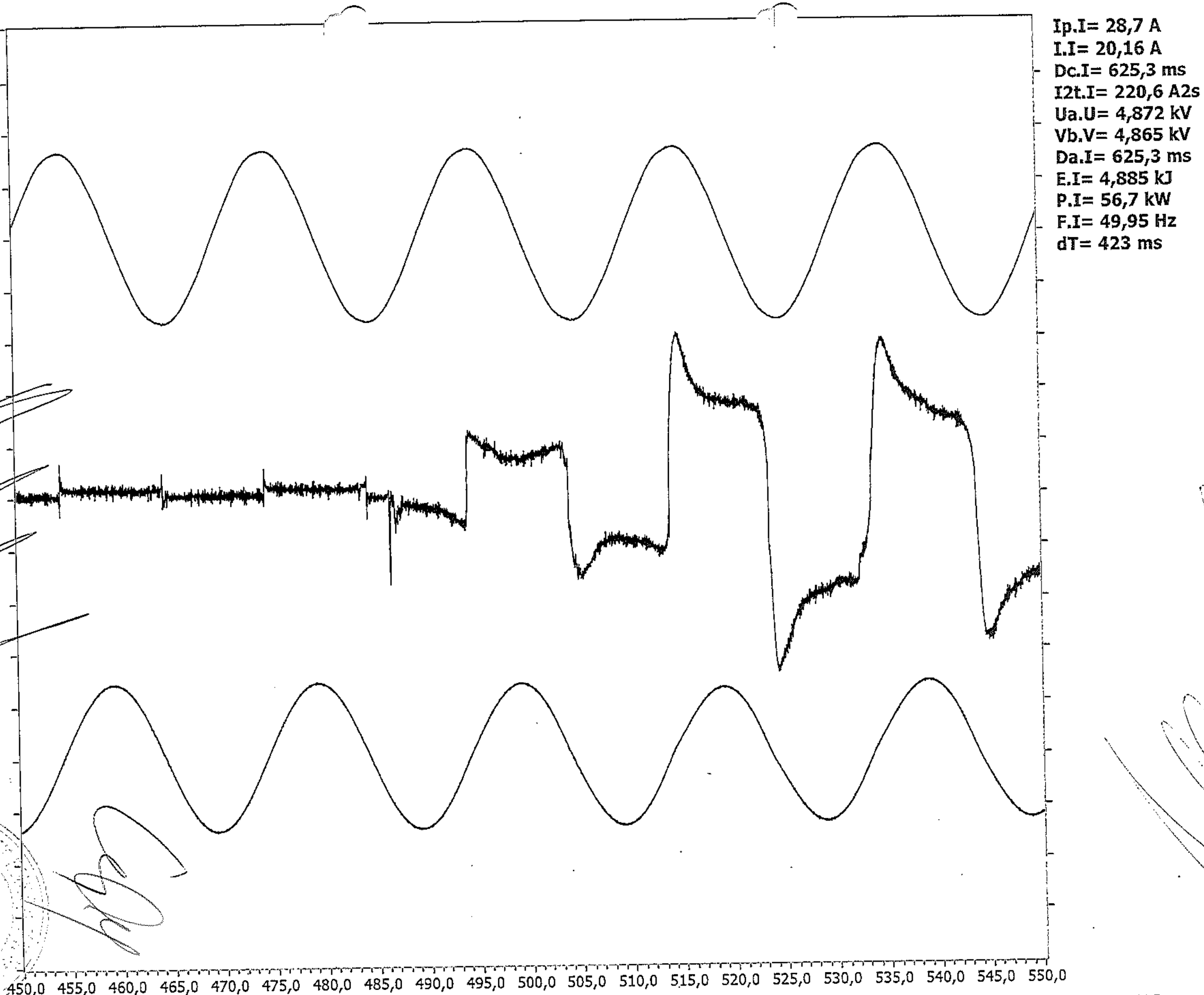
Ip.I= 28,7 A
I.I= 20,16 A
Dc.I= 625,3 ms
I2t.I= 220,6 A2s
Ua.U= 4,872 kV
Vb.V= 4,865 kV
Da.I= 625,3 ms
E.I= 4,885 kJ
P.I= 56,7 kW
F.I= 49,95 Hz

CESI P102 B1/027905, Oscill. No. 0024

Sam: 2S, Osc: INT-BD1F, Cal: INT1F

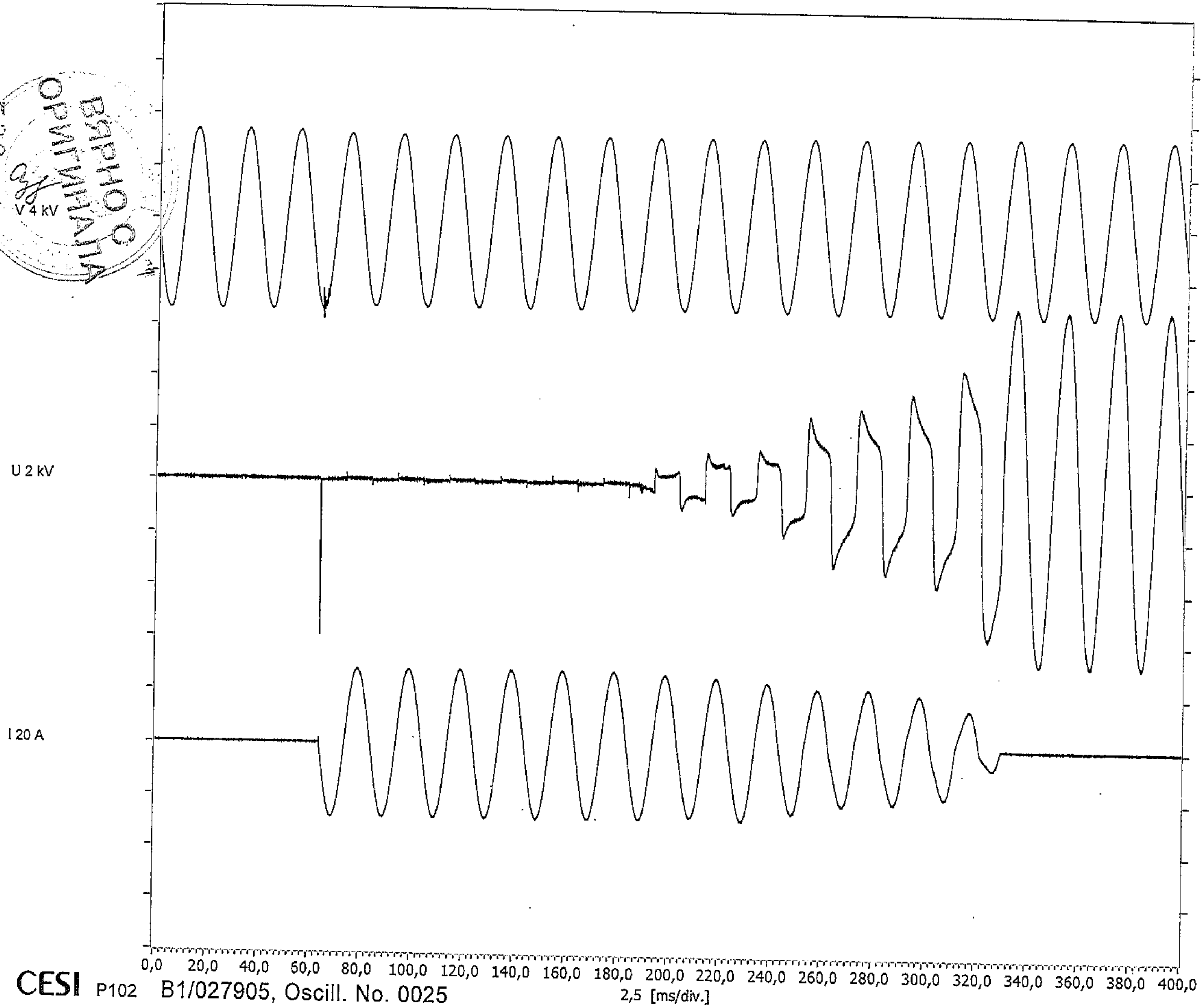
ВЯРНО С ОРИГИНАЛА

564



CESI P102 B1/027905, Oscill. No. 0024

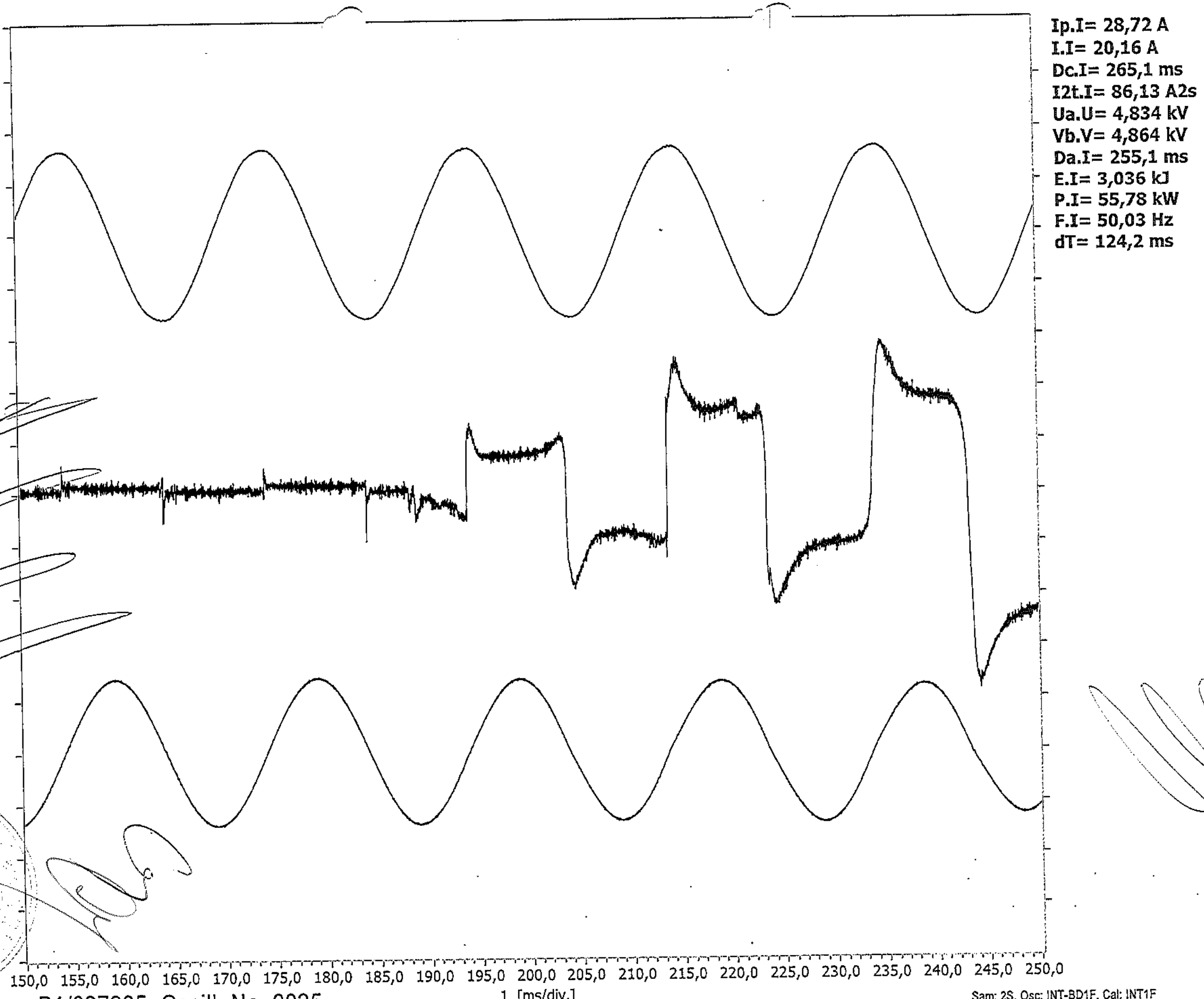
ВЯРНО С ОРИГИНАЛА



Ip.I= 28,72 A
I.I= 20,16 A
Dc.I= 265,1 ms
I2t.I= 86,13 A2s
Ua.U= 4,834 kV
Vb.V= 4,864 kV
Da.I= 255,1 ms
E.I= 3,036 kJ
P.I= 55,78 kW
F.I= 50,03 Hz

CESI P102 B1/027905, Oscill. No. 0025

Sam: 2S, Osc: INT-BD1F, Cal: INT1F

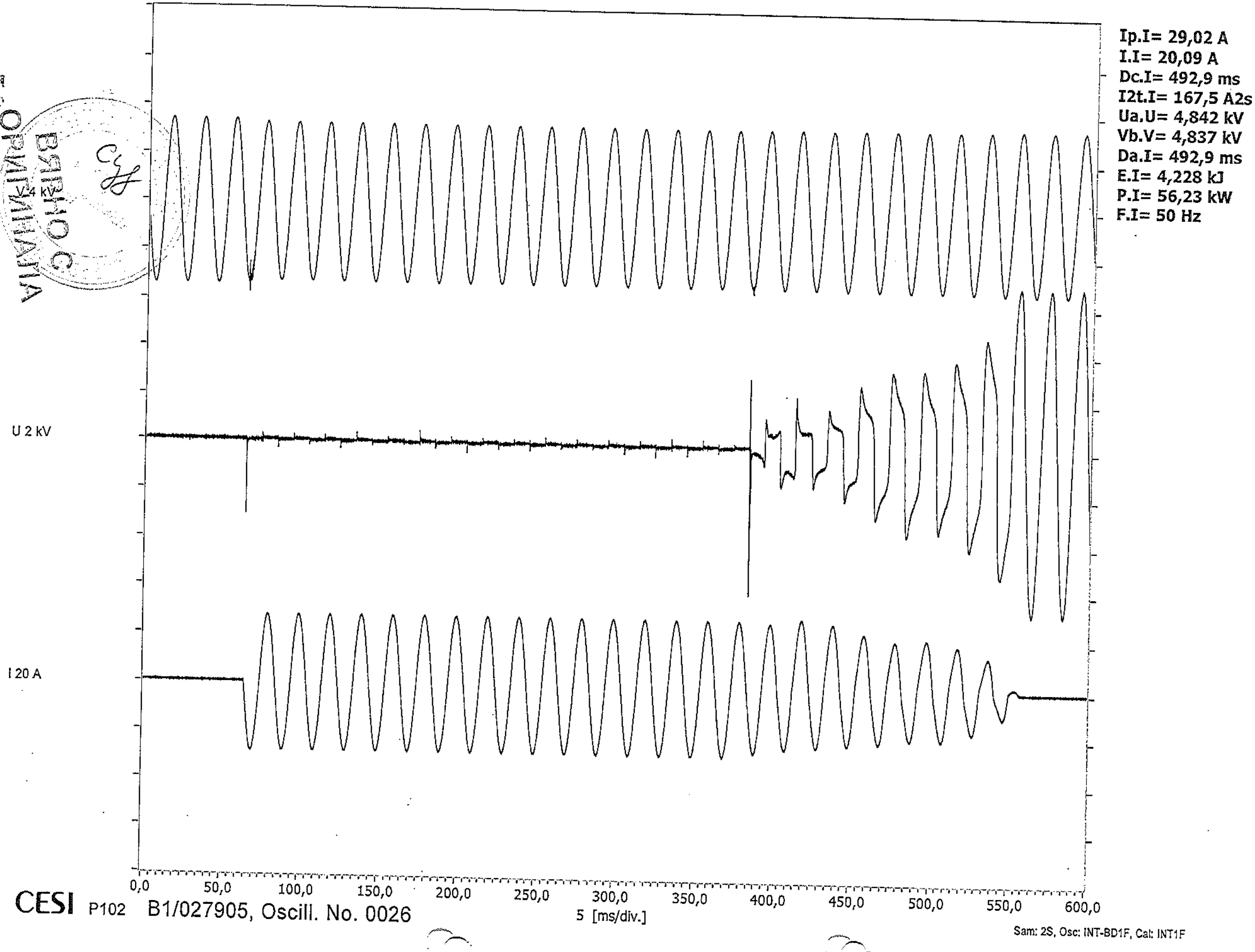


CESI P102 B1/027905, Oscill. No. 0025

Sam: 2S, Osc: INT-BD1F, Cal: INT1F

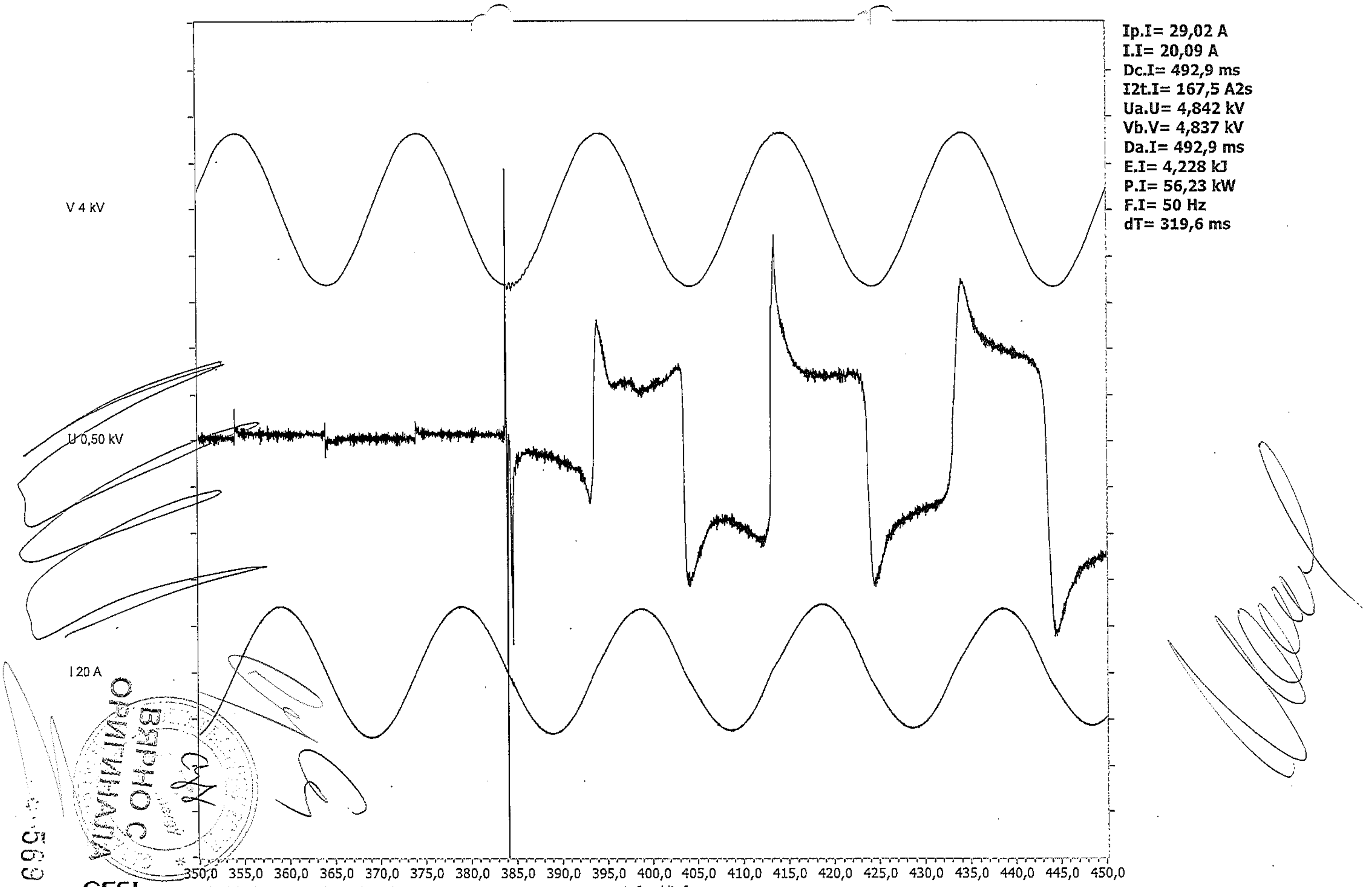
ВЯРНО С ОРИГИНАЛА

567



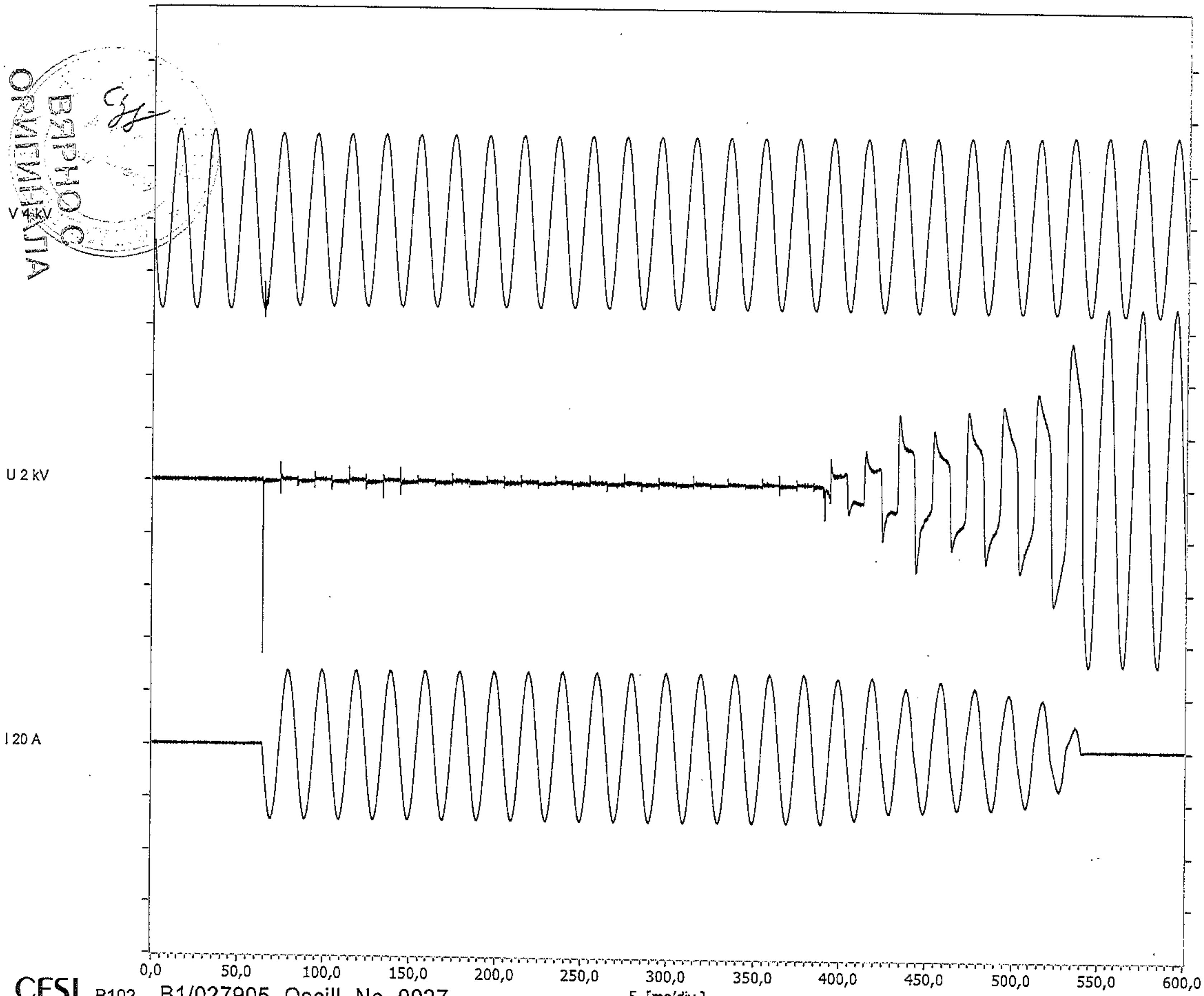
CESI P102 B1/027905, Oscill. No. 0026

509



CESI P102 B1/027905, Oscill. No. 0026

Sam: 2S, Osc: INT-BD1F, Cal: INT1F

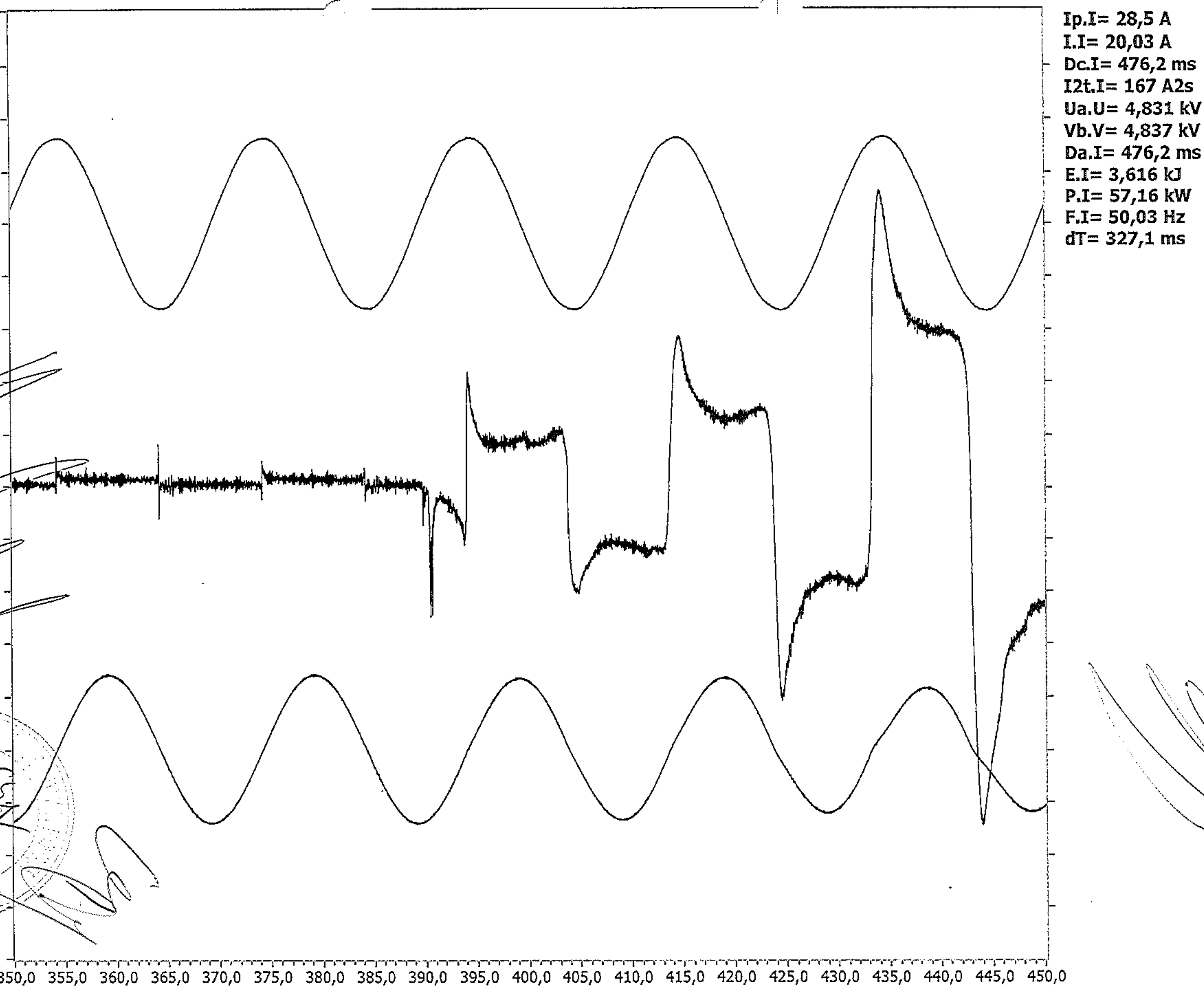


Ip.I= 28,5 A
I.I= 20,03 A
Dc.I= 476,2 ms
I2t.I= 167 A2s
Ua.U= 4,831 kV
Vb.V= 4,837 kV
Da.I= 476,2 ms
E.I= 3,616 kJ
P.I= 57,16 kW
F.I= 50,03 Hz

CESI P102 B1/027905, Oscill. No. 0027

Sam: 2S, Osc: INT-BD1F, Cal: INT1F

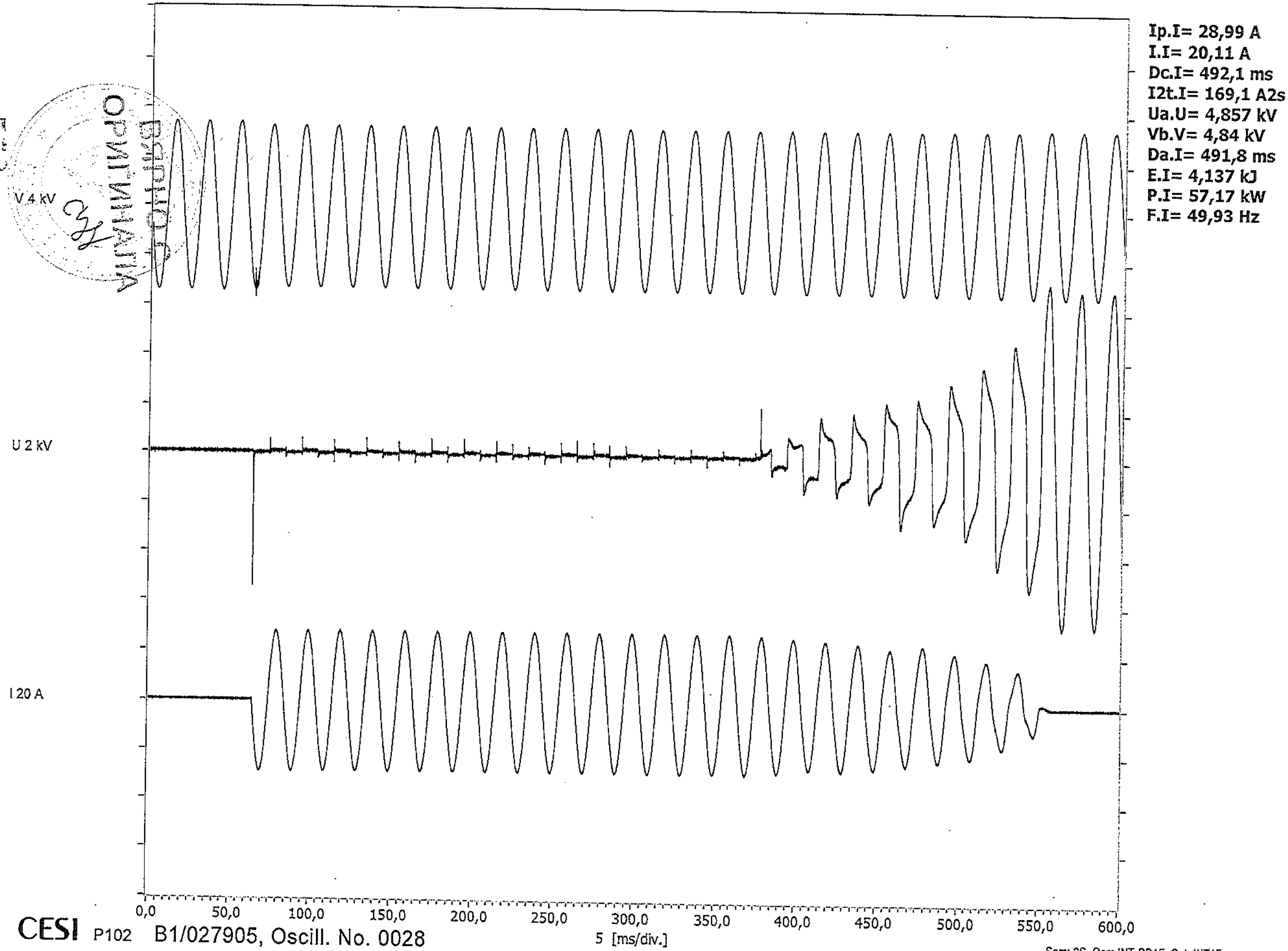
ВЯРНО С ОРИГИНАЛА



ВЯРНО С ОРИГИНАЛА

CESI P102 B1/027905, Oscill. No. 0027

Sam: 2S, Osc: INT-BD1F, Cal: INT1F

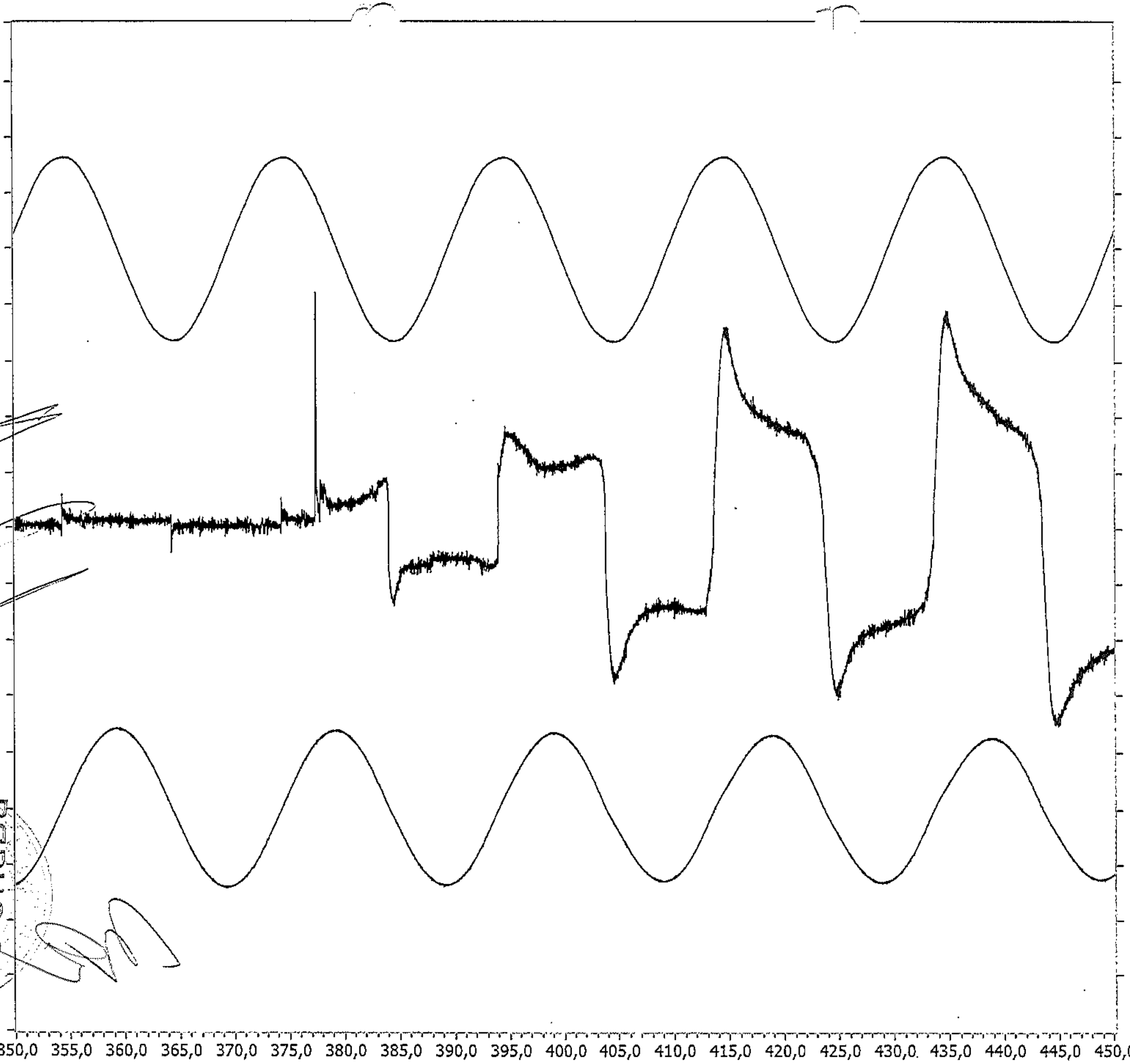


CESI P102 B1/027905, Oscill. No. 0028

Sam: 2S, Osc: INT-BD1F, Cal: INT1F

ВЯРНО С ОРИГИНАЛА

572



Ip.I= 28,99 A
I.I= 20,11 A
Dc.I= 492,1 ms
I2t.I= 169,1 A2s
Ua.U= 4,857 kV
Vb.V= 4,84 kV
Da.I= 491,8 ms
E.I= 4,137 kJ
P.I= 57,17 kW
F.I= 49,93 Hz
dT= 314,2 ms

CESI P102 B1/027905, Oscill. No. 0028

Sam: 2S, Osc: INT-BD1F, Cal: INT1F

ВЯРНО С ОРИГИНАЛА

CESI

Client	AREVA Parafoudres S.A. Bagneres de Bigorre - FRANCE	
Tested equipment	Polymer-housed metal-oxide surge arresters	
Tests carried out	Short-circuit tests	
Standards/Specifications	IEC 60099-4 (2006-07)	
Test date	**from** May 20, 2008	**to** May 21, 2008

PUBBLICATO A8018577 (PAD - 1073222)

The results reported in this document relate only to the tested equipment.
Partial reproduction of this document is permitted only with the written permission from CESI

No. of pages	18	**No. of pages annexed**	7
Issue date	June 25, 2008		
Prepared	Unit LABORATORIES - P. Beccarini		
Verified	Unit LABORATORIES - D. Ronchi		
Approved	Unit LABORATORIES - R. Nicolini		

CESI S.p.A.
Energy Division
Technical Area Components
"Testing Laboratories"
Manager

ВЯРНО С ОРИГИНАЛА

Tests witnessed by

Mr. F. Malpiece	AREVA Parafoudres S.A. - Bagneres de Bigorre - France
Mr. H. Sauvage	AREVA Parafoudres S.A. - Bagneres de Bigorre - France

Identification of the object Not requested.

Only for laboratory requirement, in order to reproduce the test conditions, all the laboratory data are contained in the document marked: A8014192

The measurement uncertainties of the test results reported in the document are the following:
voltage: ± 5 % ; **current:** ± 5 % ; **time:** ± 5 % ; **temperature:** ± 2 °C
The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to a confidence level of about 95 %) and have to be considered as maximum values.

Receipt date of the sample May 19, 2008

Contents	Page	Test date
Rated characteristics of the tested object assigned by the Client	4	
Test arrangement	5	
Tests performed		
High-current short-circuit test with 20,5 kA for 0,214 s	6	May 21, 2008
High-current short-circuit test with 12,2 kA for 0,204 s	7	May 21, 2008
High-current short-circuit test with 6,50 kA for 0,204 s	8	May 20, 2008
Low-current short-circuit test with 630 A for 1,00 s	9	May 20, 2008
Test circuit	10	
Photos	11 to 18	
Pages annexed		
Oscillograms (No.7)		

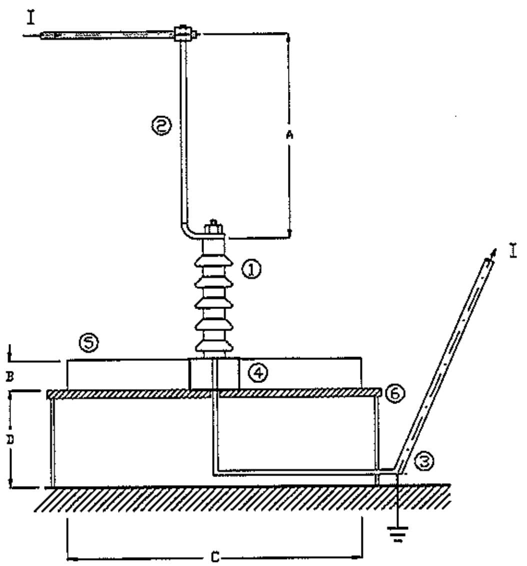
ВЯРНО С ОРИГИНАЛА

577

Rated characteristics of the tested object assigned by the Client

Polymer-housed metal-oxide surge arrester		
Manufacturer		AREVA Parafoudres S. A.
Type		HE / HE-S
Drawing		-
Rated voltage (Ur)		24 kV
Maximum continuous operating voltage (Uc)		20 kV
Rated frequency		50-60 Hz
Nominal discharge current (8/20 µs impulse shape)		10 kA
Line discharge class		1
Rated short circuit current		
High current	for 0,2 s ;	20,0 kA
Low current	for 1,0 s ;	0,60 kA

D8046 - Test arrangement



1 : Surge arrester
2 : Flexible conductor
3 : Rigid conductor
4 : Base
5 : Surrounding fence
6 : Insulating wood platform

A : 1,00 m
B : 0,40 m
C : 1,80 m
D : 1,00 m

The arrester to be tested was installed on a base at 1,40 m to ground in the middle of an enclosure of 1,80 m in side.
The enclosure was positioned on the insulating wood platform.
The live side of the supply was connected to the upper end of the arrester while the return circuit, earthed, was connected to the lower end. The live conductor was directed to the opposite direction as the earth conductor

ВЯРНО С
ОРИГИНАЛА

High-current short-circuit test with 20,5 kA for 0,214 s

Test circuit : See D0046 Power factor : <0,15 Frequency : 50 Hz

Prospective test current			
Oscillogram		rms value	Peak value
No.	Sheets	kA	kA
-	-	-	-

Test arrangement : See D8046
A photo detector was used to determine the venting time.
In order to o achieve the internal discharge the surge arrester has been electrically pre-failed by means of a power frequency over-voltage application using an auxiliary low power source.
The short-circuit current of the auxiliary low power source has been set at about 20 A.
The voltage applied to the arrester was increased in order to get a current equal to 100 mA (0-peak) and kept at this value or slightly adjusted till arrester failure.
The pre-failure process duration was 2 minutes and 45 seconds.
The short-circuit test was performed 4 minutes and 01 sec after the completion of the pre-failure process.

Condition of the apparatus before the tests: new.

Date: May 21, 2008

Test	Oscillogram		Arrester under test	Duration	Test voltage	Test current		Time to flame extinction after the test	Venting time	Notes
						Peak value	rms value			
No.	No.	Sheets	No.	s	kV	kA	kA	s	ms	No.
1	30	1	4	0,214	18,0	48,6	20,5	14	1,0	-

Condition of the apparatus after the tests: see photos No.1 and 2
- There was not violent shattering.
- The arrester structure was damaged by the test.
- The arrester remained connected to the supply and return circuit.
- No fragment were found inside or outside the enclosure.

Acceptance criteria: Fulfilled.
Test result: Positive.

High-current short-circuit test with 12,2 kA for 0,204 s

Test circuit : See D0046 Power factor : <0,15 Frequency : 50 Hz

Prospective test current			
Oscillogram		rms value	Peak value
No.	Sheets	kA	kA
27	1	12,2	33,8

Test arrangement : See D8046
A photo detector was used to determine the venting time
In order to o achieve the internal discharge the surge arrester has been electrically pre-failed by means of a power frequency over-voltage application using an auxiliary low power source.
The short-circuit current of the auxiliary low power source has been set at about 20 A.
The voltage applied to the arrester was increased in order to get a current equal to 100 mA (0-peak) and kept at this value or slightly adjusted till arrester failure.
The pre-failure process duration was 2 minutes and 40 seconds
The short-circuit test was performed 3 minutes and 50 sec after the completion of the pre-failure process.

Condition of the apparatus before the tests: new.

Date: May 21, 2008

Test	Oscillogram		Arrester under test	Duration	Test voltage	Test current		Time to flame extinction after the test	Venting time	Notes
						Peak value	rms value			
No.	No.	Sheets	No.	s	kV	kA	kA	s	ms	No.
2	28	1	3	0,204	18,0	31,0	12,2	-	1,0	-

Condition of the apparatus after the tests: see photos No.3 and 4
- There was not violent shattering.
- The arrester structure was damaged by the test.
- The arrester remained connected to the supply and return circuit.
- No fragment were found inside or outside the enclosure.

Acceptance criteria: Fulfilled.
Test result: Positive.

High-current short-circuit test with 6,50 kA for 0,204 s

Test circuit : See D0046 Power factor : <0,15 Frequency : 50 Hz

Prospective test current			
Oscillogram		rms value	Peak value
No.	Sheets	kA	kA
25	1	6,60	18,1

Test arrangement : See D8046
A photo detector was used to determine the venting time.
In order to achieve the internal discharge the surge arrester has been electrically pre-failed by means of a power frequency over-voltage application using an auxiliary low power source.
The short-circuit current of the auxiliary low power source has been set at about 20 A.
The voltage applied to the arrester was increased in order to get a current equal to 100 mA (0-peak) and kept at this value or slightly adjusted till arrester failure.
The pre-failure process duration was 3 minutes and 0 seconds.
The short-circuit test was performed 4 minutes and 10 sec after the completion of the pre-failure process.

Condition of the apparatus before the tests: new.

Date: May 20, 2008

Test	Oscillogram		Arrester under test	Duration	Test voltage	Test current		Time to flame extinction after the test	Venting time	Notes
						Peak value	rms value			
No.	No.	Sheets	No.	s	kV	kA	kA	s	ms	No.
3	26	1	2	0,204	18,0	16,0	6,50	-	2,0	-

Condition of the apparatus after the tests: see photos No.5 and 6
- There was not violent shattering.
- The arrester structure remained (almost) intact.
- The arrester remained connected to the supply and return circuit.
- No fragment were found inside or outside the enclosure.

Acceptance criteria: Fulfilled.
Test result: Positive.

Low-current short-circuit test with 630 A for 1,00 s

Test circuit : See D0046   Power factor : <0,15   Frequency : 50 Hz

Prospective test current			
Oscillogram		rms value	Peak value
No.	Sheets	A	A
22	1	630	1590

Test arrangement : See D8046
A photo detector was used to determine the venting time.
In order to o achieve the internal discharge the surge arrester has been electrically pre-failed by means of a power frequency over-voltage application using an auxiliary low power source.
The short-circuit current of the auxiliary low power source has been set at about 20 A.
The voltage applied to the arrester was increased in order to get a current equal to 100 mA (0-peak) and kept at this value or slightly adjusted till arrester failure.
The pre-failure process duration was 3 minutes and 05 seconds.
The short-circuit test was performed 3 minutes and 15 sec after the completion of the pre-failure process.

Condition of the apparatus before the tests: new.

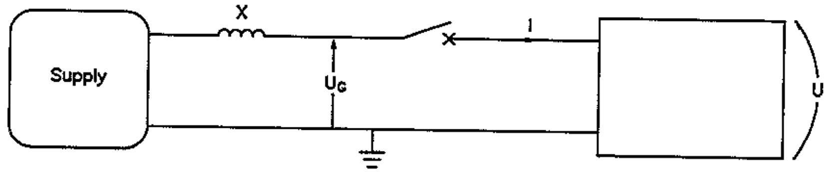
Date: May 20, 2008

Test	Oscillogram		Arrester under test	Duration	Test voltage	Test current		Time to flame extinction after the test	Venting time	Notes
						Peak value	rms value			
No.	No.	Sheets	No.	s	kV	A	A	s	ms	No.
4	24	1	1	1,00	23,0	1190	630	105	8,0	-

Condition of the apparatus after the tests: see photos No.7 and 8
- There was not violent shattering.
- The arrester structure was damaged by the test.
- The arrester remained connected to the supply and return circuit.
- No fragment were found inside or outside the enclosure.

Acceptance criteria: Fulfilled.
Test result: Positive.

Test circuit D0046



Symbols used in this diagram are the same as those on the oscillograms.

D0046IG

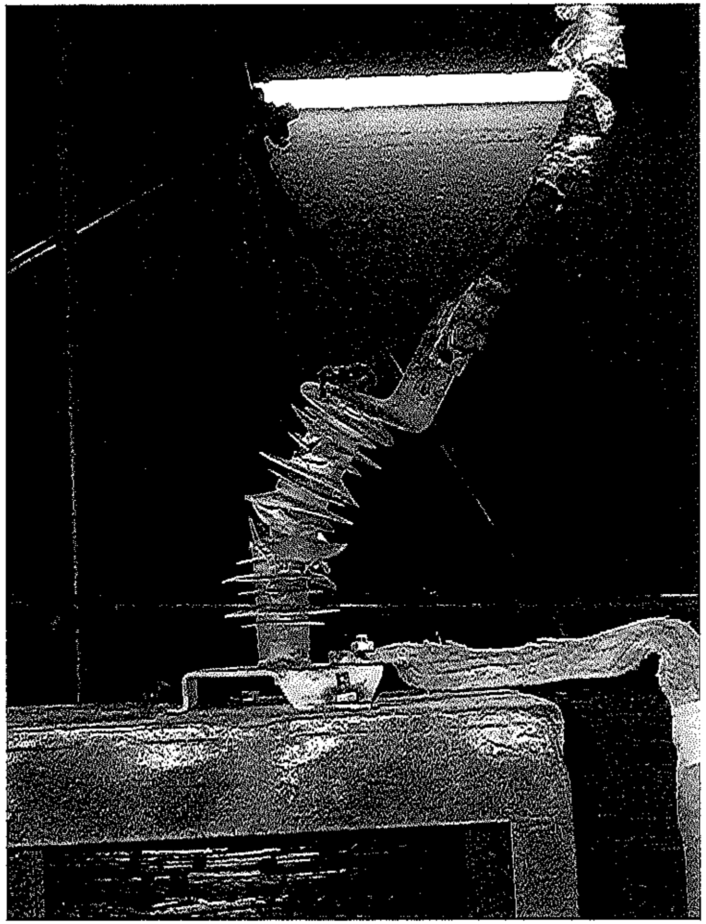


Photo No.1

ВЯРНО С
ОРИГИНАЛА

535

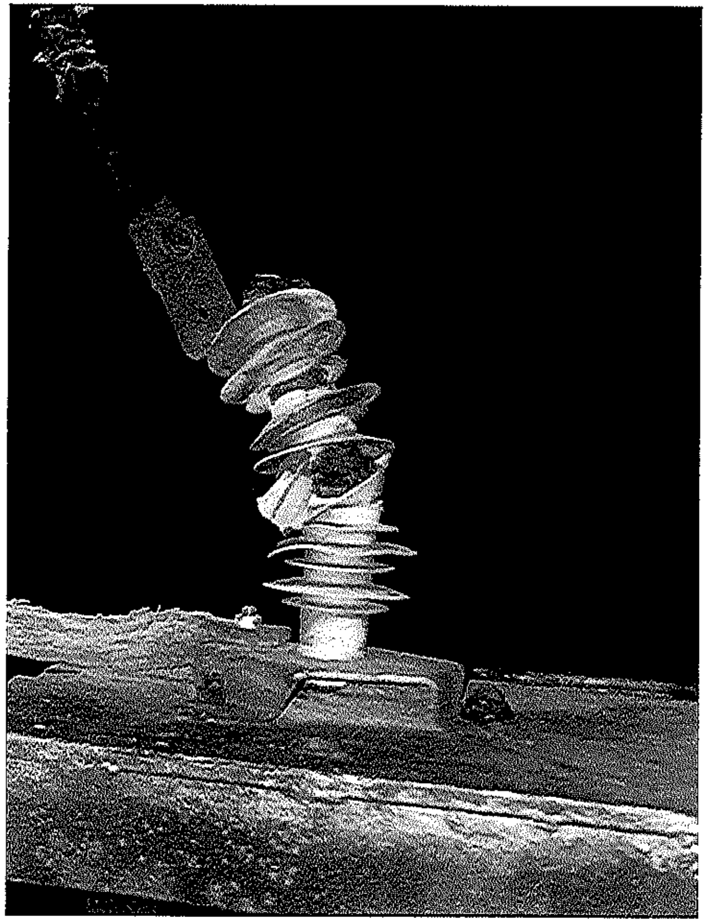


Photo No.2

536

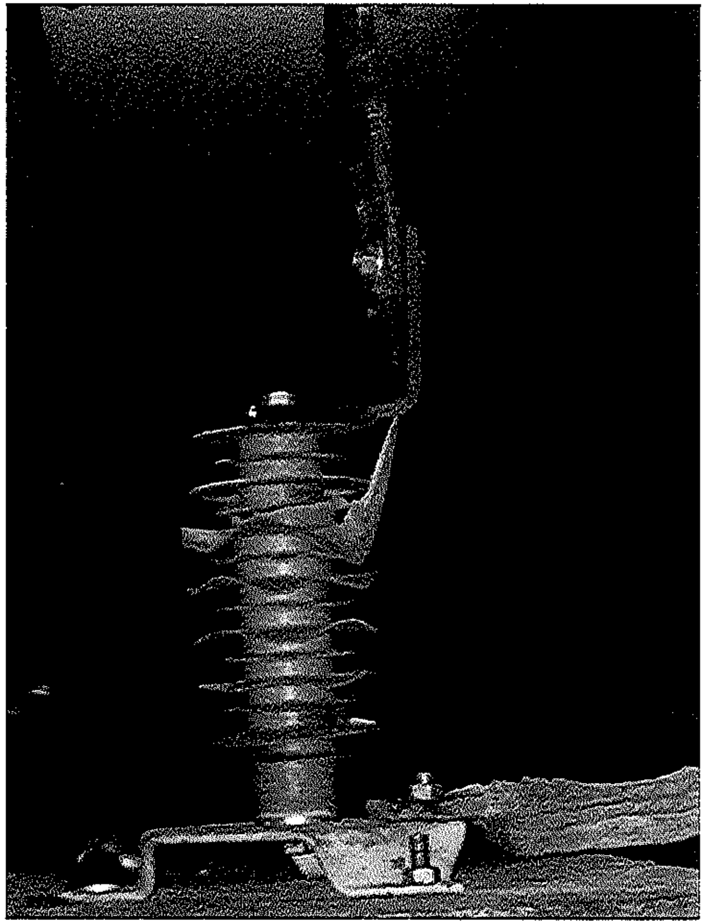


Photo No.3

ВЯРНО С ОРИГИНАЛА

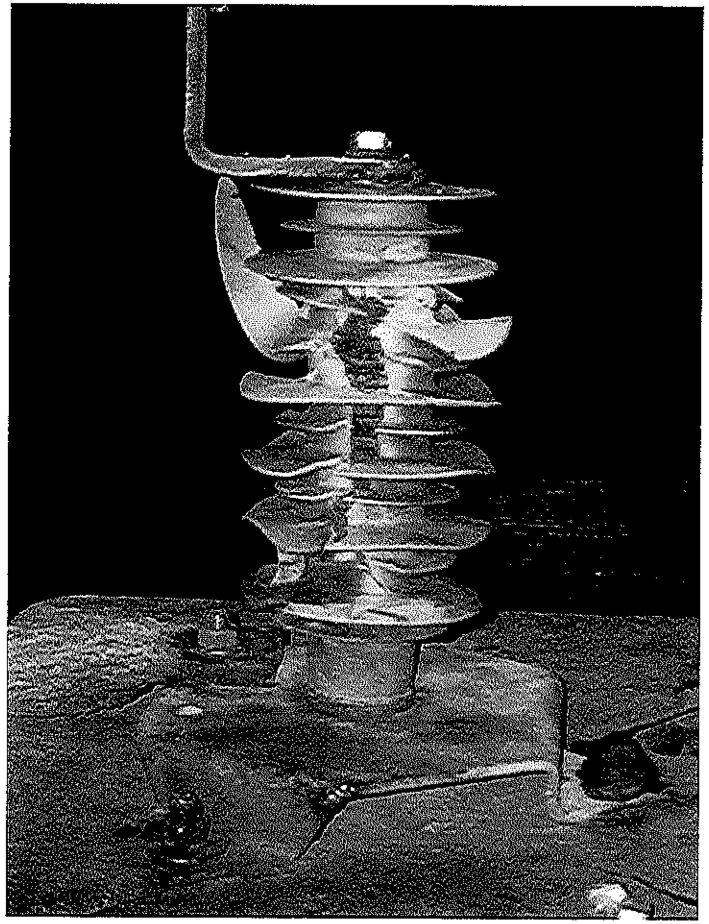


Photo No.4

538

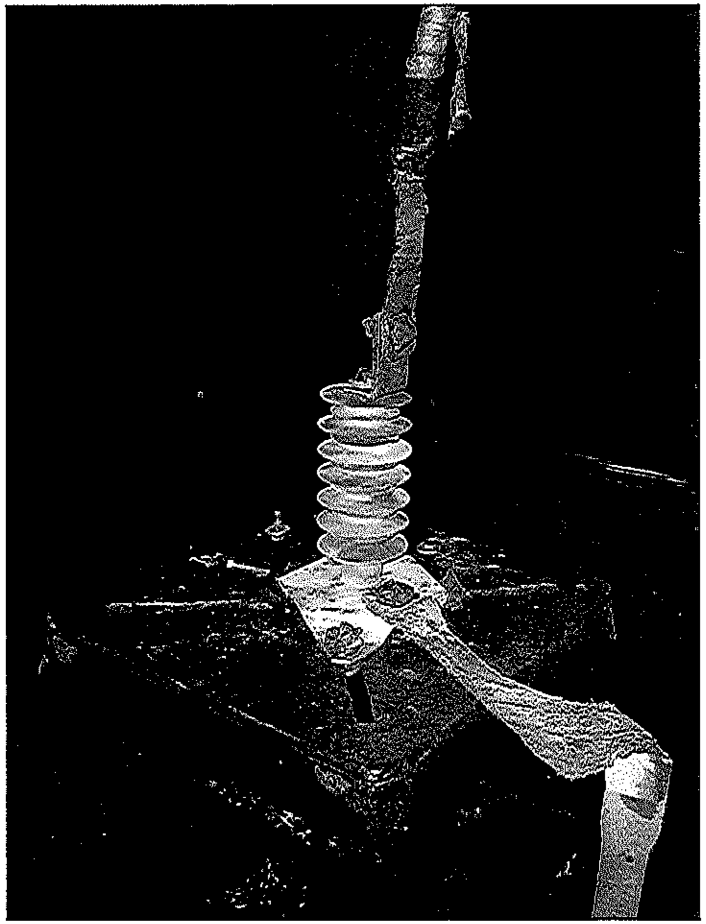


Photo No.5

D1093IG

ВЯРНО С ОРИГИНАЛА

539

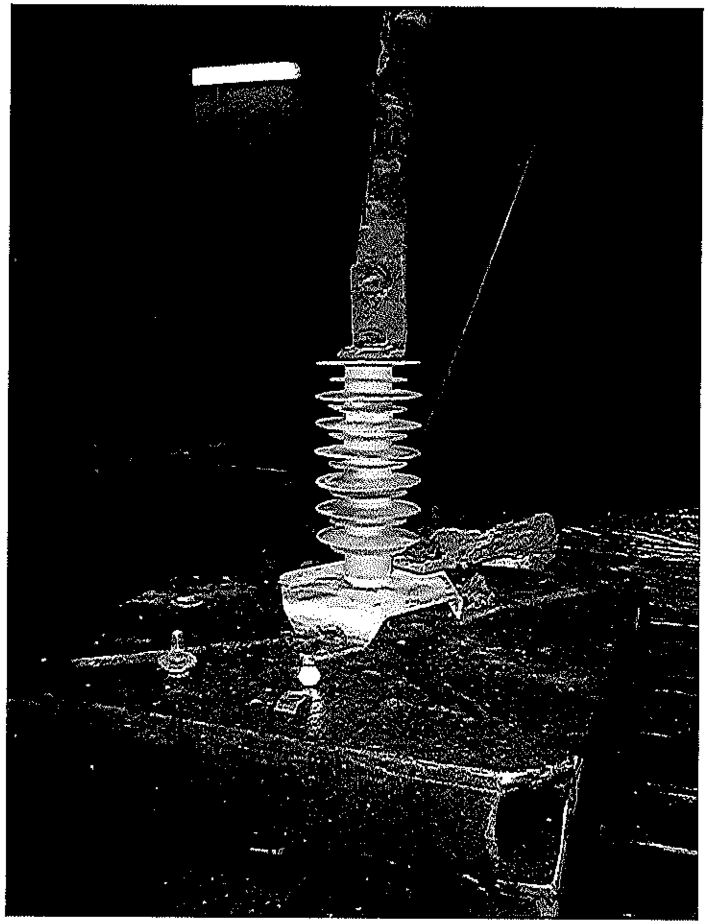


Photo No.6

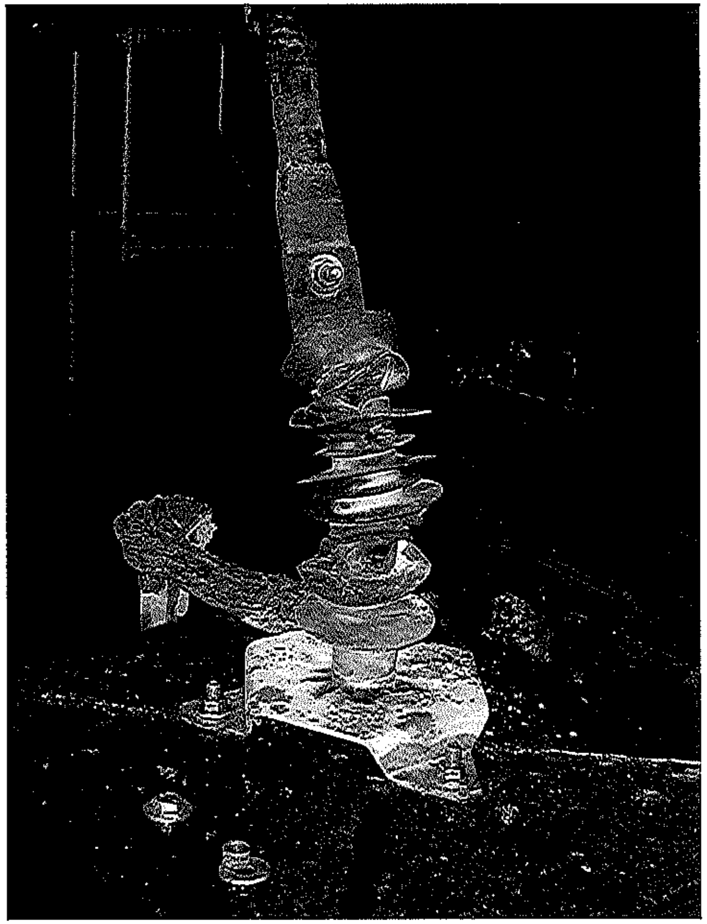


Photo No.7

ВЯРНО С
ОРИГИНАЛА

591

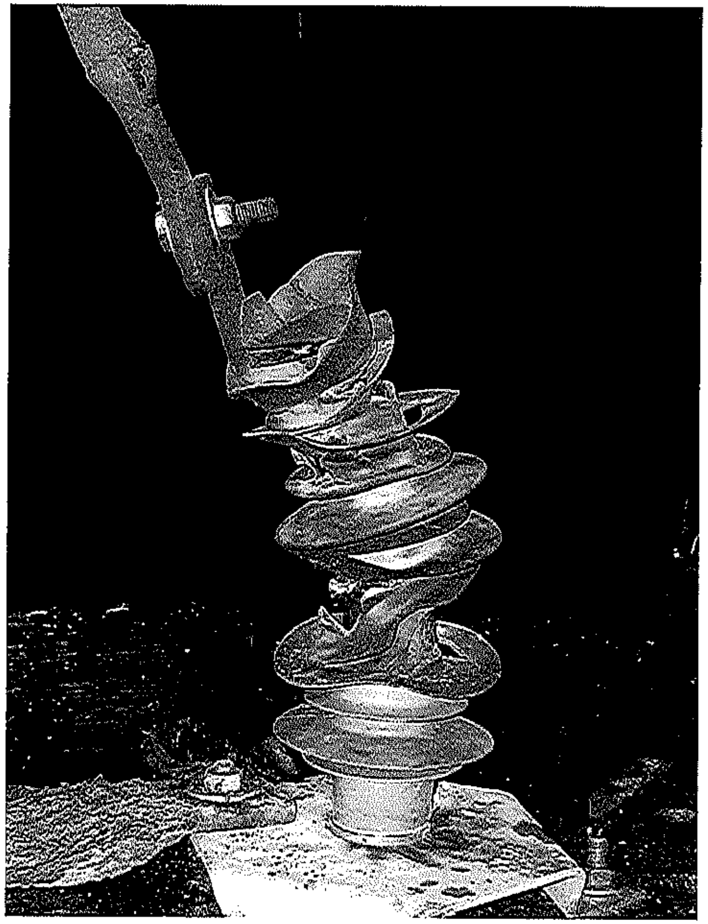
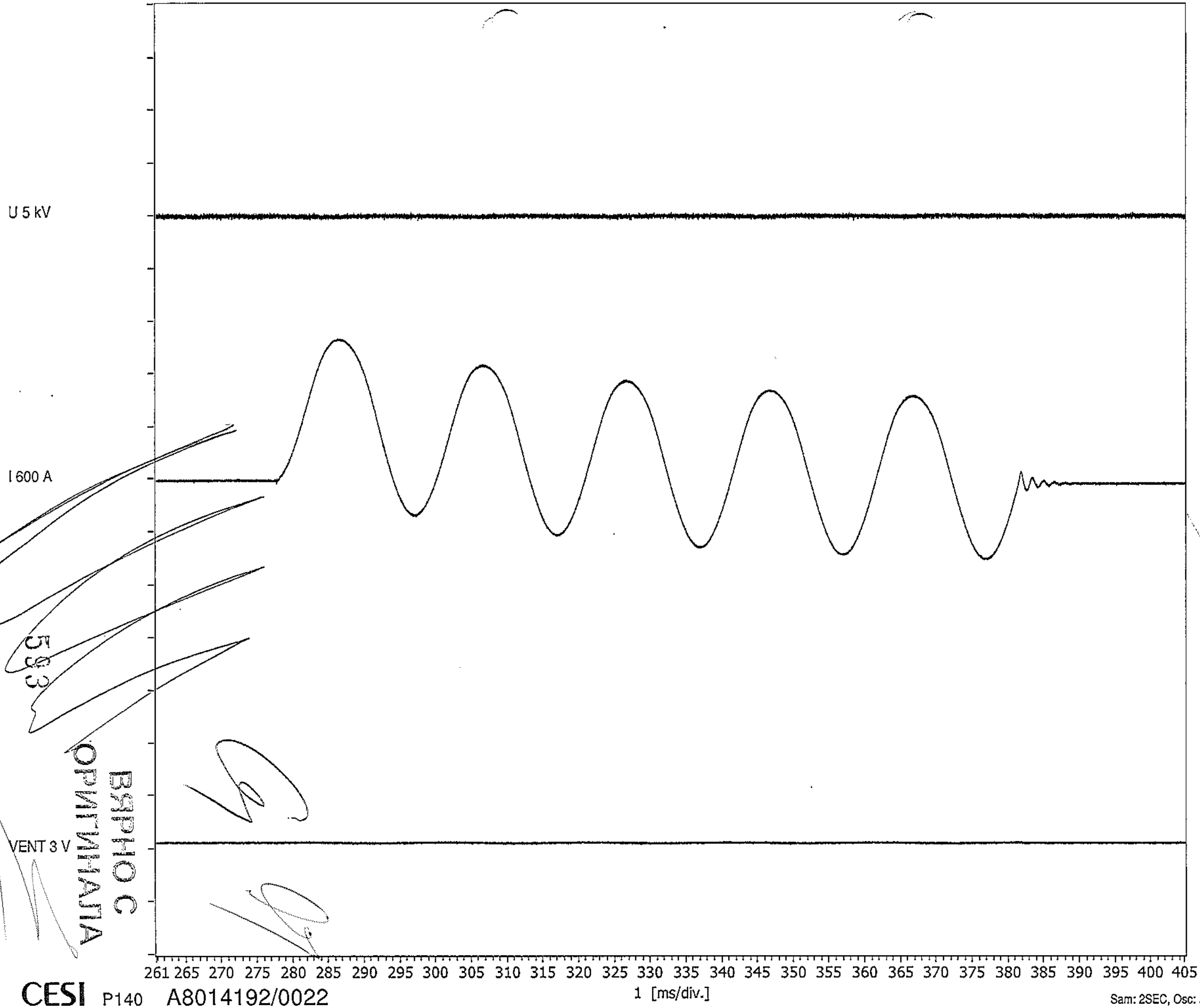


Photo No.8

592

I= 637 A
Ip= 1,59 kA
dT= 104 ms



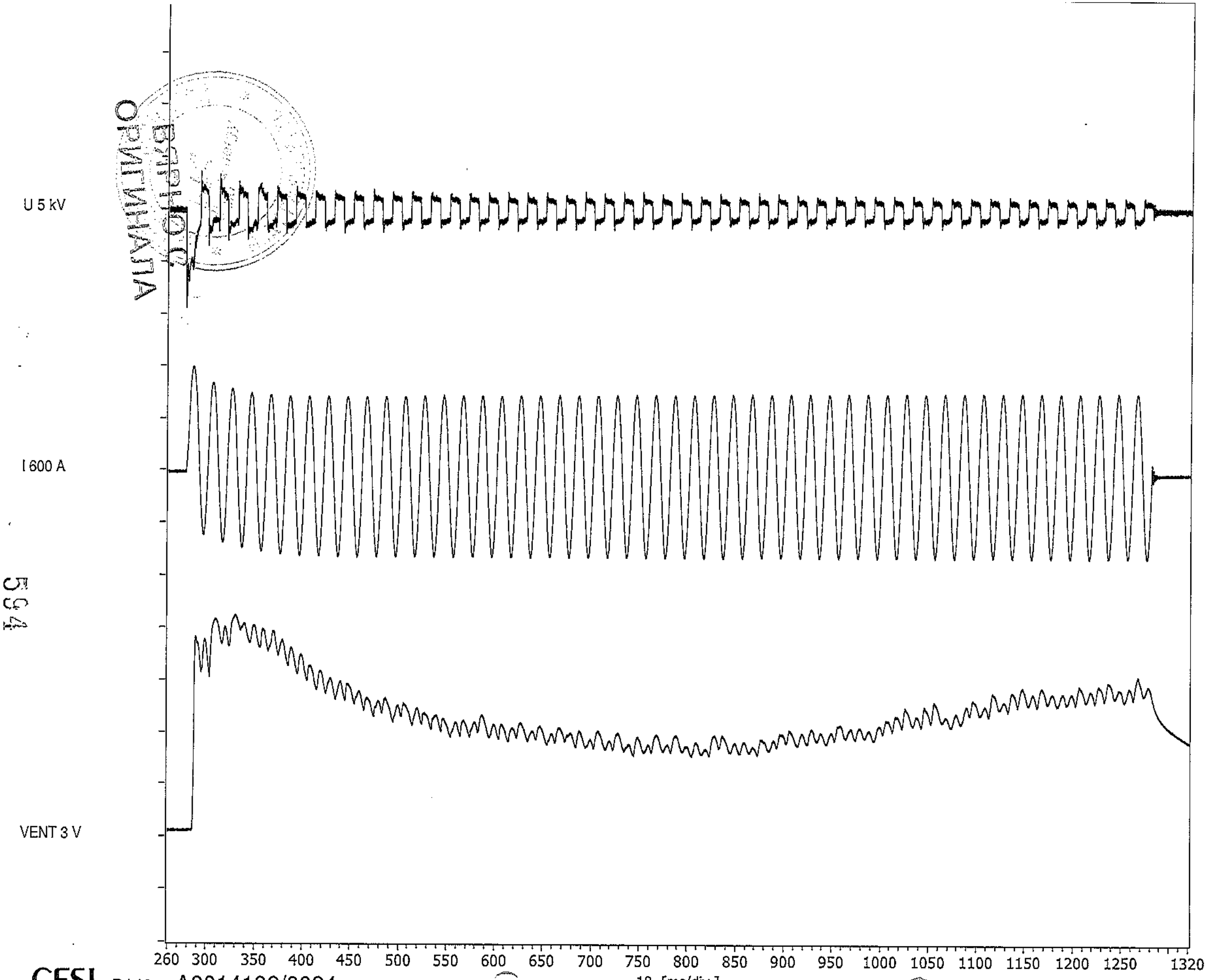
CESI P140 A8014192/0022

Sam: 2SEC, Osc: BD3F, Cal: BD3F

ВЯРНО С ОРИГИНАЛА

593

I= 630 A
Ip= 1,19 kA
dT= 1 s
dT= 8,0 ms

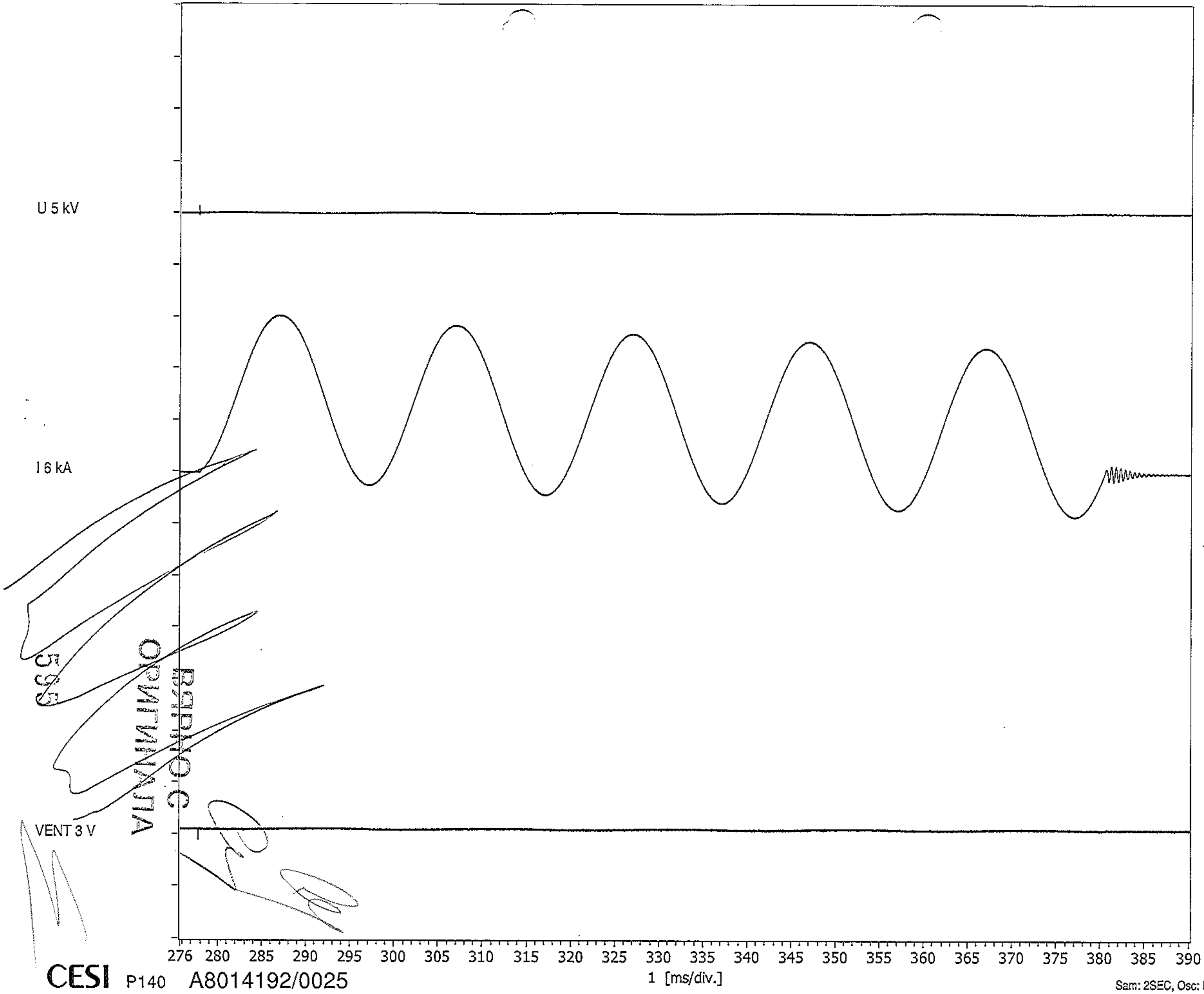


CESI P140 A8014192/0024

Sam: 2SEC, Osc: BD3F, Cal: BD3F

ВЯРНО С
ОРИГИНАЛА

594



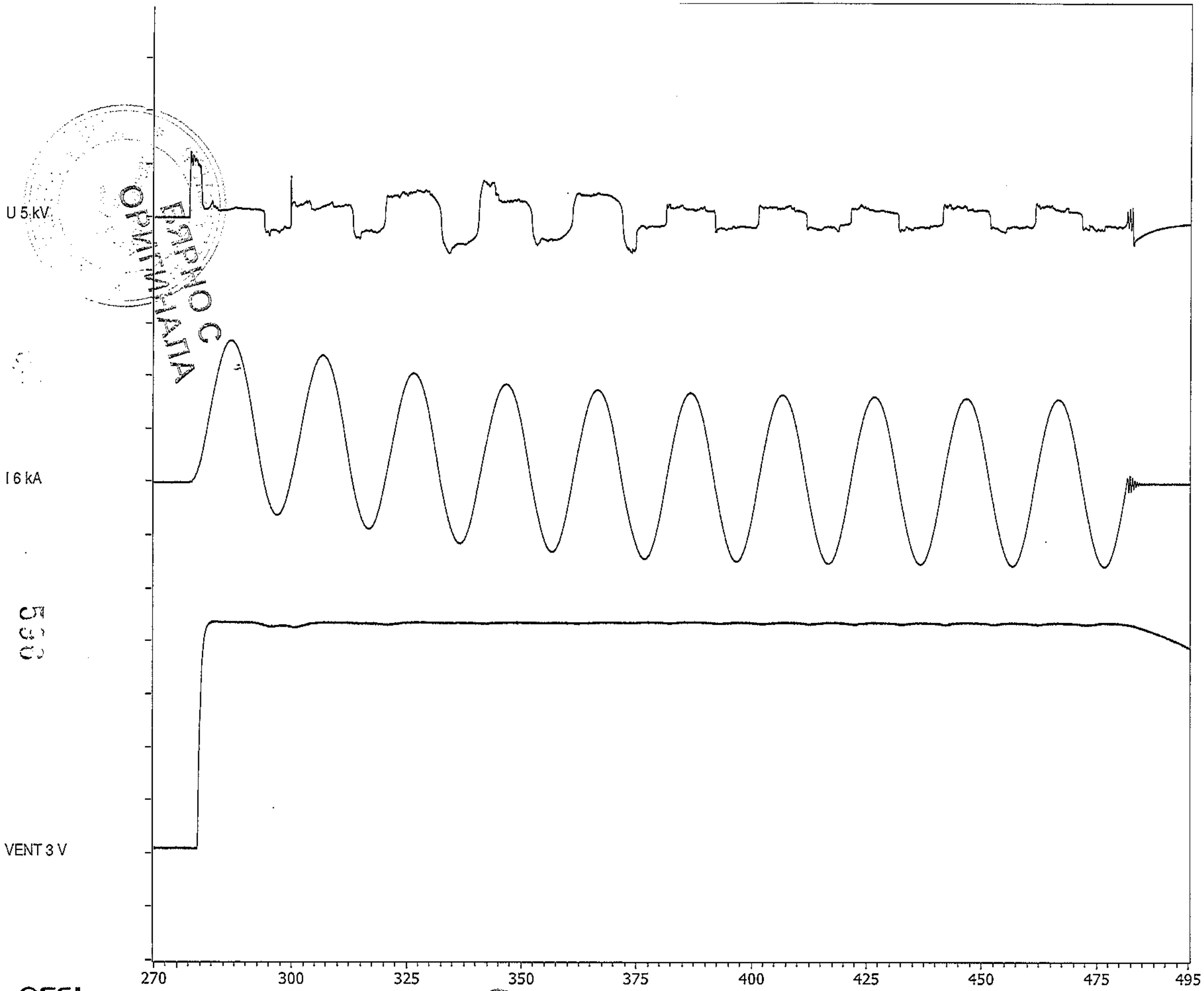
I= 6,59 kA
Ip= 18,1 kA
dT= 103 ms

CESI P140 A8014192/0025

Sam: 2SEC, Osc: BD3F, Cal: BD3F

ВЯРНО С ОРИГИНАЛА

595



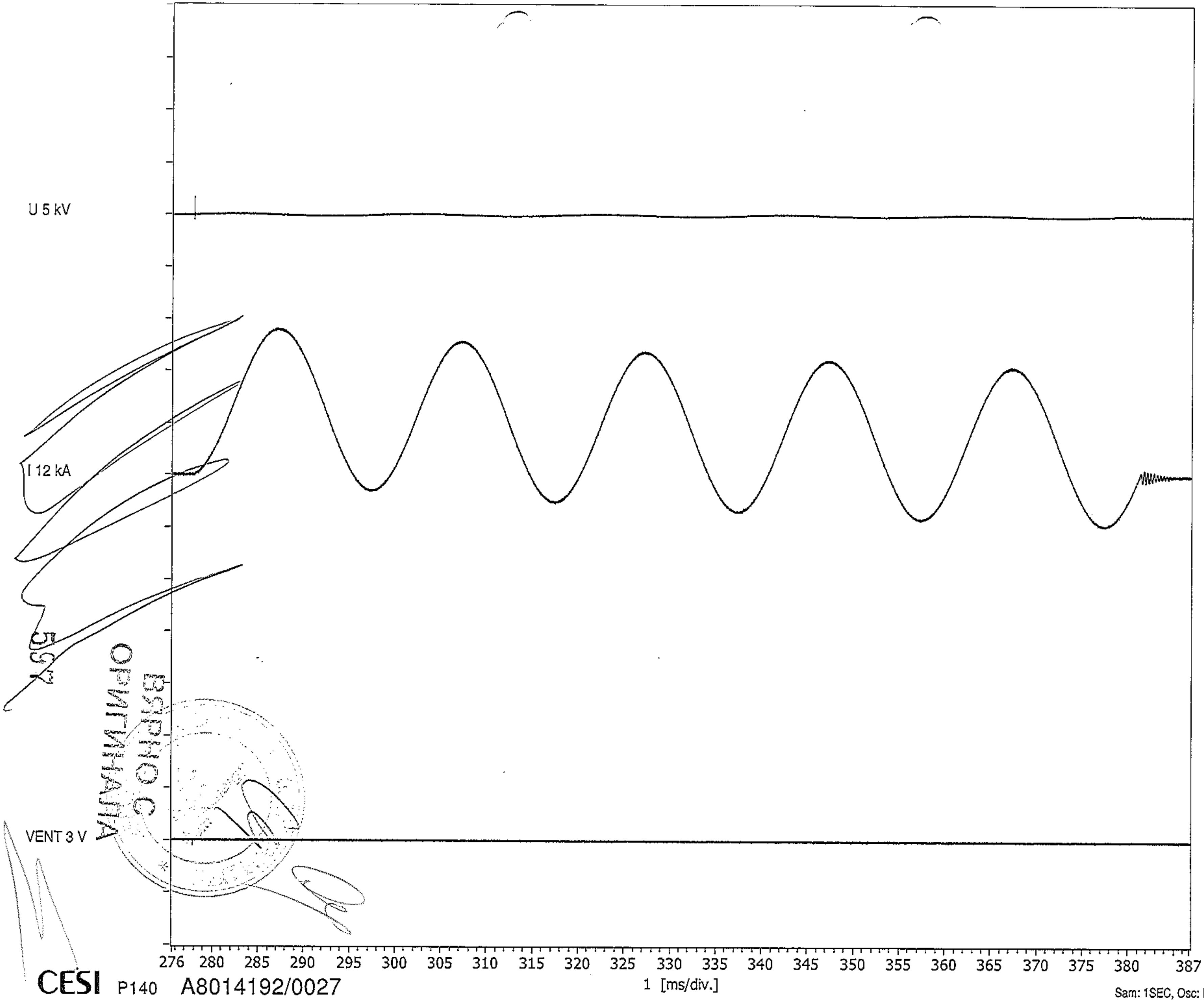
CESI P140 A8014192/0026

Sam: 2SEC, Osc: BD3F, Cal: BD3F

ВЯРНО С ОРИГИНАЛА

588

I= 12,2 kA
Ip= 33,8 kA
dT= 104 ms

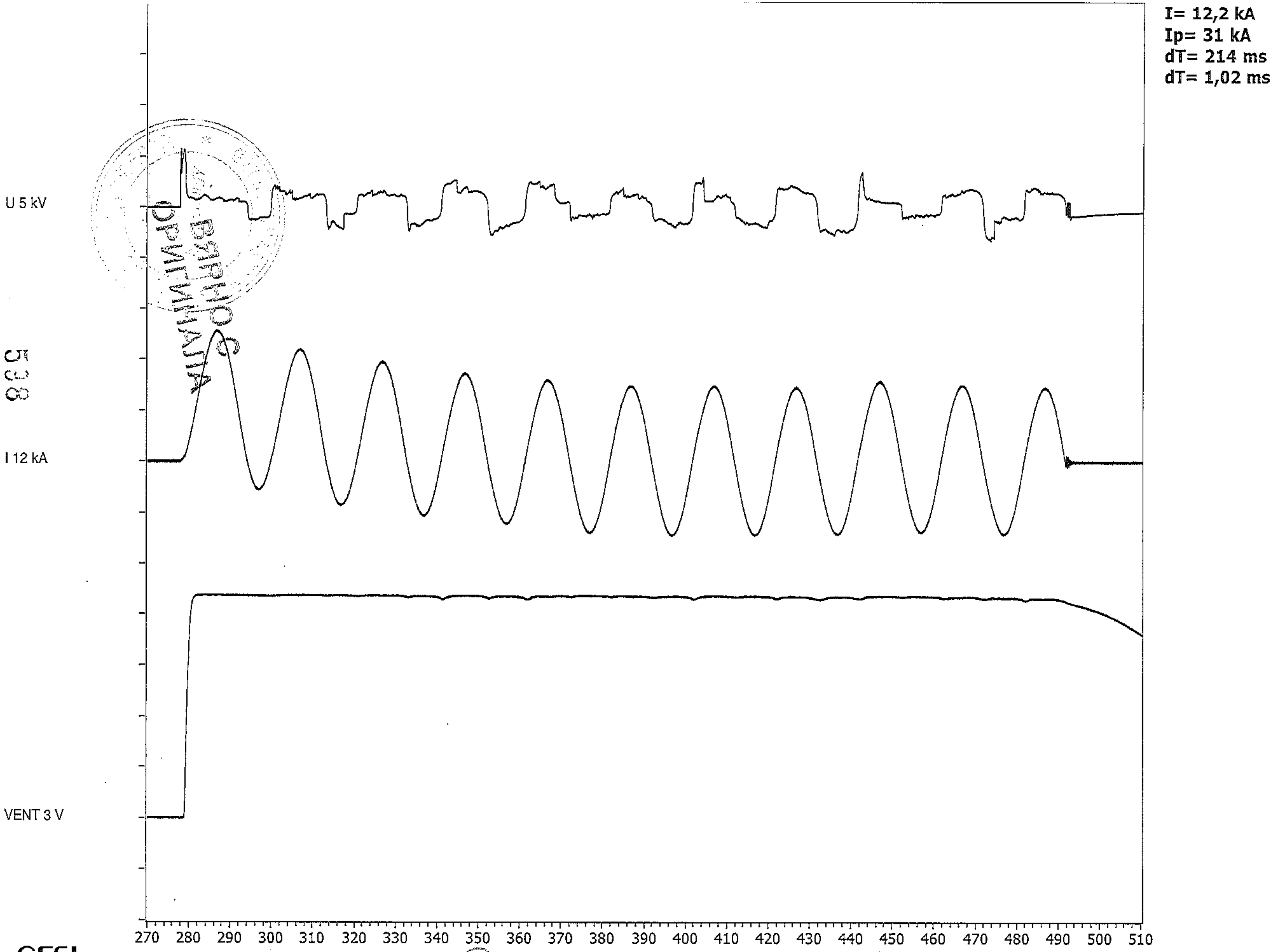


CESI P140 A8014192/0027

Sam: 1SEC, Osc: BD3F, Cal: BD3F

ВЯРНО С ОРИГИНАЛА

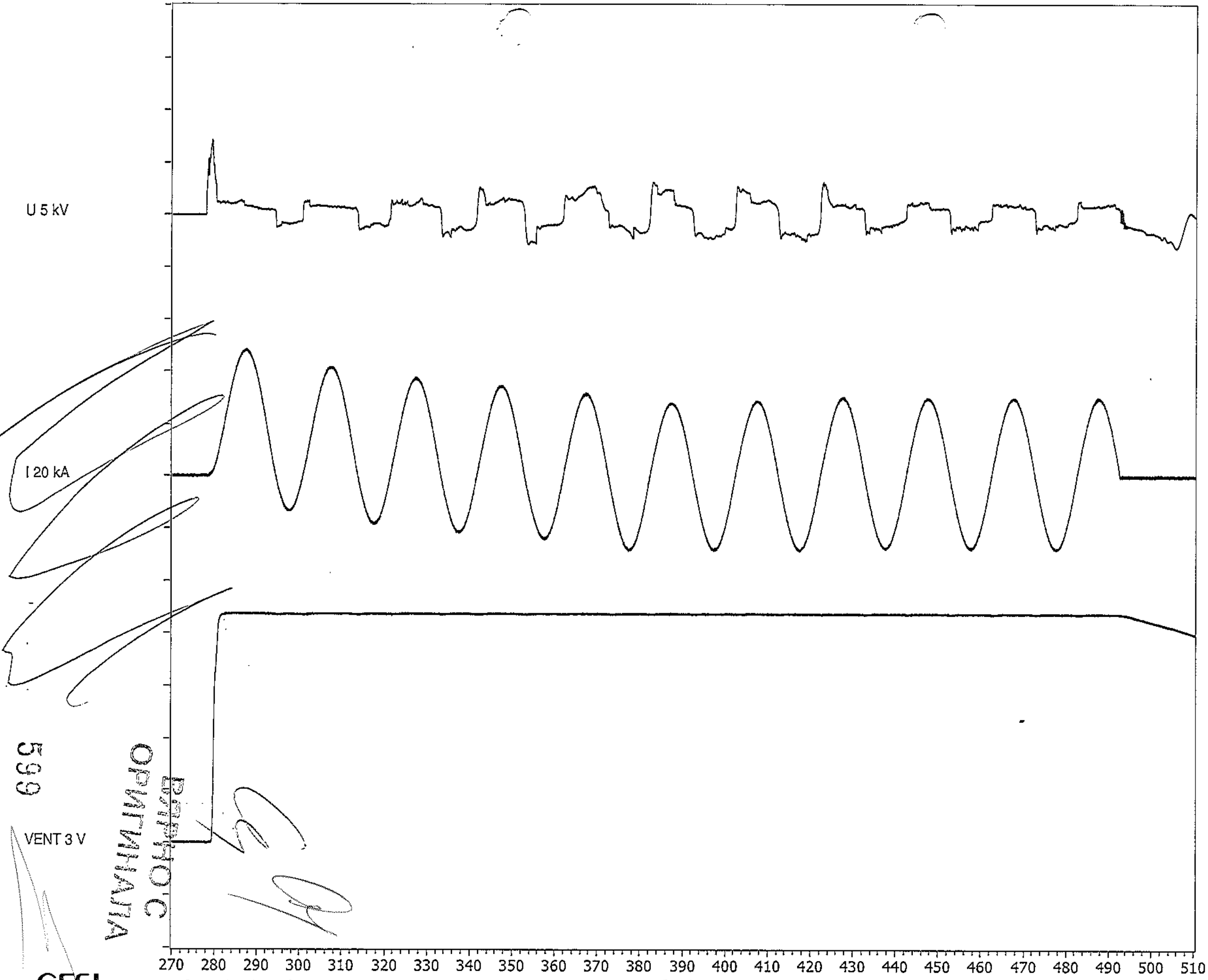
589



CESI P140 A8014192/0028

Sam: 1SEC, Osc: BD3F, Cal: BD3F

I= 20,5 kA
Ip= 48,6 kA
dT= 214 ms
dT= 1,53 ms



ВЯРНО С ОРИГИНАЛА

599

CESI P140 A8014192/0030

Sam: 1SEC, Osc: BD3F, Cal: BD3F

client	ALSTOM Parafoudres S.A. - Bagneres de Bigorre Cedex (France)
equipment under test	three 10kA polymer housed surge arresters, type HE
tests performed	partial discharges test
normative documents	IEC 60099-4 (1991-06)
receipt date of the sample	december 15, 2000
test date	from december 22, 2000 to december 22, 2000

the test results relate only to the sample tested
this document shall not be reproduced except in full without the written approval of CESI
and of the accreditation body, if any

n° 0030

no. of pages 10 no. of pages annexed 2

issue date	december 22, 2000
prepared	PeC/TEST - C. Del Giorgio
verified	PeC/TEST - A. Sironi
approved	PeC/TEST - V. Scarioni

CESI CENTRO ELETTROTECNICO SPERIMENTALE ITALIANO
Business Unit
Prove e Componenti
Il Responsabile del Laboratorio

CESI
Centro Elettrotecnico Sperimentale Italiano Giacinto Motta spa
Via R. Rubattino 54
20134 Milano - Italia
Telefono +39 0221251
Fax +39 0221255440
http://www.cesi.it
Capitale sociale 17,1 miliardi interamente versato
CCIAA di Milano n. 429222
Registro delle Imprese di Milano n. 84067
Sezione Ordinaria Tribunale Milano
P.I. IT00793580150
C.F. 00793580150

ВЯРНО С ОРИГИНАЛА

009

1600

tests witnessed by: Mr. F. Malpiece - ALSTOM Parafudre S.A.

identification of the object effected

The Manufacturer guarantees that the tested object is manufactured according to the submitted drawings.

CESI checked that this drawing adequately represents in shape and dimensions the essential details and the parts of the tested object.

This drawing identified by CESI and numbered A0/042527 no.1 is annexed to this document.

The measurement uncertainties of the test results reported in this document are the following:

- dielectric tests with impulse voltage : peak voltage: ± 3 % ; time parameters: ± 10 %
- dielectric tests with impulse current : peak value: ± 3 % ; time parameters: ± 10 %
- dielectric tests with alternating voltage : voltage (rms): ± 3 %
- dielectric tests with direct voltage : voltage: ± 3 %

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to a confidence level of about 95 %) and have to be considered as maximum values.

laboratory information

CESI testing team: Mr. M. Amato

test laboratory: P220 (faraday Cage)

activity code: 29380X

keywords: 12015R 23801L 31020W 41040M 53001D 62501B

ВЯРНО С
ОРИГИНАЛА

601

ВЯРНО С
ОРИГИНАЛА
602

MOD A1002/3

contents	page	test date
rated characteristics of the test voltage declared by the manufacturer	4	
panoramic view of the test samples	5	
panoramic view of the test arrangement	6	
test voltage values	7	
circuit A027 - partial discharges measurement - high voltage circuit	8	
circuit A022 - partial discharges measurement - direct circuit - scheme 1a	9	
partial discharges test	10	december 22, 2000

pages annexed

Oscillogram (total pages:2)

reference document annexed

drawing no. W 8997 01 36 identified by CESI and numbered A0/042527 no.1

rated characteristics of the test voltage declared by the manufacturer

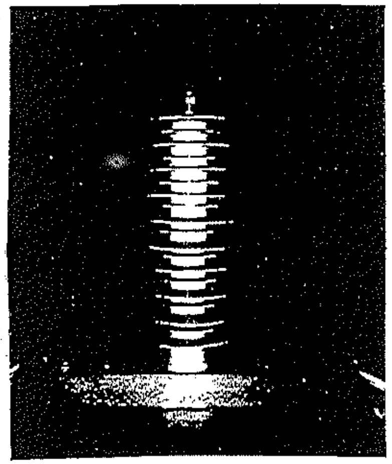
polymer housed surge arrester

manufacturer	ALSTOM Parafudre S.A.
type	HE
drawing no.	W 8997 01 36
rated voltage (U_r)	36 kV
continuous operating voltage (U_c)	30 kV_{rms}
nominal discharge current (I_N)	10 kA
line discharge class	1
dry lightning impulse withstand voltage	170 kV_{pk}
wet power frequency withstand voltage	70 kV_{rms}

NOTE: CESI marked the three polymer housed surge arresters from no.1 to no.3

603

panoramic view of the test sample

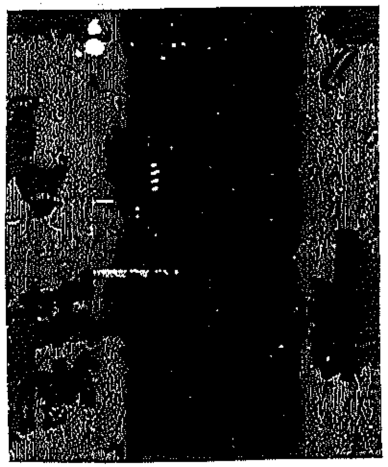


MOD.A1170IO

ВЯРНО С
ОРИГИНАЛА

604

panoramic view of the test arrangement



test voltage values

Partial discharges test

prestressing (≤10s) = U_r = 36,0 kV

measure = 1,05xU_e = 1,05x30,0 = 31,5 kV

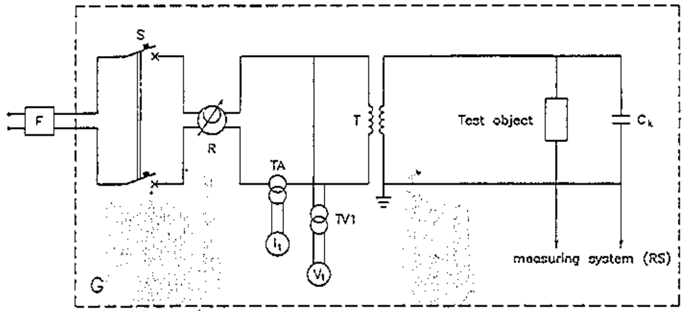
MOD.A117810

ВЯРНО С ОРИГИНАЛА

638

circuit A027

Plant P220. High voltage circuit
partial discharges measurement



F : wide band filter TELEC; 380 V; 100 A
G : Faraday cage
S : single phase circuit breaker SACE; 600 V; 800 A
R : regulator CORMES; power 66 kVA; voltage 380 V/0 ÷ 220 V
T : booster transformer PIVI; power 250 kVA; voltage 200-400 V/250 kV
C_k : coupling capacitor PASSONI & VILLA; 300 pF; 250 kV (internal to T)
TA : current transformer CGS; ratio 150-300 A/5 A
TV_1: voltage transformer; ratio 220 V/100 V
V_1 : voltmeter CESI no. 6393
RS : partial discharge detector BIDDLE; CESI no. 09596

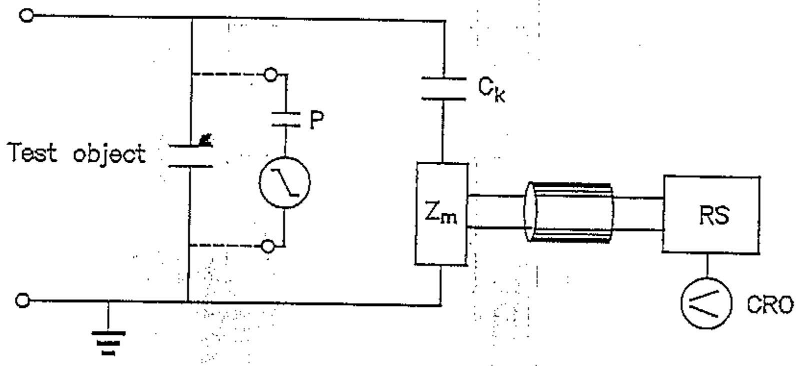
ВЯРНО С ОРИГИНАЛА

607

circuit A022

partial discharges measurement

direct circuit
scheme 1a



C_k : coupling capacitor 300 pF; CESI no. -----
Z_m : coupling impedance
P : calibrator CESI no.02526
RS : partial discharge detector BIDDLE; CESI no.09596
CRO: oscilloscope CESI no.06351

ВЯРНО С
ОРИГИНАЛА

609

ВЯРНО С
ОРИГИНАЛА

MOD A1172-3

partial discharges test

test object: polymer housed surge arresters, type HE

test circuit: A027

measurement circuit: A022 ("direct" calibration : 0,2 pC/mV, on CRO, oscillogram no.1)

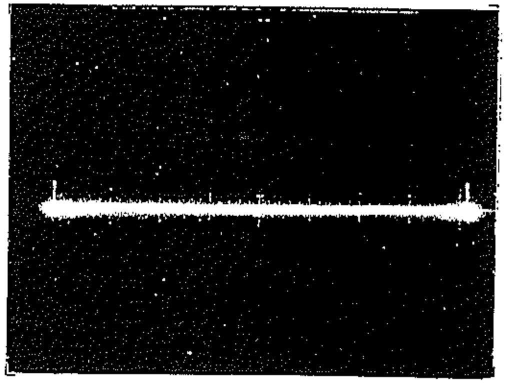
arrangement: see page 6

atmospheric conditions		
b	t	h
kPa	°C	g / m³
101,5	20,0 (13,5)	7,3

date: december 22, 2000

test sample	applied voltage	duration of voltage application	temperature of the test object	partial discharge measurement: voltage increase, CRO readout	voltage increase, Q max	voltage decrease, CRO readout	voltage decrease, Q max	oscillogram	note
	kV_{rms}	sec	°C	mV	pC	mV	pC	no.	
1	36,0 (U_r)	≤10	20,0	--	--	--	--	-	
	31,0 (1,05U_c)	measure	20,0	--	--	≤5	≤1	4	
2	36,0 (U_r)	≤10	20,0	--	--	--	--	-	
	31,0 (1,05U_c)	measure	20,0	--	--	≤5	≤1	5	
3	36,0 (U_r)	≤10	20,0	--	--	--	--	-	
	31,0 (1,05U_c)	measure	20,0	--	--	≤5	≤1	6	

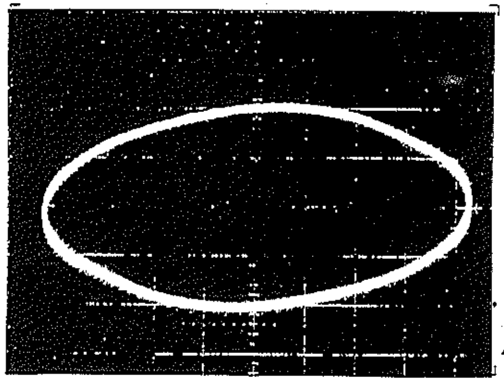
before the test have been made: measure of the background noise; the result: p.d. ≤5mV ≤1pC (oscillogram no.2)
Corona's effect (oscillogram no.3)



Oscillogram no.1

Channel 1 :
voltage : 100 mV/div

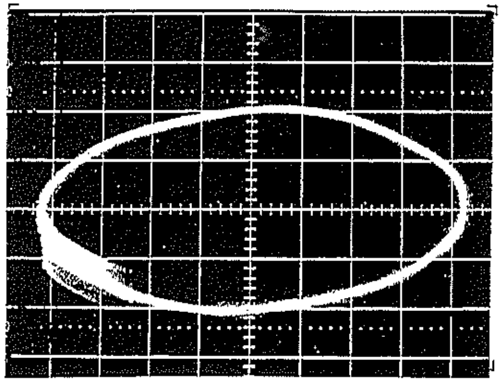
calibration of the measure circuit
q =50pC =250mV
K = 0,2pC/mV



Oscillogram no.2

Channel 1 :
voltage : 20 mV/div

measure of the background noise
p.d. ≤5mV ≤1pC



Oscillogram no.3

Channel 1 :
voltage : 100 mV/div

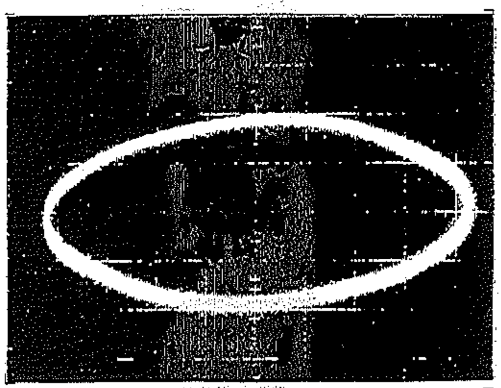
corona effect
negative polarity

MOD.A09CIG

НЕКСТ ЕНЕРДЖИ ЕООД

ВЯРНО С ОРИГИНАЛА

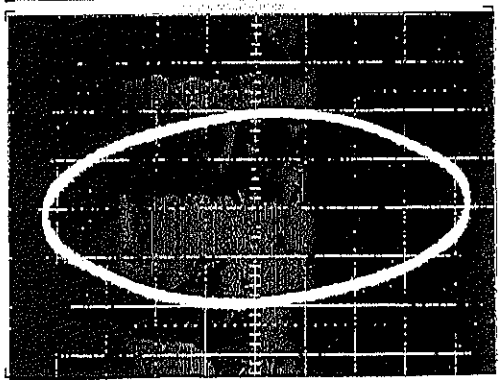
610



Oscillogram no.4

Channel 1 :
voltage : 20 mV/div

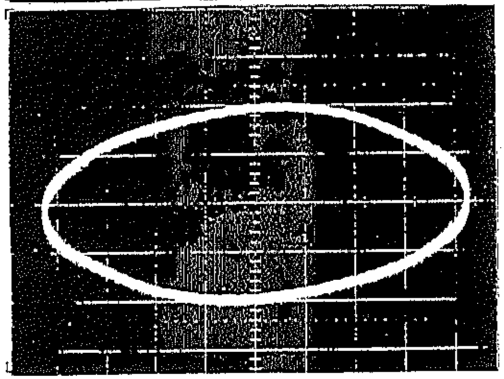
sample no.1
U =31kV
p.d. ≤5mV ≤1pC



Oscillogram no.5

Channel 1 :
voltage : 20 mV/div

sample no.2
U =31kV
p.d. ≤5mV ≤1pC



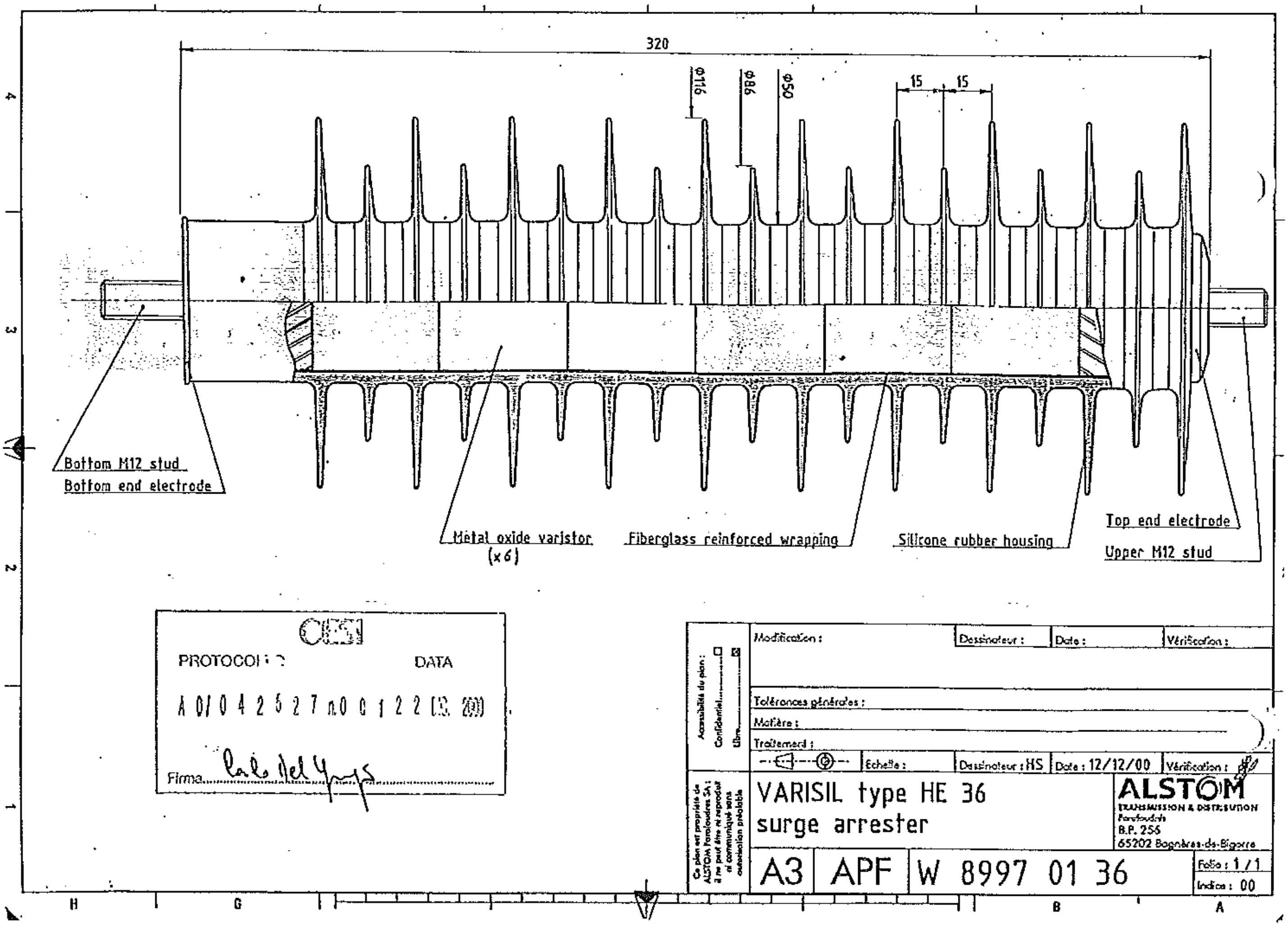
Oscillogram no.6

Channel 1 :
voltage : 20 mV/div

sample no.3
U =31kV
p.d. ≤5mV ≤1pC

ВЯРНО С ОРИГИНАЛА

611



ВЯРНО С ОРИГИНАЛА

612

Type Test Report
No.: TR-E 12019BM

Equipment under test:	Polymer housed surge arrester of line discharge class 1, type series VARISIL HE-S TRIDELTA Parafoudres S.A.
Normative documents:	IEC 60099-4 Edition 2.2 clause 10.8.9 / 8.9
Test performed:	Bending moment test
Test date:	18th of October 2012 to 13th of November 2012
Number of pages:	19

First issue date: 15th of November 2012

Dipl.-Ing.	T. Holzer	Torsten Holzer	(Test Engineer, Tridelta)
Dipl.-Ing.	H. Klaube	H. Kl	(R&D Head, Tridelta)
Dipl.-Ing.	S. Schreib		(Head SCUS GmbH)

Hermsdorf, 15th of November 2012

TRIDELTA Überspannungsableiter GmbH
Marie-Curie-Straße 3
07629 Hermsdorf - Deutschland
Telefon +49 (0)3 66 01/9328 300
Fax +49 (0)3 66 01/9328 301
Internet http://www.tridelta.de

ВЯРНО С ОРИГИНАЛА

613

subject
Test of Bending Moment Surge Arrester Series VARISIL HE-S

manufacturer
TRIDELTA Parafoudres S.A. Boulevard de l'Adour – B.P. 256 F – 65202 Bagnères de Bigorre Cedex

caused by
Type Test acc. to IEC 60099-4 Ed.2.2 Item 10.8.9 (2009-05) Confirmation of SLL: 200 Nm SSL: 250 Nm

Test arrangement/course of test

Test acc. to IEC 60099-4 Ed. 2.2. Item 10.8.9 (2009-05)

The test was performed on 3 arresters made of 1 mechanical unit. The arresters were attached directly to the mounting surface of the testing machine. The direction of the load was through and perpendicular to the longitudinal axis of the arrester unit.

Test procedure:

1. Sample preparation/ Initial measurements acc. to 10.8.9.2
2. Bending moment test with SSL acc. to 10.8.9.3 a on 2 arrester units
3. Mechanical/thermal preconditioning acc. to 10.8.9.3.1 on 1 arrester unit
4. Water immersion test acc. to 10.8.9.3.2 on 3 arrester units
5. Test evaluation/ Final measurements acc. to 10.8.9.4

Sample	Type
A	VARISIL HE-S 42
B	VARISIL HE-S 42
C	VARISIL HE-S 42

The surge arrester type series "VARISIL HE-S" passed all tests, acc. to IEC 60099-4 Ed. 2.2 10.8.9, successfully. SLL = 200 Nm, SSL = 250 Nm; terminal torque = 45 Nm

Coordinated by :	S. Schreib, see test report "12-137 PB2_rev1 Product test - VARISIL TM HE-S 42" from SCUS
worked out by :	T. Hölzer
checked by :	H. Klaube

ВЯРНО С ОРИГИНАЛА

614

Test results

1. Sample preparation/ Initial measurements

Watt losses at Uc

Sample No.	Voltage kV	watt losses W
A	35	3,63
B	35	3,79
C	35	3,72

Ambient temperature 20 °C

Partial discharge test

Sample No.	voltage kV	measured value pC	max. permitted value pC	ground noise pC	evaluation/ result
A	36,75	< 2	10	< 2	passed
B	36,75	< 2	10	< 2	passed
C	36,75	< 2	10	< 2	passed

Residual voltage test

Sample No.	measured value kV	current kA
A	114,9	10,2
B	114,6	10,2
C	114,6	10,2

ВЯРНО С ОРИГИНАЛА

615

2. **Bonding Moment test with SSL**

Sample No.	Cantilever mm	Force N	Bending moment Nm	maximum deflection mm	residual deflection mm
A	397	630	250	4,53	-0,55
B	397	630	250	4,72	0,52
Sample C was subjected to the mechanical/thermal preconditioning					

The residual deflection was measured in the interval 1 min to 10 min after release of the load.
There was no visible damage.

3. **Mechanical/thermal preconditioning**

a. **Terminal torque preconditioning**

The arrester terminal torque of 45 Nm was applied for duration of 30s.

Cantilever mm	Force N	Torque moment Nm
300	150	45

There was no visible damage.

b. **Thermo-mechanical preconditioning**

The sample was subjected to the thermo-mechanical preconditioning acc. to 10.8.9.3.1.2 with the specified long-term load (SLL) of 200 Nm.

Cantilever = 397 mm; Force = 504 N

Measured displacement:

	Start without load	Start with load	End with load	maximum deflection	End without load
Position 0° (+60°C)	0 mm	4,07 mm	11,26 mm	11,4 mm	2,57 mm
Position 180° (-25°C)	0 mm	11,89 mm	14,04 mm	14,2 mm	0,82 mm
Position 270° (+40°C)	0 mm	10,07 mm	11,97 mm	12,2 mm	0,26 mm
Position 90° (-40°C)	0 mm	11,19 mm	13,48 mm	13,7 mm	0,48 mm

4. **Water immersion test**

All samples were subjected to the water immersion test acc. to 10.8.9.3.2

5. **Test evaluation/ Final measurements**

Watt losses at Uc

Sample No.	Voltage kV	watt losses W	Increase from initial measurement %	evaluation/ result
A	35	3,62	-0,3	passed
B	35	3,64	-4	passed
C	35	3,63	-2,4	passed

Ambient temperature 20 °C
The increase in watt losses is not more than 20% from the initial measurements. After the end of boiling, the arresters were removed from the water (50 °C) (09:15 AM; 09.11.2012) and cooled to ambient temperature. The measurement was executed within 8h after cooling (02:30 PM; 09.11.2012).
The ambient temperature does not deviate more than 3K from the initial measurements.

Partial discharge test

Sample No.	voltage kV	measured value pC	max. permitted value pC	ground noise pC	evaluation/ result
A	36,75	<2	10	<2	passed
B	36,75	<2	10	<2	passed
C	36,75	<2	10	<2.	passed

Reference voltage before two impulses at nominal discharge current

Sample No.	measured value kV
A	40,7
B	40,6
C	40,7

Residual voltage test (first impulse)

Sample No.	measured value kV	current kA	Increase from initial measurement %	evaluation/ result
A	114,5	10,2	-0,3	passed
B	115,1	10,2	+0,4	passed
C	114,3	10,2	-0,3	passed

The measured values are not more than 5% different from the initial measurement.

Residual voltage test (second impulse)

Sample No.	measured value kV	current kA	Increase from initial measurement %	Increase from first impulse %	evaluation/ result
A	115,2	10,2	+0,3	+0,6	passed
B	115,4	10,2	+0,7	+0,3	passed
C	115,2	10,2	+0,5	+0,8	passed

The measured values are not more than 5% different from the initial measurement. The difference in voltage between two successive impulses at nominal discharge current does not exceed 2%. The oscillograms of voltage and current do not reveal any partial or full breakdown of the test sample.

Reference voltage after two impulses at nominal discharge current

Sample No.	measured value kV	Increase %	evaluation/ result
A	41,2	+1,2	passed
B	41,2	+1,5	passed
C	41,3	+1,5	passed

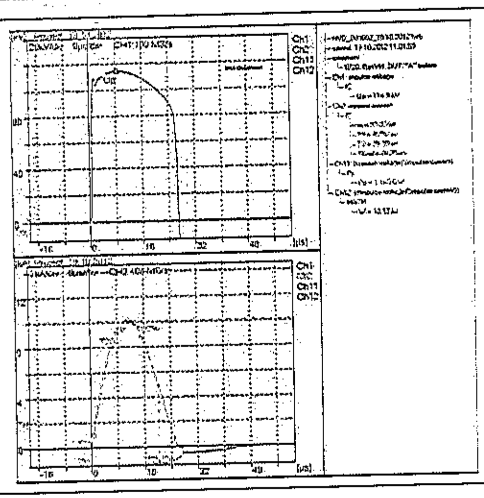
The change in reference voltage measured before and after the two residual voltage tests does not exceed 2%.

The surge arrestor type series "VARISIL HE-S" passed all tests, acc. to IEC 60099-4 Ed. 2.2 10.8.9, successfully. SLL = 200 Nm, SSL = 250 Nm and terminal torque = 45 Nm

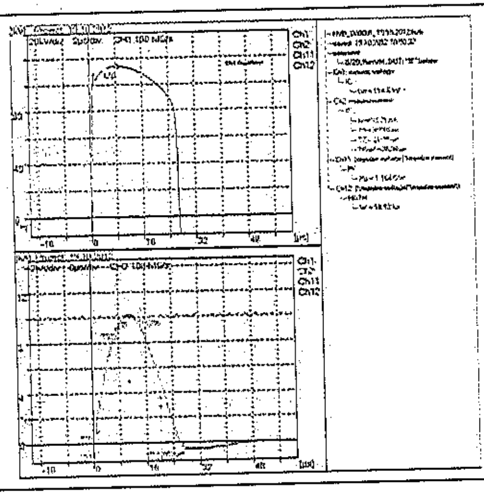
ВЯРНО С
ОРИГИНАЛА

617

Appendix 1 Sample preparation/ Initial measurements



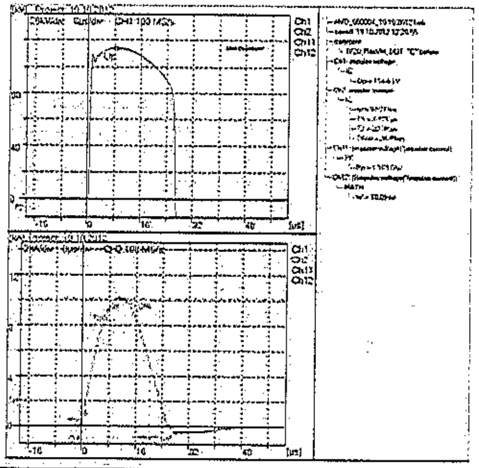
Residual voltage test of sample No.A



Residual voltage test of sample No.B

ВЯРНО С ОРИГИНАЛА

618

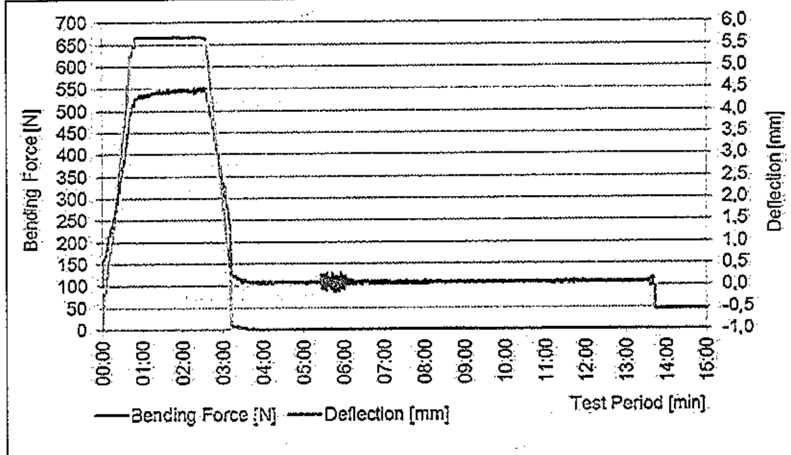


Residual voltage test of sample No.C

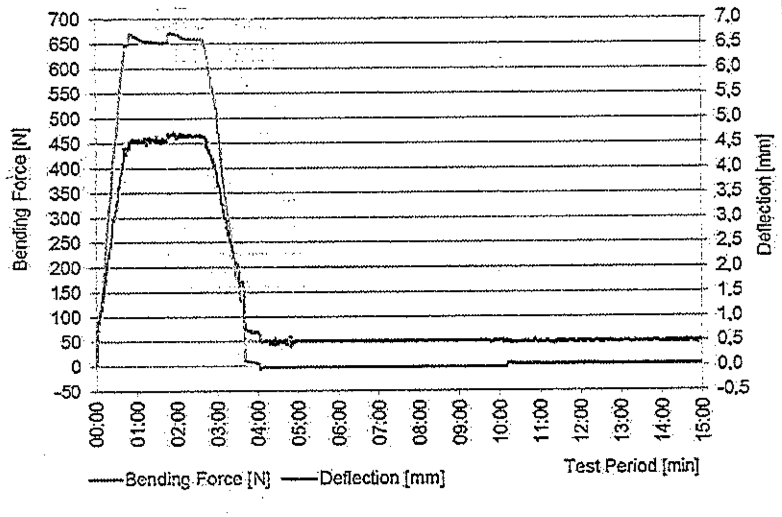
ВЯРНО С
ОРИГИНАЛА

619

Appendix 2 Bending moment test with SSL



Force vs. time and deflection vs. time of sample A

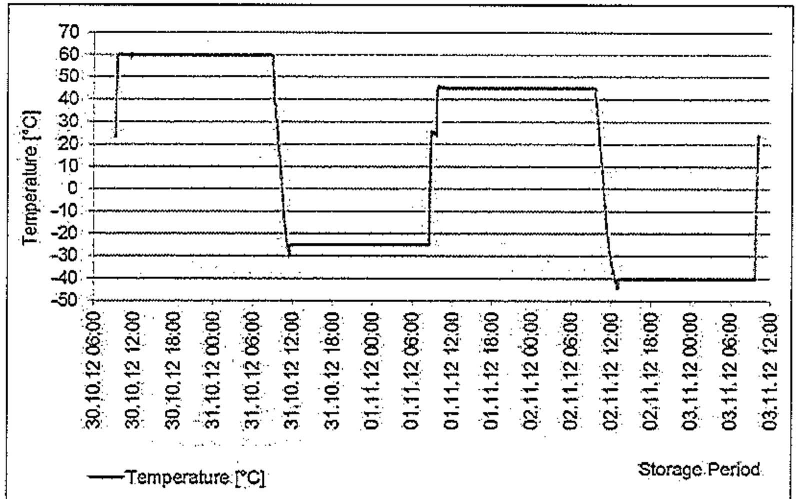


Force vs. time and deflection vs. time of sample B

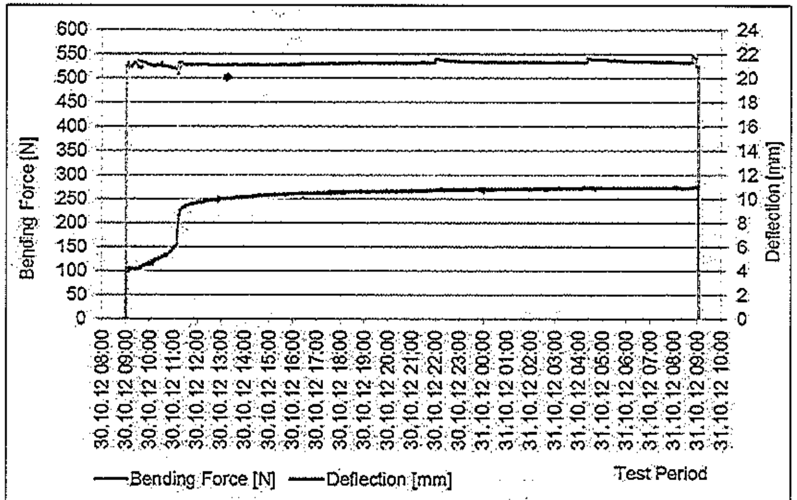
ВЯРНО С
ОРИГИНАЛА

610

Appendix 3 Thermo-mechanical preconditioning



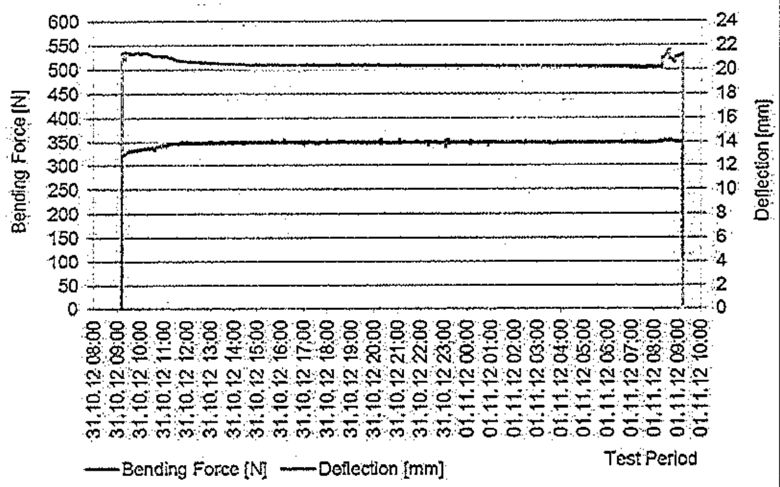
Temperature profile of Thermo-mechanical preconditioning



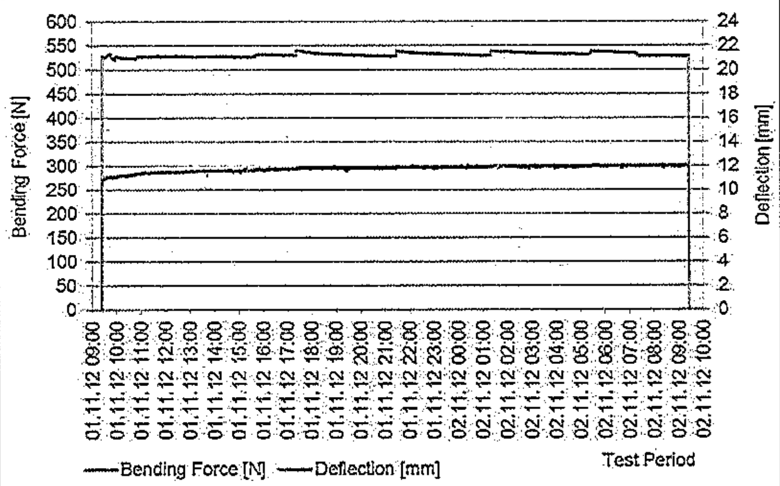
Force vs. time and deflection vs. time of sample C Position 0°

ВЯРНО С ОРИГИНАЛА

621



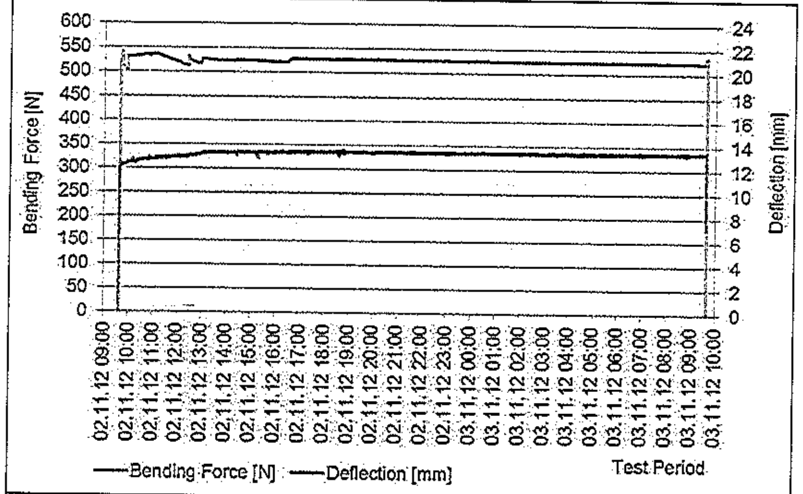
Force vs. time and deflection vs. time of sample C Position 180°



Force vs. time and deflection vs. time of sample C Position 270°

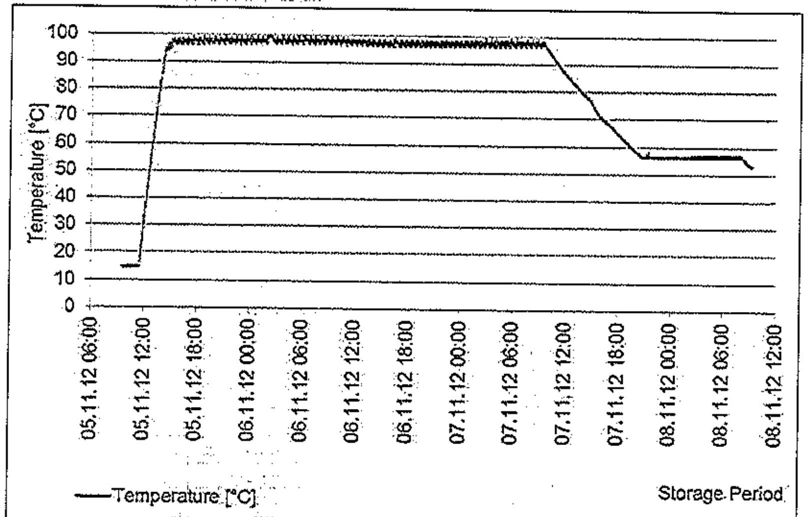
ВЯРНО С
ОРИГИНАЛА

022



Force vs. time and deflection vs. time of sample C Position 90°

Appendix 4 Water Immersion test

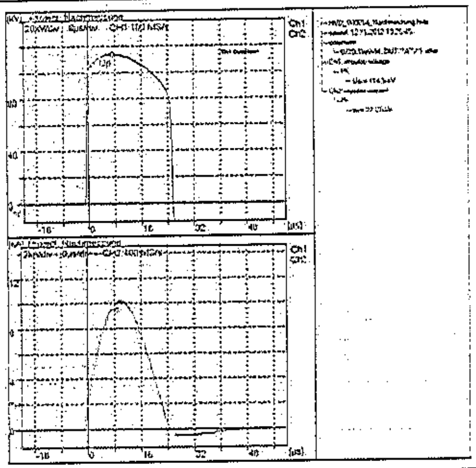


Temperature vs. time

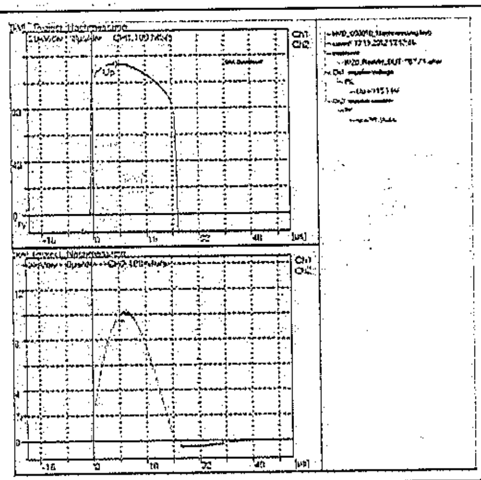
ВЯРНО С ОРИГИНАЛА

023

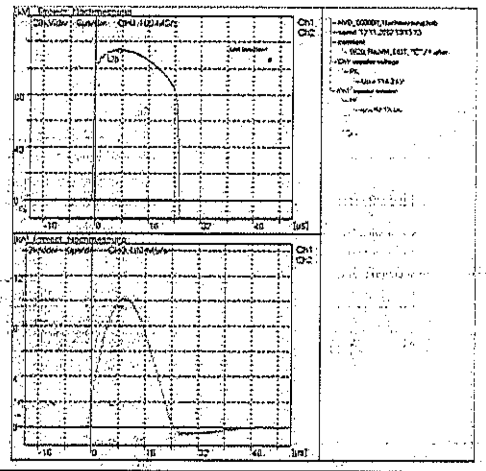
Appendix 5 Test evaluation/ Final measurements



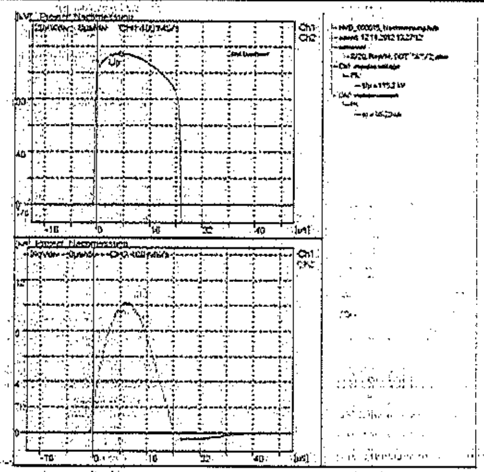
Residual voltage test of sample No. A (first impulse)



Residual voltage test of sample No. B (first impulse)

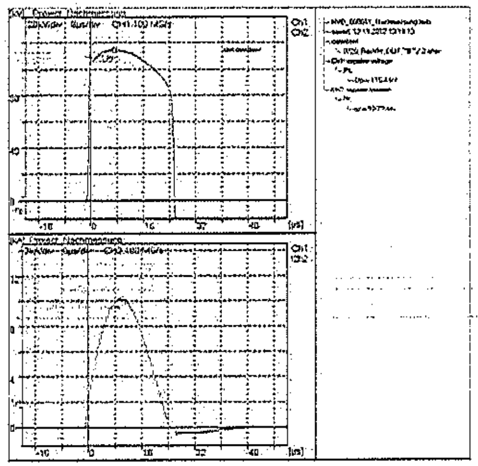


Residual voltage test of sample No. C (first impulse)

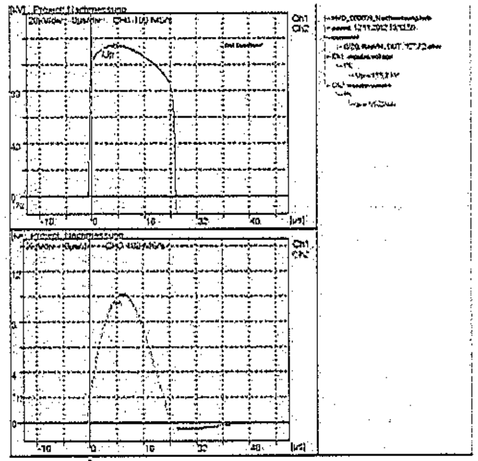


Residual voltage test of sample No. A (second impulse)

ВЯРНО С ОРИГИНАЛА



Residual voltage test of sample No. B (second impulse)

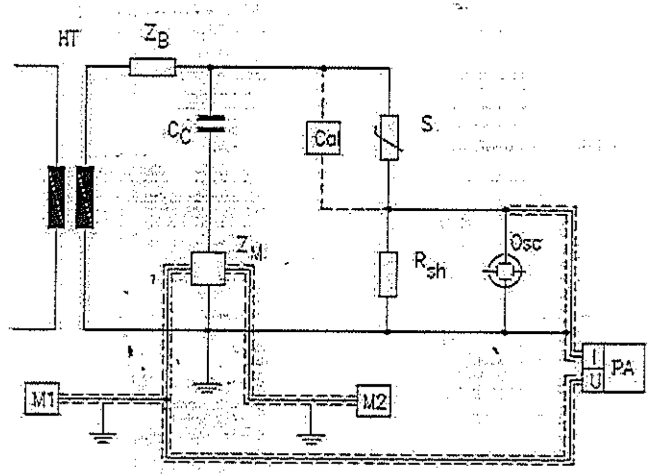


Residual voltage test of sample No. C (second impulse)

ВЯРНО С
ОРИГИНАЛА

626

Appendix 6 Test arrangement

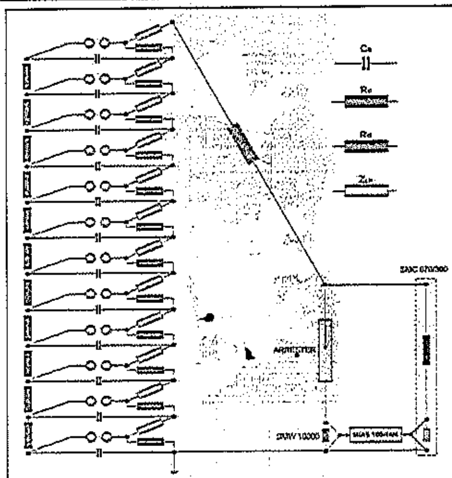


HT	Test transformer	PEO 8/100 A/K-2
M1	AC peak voltmeter	MU 14
M2	Partial discharge detector	MTE 3
Osc	Oscilloscope	Philips PM 3208
R_{sh}	Shunt resistor	1000Ω
Z_B	Blocking impedance	40mH
C_C	Coupling capacity	C 06
Z_M	Measuring impedance	H 322
Cal	Calibrator	PET 2-1
TS	Test sample	
PA	Power Analyzer	ZES ZIMMER LMG95

Test circuit for measurement of reference voltage and partial discharges

ВЯРНО С ОРИГИНАЛА

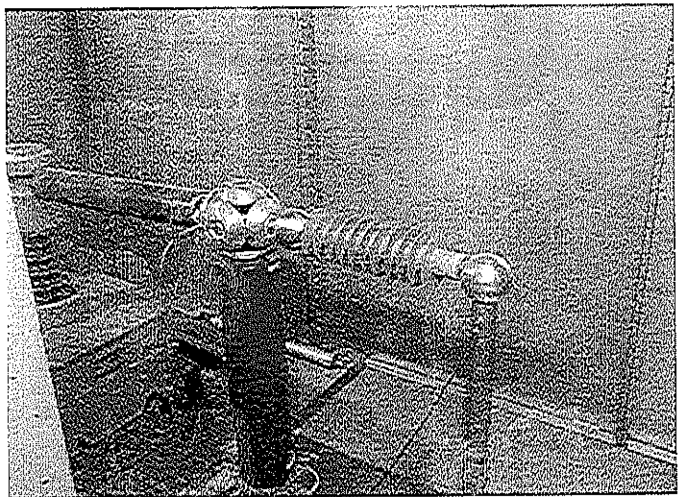
627



GENERAL INFORMATION				
Impulse Generator IP 120/1200 M:				
• Number of stages:	n		12	
• Capacitance per stage	C_s		2000	nF
• Max. lightning current impulse	I_m	≤	10	kA
• Total charging energy	W	≤	120	kJ
Individual Components:				
• Charging resistor R_c (18 kΩ)	n		12	
• Discharge resistors R_d (1,05 kΩ)	n		12	
• Front impedance Z_{LK} (32 µH; 1,3 Ω)	n		12	
• Controlled capacitive L/V divider	SMC 070/300			
• 10 kA Shunt	SMW 10000			
• Digital impulse voltage measuring system	MIAS 100-14/4			

Test circuit for residual voltage

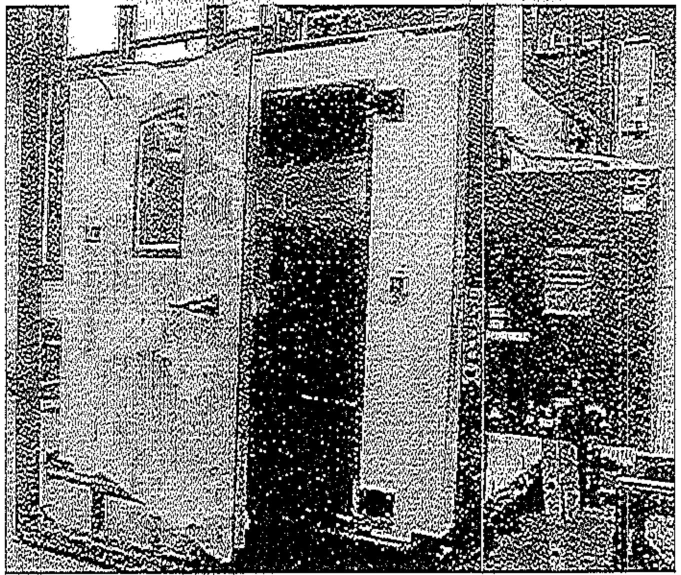
Appendix 7 Photos



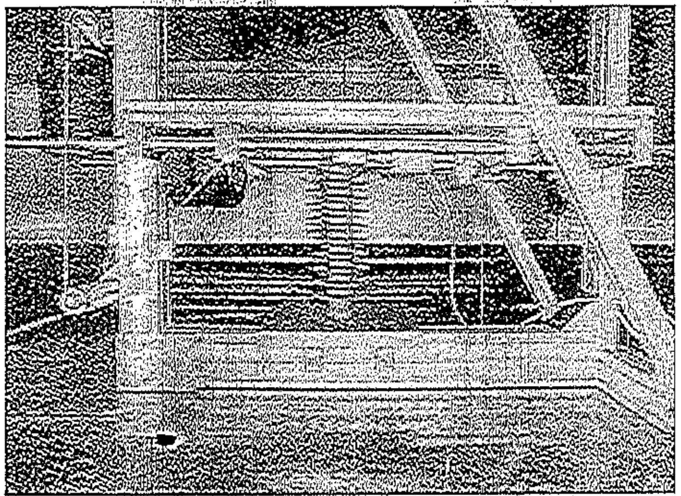
test arrangement for measuring of partial discharge, reference voltage and power losses

ВЯРНО С ОРИГИНАЛА

628



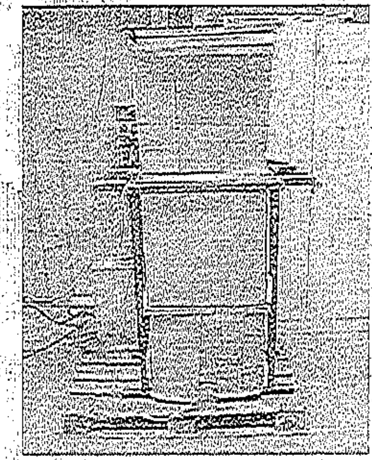
climatic chamber for bending moment test and thermo-mechanical preconditioning



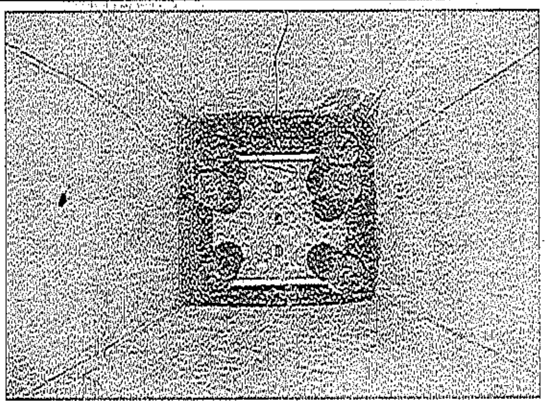
test arrangement inside the climatic chamber for bending moment test and thermo-mechanical preconditioning

ВЯРНО С ОРИГИНАЛА

629



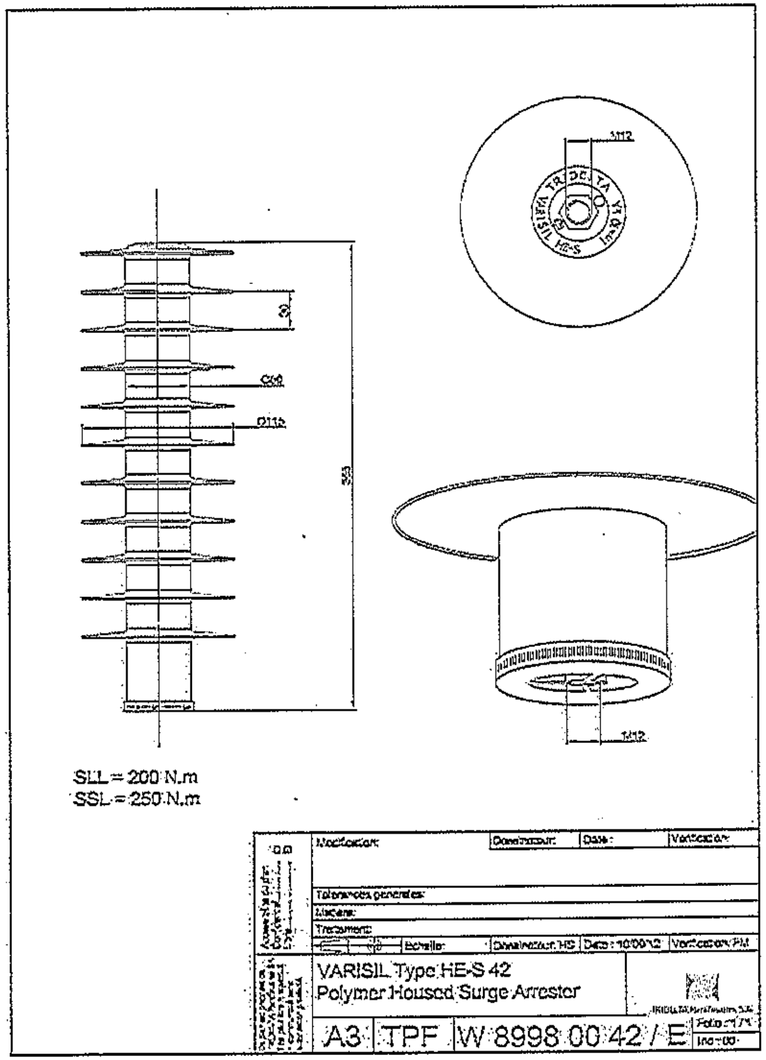
Water immersion test arrangement / boiling tank



Water immersion test arrangement / boiling tank with arrester

ВЯРНО С ОРИГИНАЛА

630



ВЯРНО С
ОРИГИНАЛА

631

client	ALSTOM Parafoudres S.A. - Bagneres de Bigorre (France)
equipment under test	Polymer housed metal-oxide surge arrester type VARISIL HE 36
tests performed	Weather ageing test - Test series A
normative documents	IEC 60099-4 (2001-12) edition 1.2
receipt date of the sample	July 18, 2002
test date	from August 07, 2002 to October 18, 2002

the test results relate only to the sample tested
this document shall not be reproduced except in full without the written approval of CESI and of the accreditation body, if any

no. of pages	23	no. of pages annexed	4
issue date	December 18, 2002		
prepared	PeC/TEST - M. Bonomelli		
verified	PeC/TEST - A. Sironi		
approved	PeC/TEST - V. Scarioni		

ВЯРНО С ОРИГИНАЛА

632

tests witnessed by: /

Identification of the object: The manufacturer guarantees that the tested object is manufactured according to the submitted drawings.
CESI checked that drawing adequately represents in shape and dimension the essential detail and the parts of the tested object.
The drawing identified by CESI and numbered A2/016115 is annexed to this document.

The measurement uncertainties of the test results reported in this document are the following:
- dielectric tests with impulse voltage : peak voltage: ± 3 % ; time parameters: ± 10 %
- dielectric tests with impulse current : peak value: ± 3 % ; time parameters: ± 10 %
- dielectric tests with alternating voltage : voltage (rms): ± 3 %

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to a confidence level of about 95 %) and have to be considered as maximum values.

---

laboratory information

CESI testing team: Mr. M. Bonomelli
Mr. M. Gregori - Mr. L. Podavitte

test laboratory: P177 - surge arrester laboratory
test laboratory: P189 - weather ageing laboratory
activity code: 33618J
keywords: 12015R, 22360O, 31020W, 44060J, 53001D, 62570N

ВЯРНО С
ОРИГИНАЛА

613

634

ВЯРНО С ОРИГИНАЛА

contents	page	test date
Test object characteristics	4	
Reference standard	5	
Test procedure	6	
Summary of test result	7	
Initial measurement	8÷9	07 August 2002
Visual examination	10	28 August ÷ 10 October
Final measurement	11÷12	11 October 2002
Photos	13÷20	
Technical data of the test circuit	21÷23	

Page annexed: oscillogram n. 08

Reference document annexed: ALSTOM drawing W 8997 01 36

Test object characteristics

type: Metal-oxide surge arrester type HE 36 (sample #1)

electrical characteristics (claimed by the client)

manufacturer's name	ALSTOM Parafoudres S.A.
nominal discharge current - I_N [kA]	10,0
rated voltage - U_R [kV]	36
continuous operating voltage - U_c [kV]	30,0
minimum reference voltage - [$kV_{pk/\sqrt{2}}$]	34,1
maximum residual voltage - [kV_{pk}]	97,5
rated frequency - [Hz]	50 - 60

geometrical characteristics (measured on the test sample)

total height [mm]	325
number of large sheds	10
number of small sheds	9
shed large diameter [mm]	115
shed small diameter [mm]	85
shed spacing [mm]	30
core diameter [mm]	50
creepage distance [mm]	1200

other characteristics

housing material	polymeric
housing color	grey

ВЯРНО С ОРИГИНАЛА

635

Reference Standard

IEC 60099-4 (2001-12) edition 1.2 Clause 9.7.9
" Metal-oxide surge arrester without gaps for a.c. system"

Test carried out

test carried out	number of sample tested
initial measurements	One sample The sample was identified by the manufacturer as sample #1
weather test series A - 1000 hours	
final measurements and visual inspection	

A view of the test object is shown at page 14 (aged sample)

ВЯРНО С ОРИГИНАЛА

630

N00A11720

Test procedure

Initial measurement

- The reference voltage have been measured at reference current equal to 1 mA_{pk}

- Internal partial discharge have been measured.
  The application voltage has been increased up to rated voltage (U_r) and maintained for 10 sec. Then the voltage has been decreased to 1,05 times the continuous operating voltage (U_c) and the partial discharge level has been measured according to the reference standard.

Test series A - 1000 hours

The test specimens have been mounted inside the test chamber in vertical position.
The test specimens has been energized at U_{test} = 20.8 kV_{rms} and kept for a total duration of 1000 hours in the test chamber filled with salt fog in the following conditions:
- salinity of the water solution: 10 kg/m3 for the first 445 hours, 5 kg/m3 for the last 555 hours
- water flow rate 0.4 ± 0.1 l/h*m^3

The fog was not directly sprayed against the test specimens.

A view of the test configuration is shown on page 13

Final measurement

- The reference voltage have been measured at reference current equal to 1 mA_{pk}

- Internal partial discharge have been measured.
  The application voltage has been increased up to rated voltage (U_r) and maintained for 10 sec.The voltage has been decreased to 1,05 times the continuous operating voltage (U_c) and the partial discharge level has been measured according to the reference standard.

- The test samples have been visually inspected

Note The test was carried out in parallel with other two specimens with different design

ВЯРНО С ОРИГИНАЛА

637

Summary of test result

Test series A - 1000 hours

No overcurrent trip out occurred during the test.

Visual inspection

No tracking, shed puncture or significant erosions have been evidenced by the visual inspection carried out at the end of the test.

Variation of the reference voltage

	before test	after test	variation
	kV	kV	%
sample #1	33.93	34.09	+ 0.47

Acceptance criteria: variation before/after less than 5 %

Partial discharge level

	before test	after test
	pC	pC
sample #1	< 1	< 1

Acceptance criteria: partial discharge level less than 10 pC

All acceptance criteria according to the reference standard are satisfied and therefore the results is to be considered positive.

ВЯРНО С
ОРИГИНАЛА

638

Measurement of the reference voltage - initial

test object: Metal-oxide surge arrester
test circuit: A019

date: August 07, 2002

	sample #1					
oscill.	voltage	current	current	current	power	3rd harmonic amplitude
no.	kV	+ mA	- mA	mA	W	µA
01	33,83	1,00	1,09	0,56	9,18	151,87

ВЯРНО С
ОРИГИНАЛА

010

ВЯРНО С
ОРИГИНАЛА

Measurement of partial discharges - Initial

test object: Metal-oxide surge arrester
test circuit circuit: A012
measurement circuit: A022 ("direct" calibration : 0,2 pC/mV, on CRO, see oscillogram n. ...)
arrangement: —

atmospheric conditions		
b	t	h
kPa	°C	g / m³
	22	

date: August 07,2002

test	applied	duration of	temperature	partial discharge measurement					
				voltage increase		voltage decrease			
condition	voltage	voltage application	of the test object	CRO readout	Q max	CRO readout	Q max	oscillogram	note
	kV	sec	°C	mV	pC	mV	pC	no.	
sample #1	Calibration of the test circuit			250	50			04	
sample #1	36	10	26	≤ 5	≤ 1				
	31,5					≤ 5	≤ 1	05	

Note: background noise ≤ 1 pC, see oscillogram n. 03

Visual examination

The housing of the specimen has been inspected visually.
See photos from page 15 to 20.

No tracking, shed puncture or significant erosions have been evidenced by the visual inspection carried out at the end of the test.

ВЯРНО С
ОРИГИНАЛА

Measurement of the reference voltage - final

test object: Metal-oxide surge arrester
test circuit: A019

date: October 11, 2002

			sample no. #1			
oscill.	voltage	current	current	current	power	3rd harmonic amplitude
no.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	µA
02	34,09	0,98	0,99	0,35	8,11	141,89

ВЯРНО С ОРИГИНАЛА

612

613

ВЯРНО С ОРИГИНАЛА

HCO.A1172/3

Measurement of partial discharges - final

test object: Metal-oxide surge arrester

test circuit: A012

measurement circuit: A022 ("direct" calibration : 0,2 pC/mV, on CRO, see oscillogram n. ...)

arrangement: ---

atmospheric conditions		
b	t	h
kPa	°C	g / m³
	20	

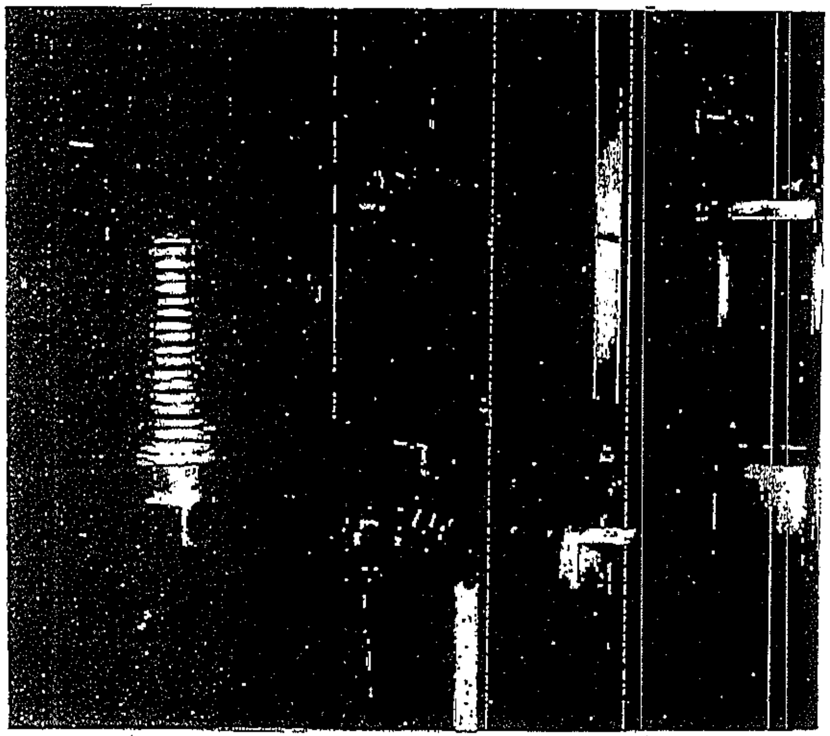
date: October 11, 2002

test condition	applied voltage	duration of voltage application	temperature of the test object	partial discharge measurement				oscillogram	note
				voltage increase		voltage decrease			
				CRO readout	Q max	CRO readout	Q max		
	kV_{rms}	sec	°C	mV	pC	mV	pC	no.	
sample #1	Calibration of the test circuit			250	50			07	
sample #1	36	10	20	≤ 5	≤ 1				
	31,5		20			≤ 5	≤ 1	08	

Note: background noise ≤ 1 pC, see oscillogram n. 06

18.DEC.2002

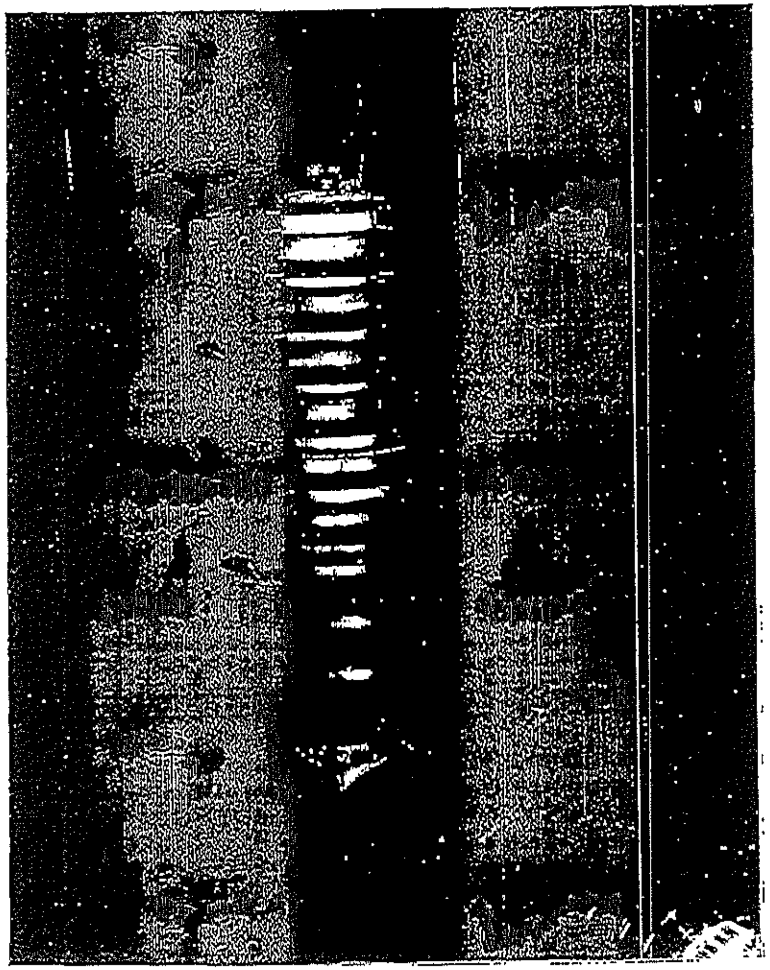
Photo n. 1: test configuration



ВЯРНО С
ОРИГИНАЛА

MOD.A12081G

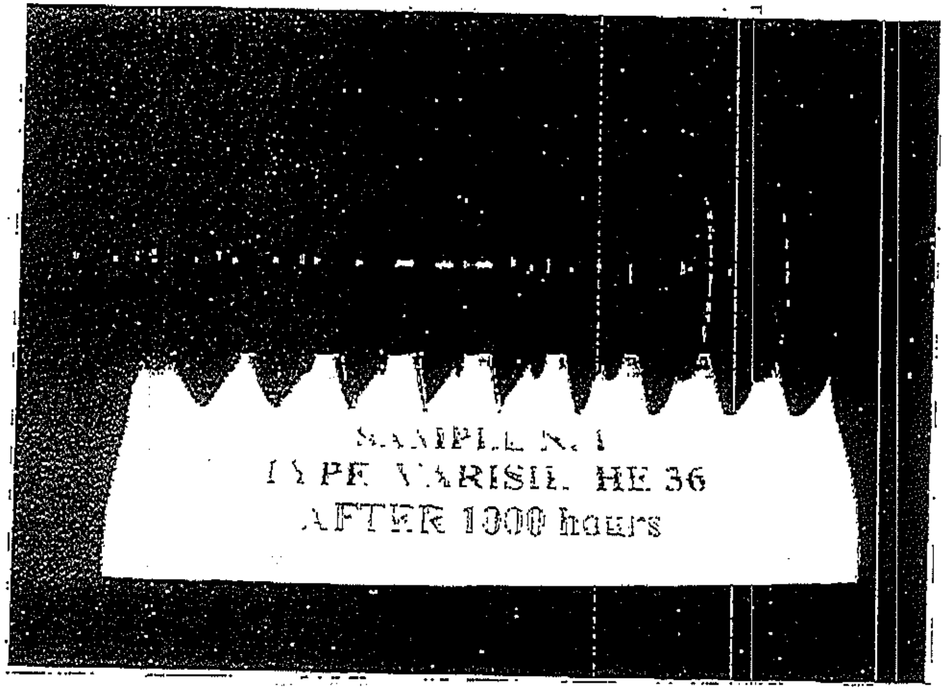
Photo n. 2 - sample #1 after the test



ВЯРНО С
ОРИГИНАЛА

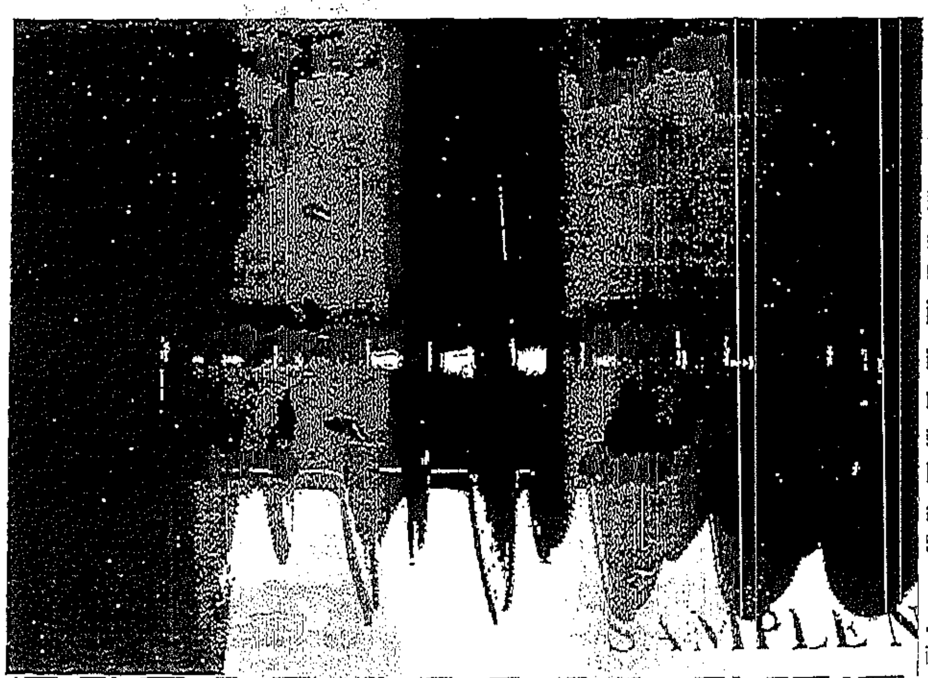
615

Photo n. 3 - sample #1 after the test



ВЯРНО С ОРИГИНАЛА

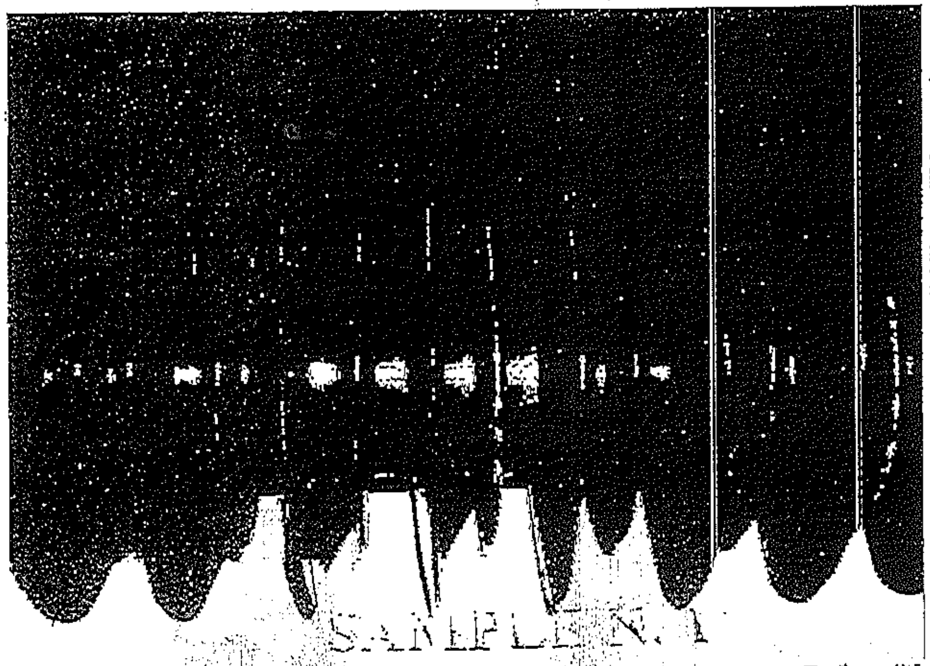
Photo n. 4 - sample #1 after the test



Mod.A12010

ВЯРНО С ОРИГИНАЛА

Photo n. 5 - sample #1 after the test



ВЯРНО С
ОРИГИНАЛА

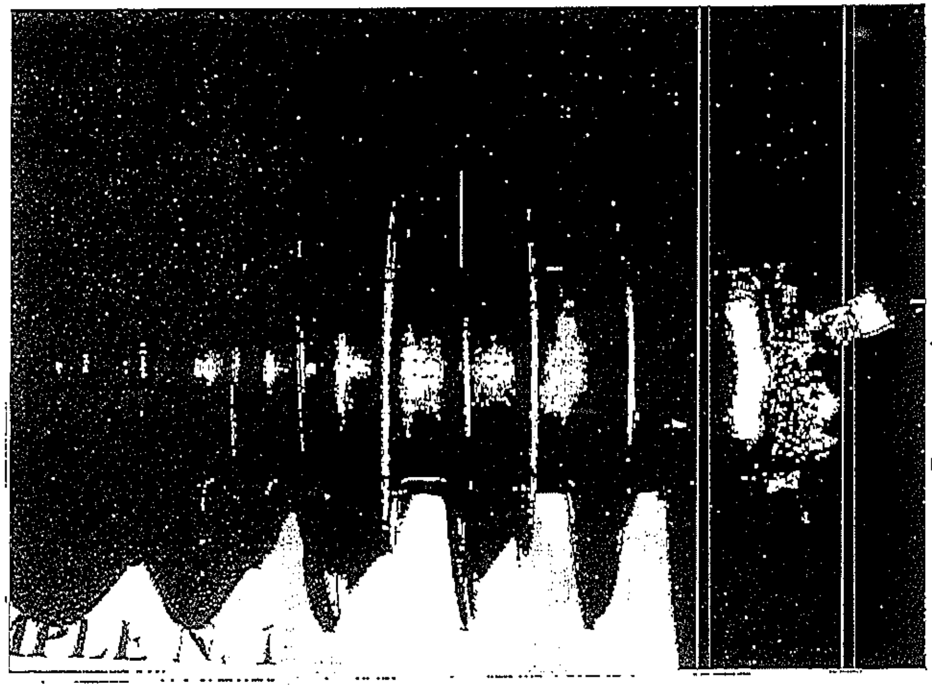
618

Photo n. 6 - sample #1 after the test

MOD.A1285/G

ВЯРНО С
ОРИГИНАЛА

Photo n. 7 - sample #1 after the test



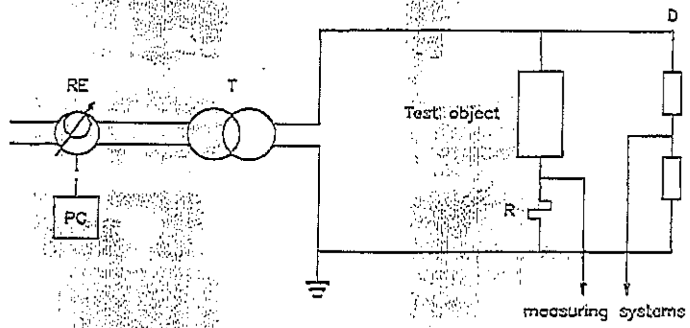
MOD.A1205IG

ВЯРНО С
ОРИГИНАЛА

Photo n. 5 - sample #1 after the test

ВЯРНО С ОРИГИНАЛА

circuit A019



power frequency supply

RE : programmable supply CESI no. 9889 ; type 3H series 3000
PC : personal computer
T : transformer type PIVI, voltage 200 V/ 50 kV

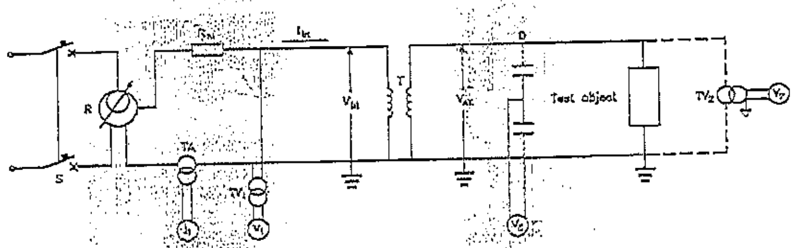
current shunt (R) CESI no.11537 ; R = 1034 Ω
oscilloscope CESI no. 4552
type Data Precision DATA 6000

voltage divider (D) CESI no.11120 K=1010
electro optical system CESI no. 11519/520
oscilloscope CESI no. 4552
type Data Precision DATA 6000

ВЯРНО С ОРИГИНАЛА

632

circuit A012



power frequency test circuit

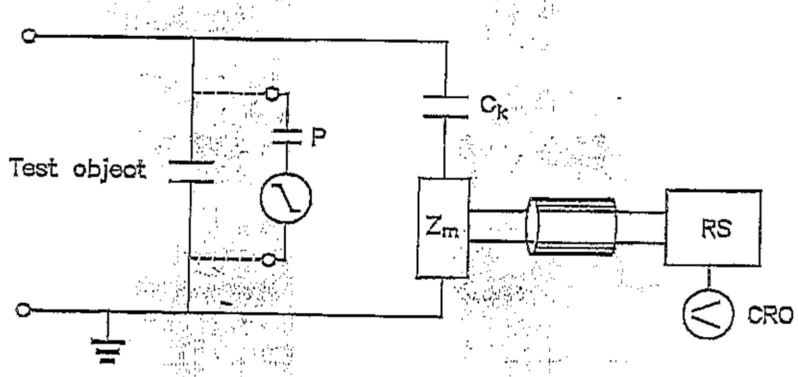
R : regulator type CORMES;power 66 kVA ; voltage 380 V/0 - 0,22 kV
TA : current trasformer CGS; ratio 150-300/5
I_1 : amperometer direct reading INDEX
TV_1: voltage transformer CGS ; ratio 220-440/100
V_1 : voltmeter direct reading TSE
R_{bt} : protection resistor — Ω
T : booster transformer PIVI ; power 250 kVA ; voltage 200-400 V/250 kV
TV_2: voltage transformer type CGS ; CESI no. 287; ratio 30000/100
V_2 : voltmeter CESI no. 6393

ВЯРНО С
ОРИГИНАЛА

circuit A022

partial discharges measurement

direct circuit
scheme 1a

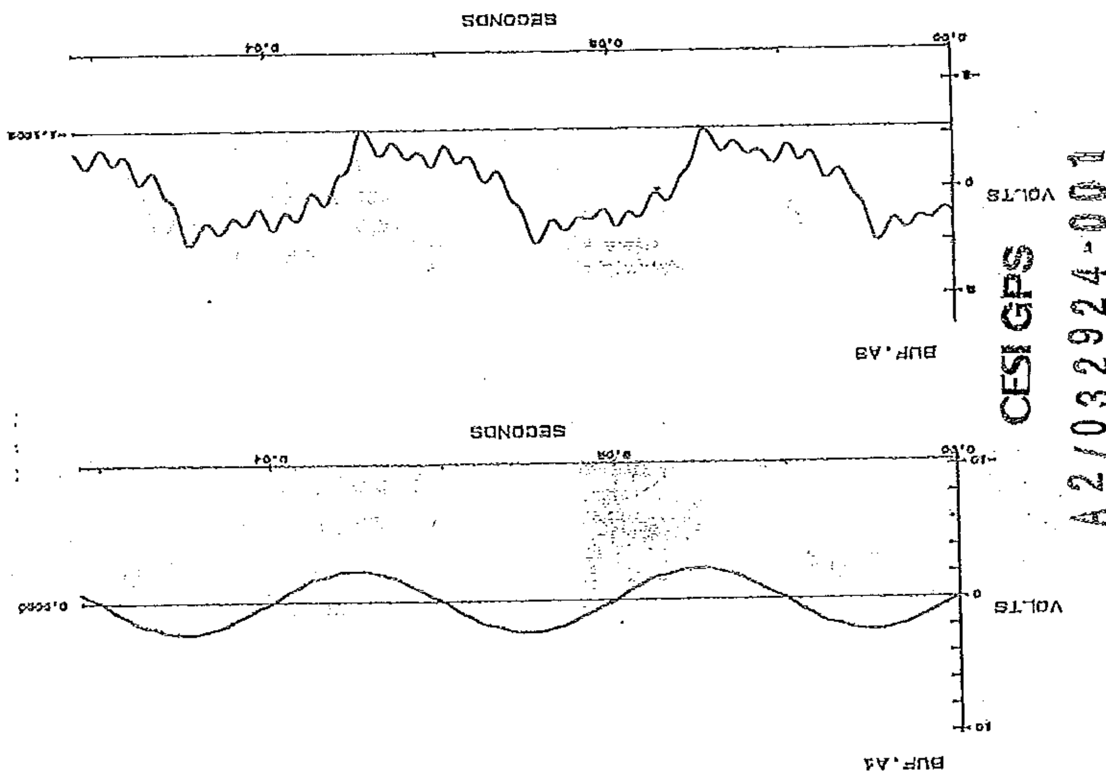


C_k : coupling capacitor 0,3 nF
Z_m : coupling impedance
P : calibrator no.Cesi 3466
RS : partial discharge detector Biddle; no. CESI 9595
CRO: oscilloscope no. CESI 6353

ВЯРНО С ОРИГИНАЛА

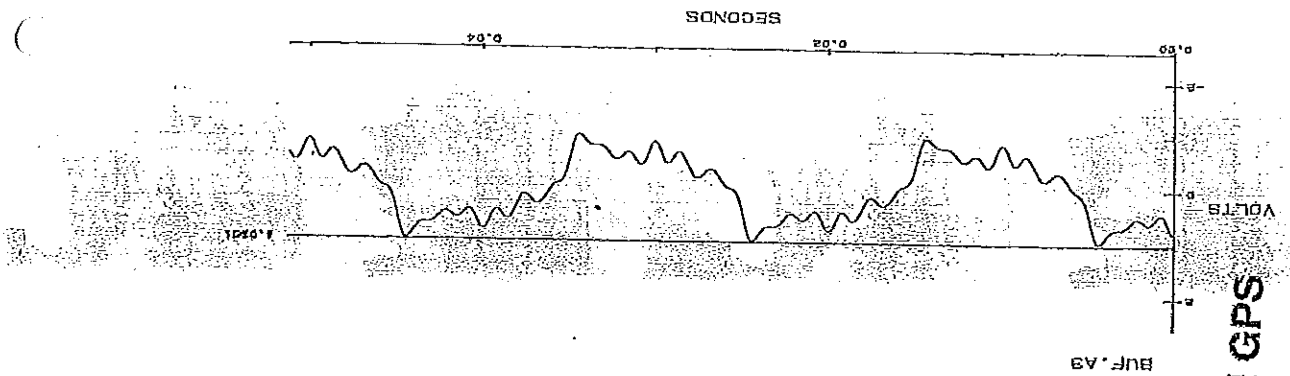
65

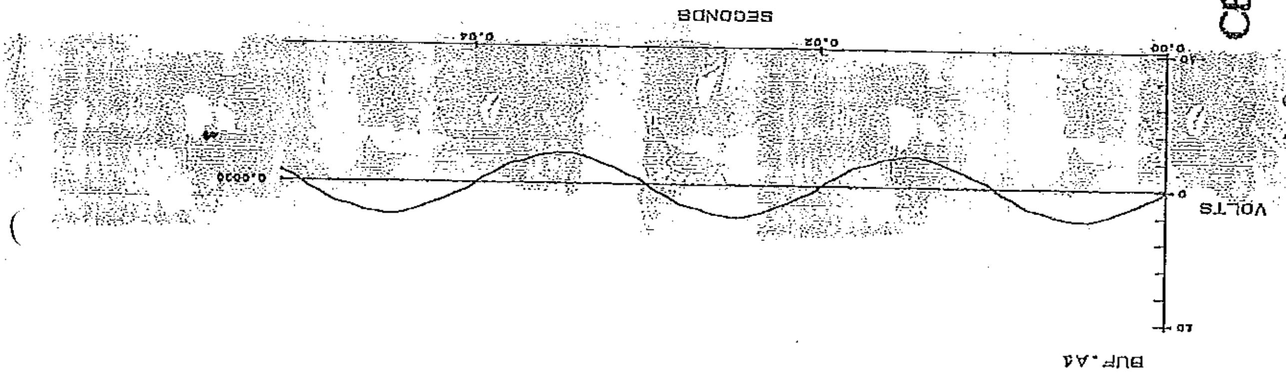
CESI GPS A2/032924-001



CESI GPS A2/032924-001

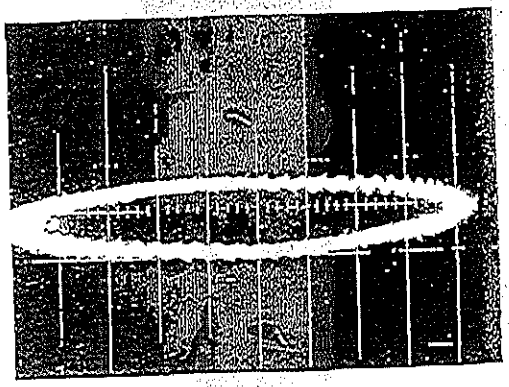
ВЯРНО С
ОРИГИНАЛА





CESI GPS
A2/032924-002

ВЯРНО С
ОРИГИНАЛА

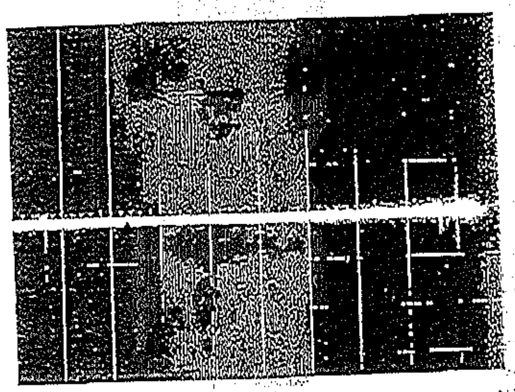


Oscillogram no. 06

Channel 1 :
voltage : 5 mV/div.
time : s

Channel 2 :
voltage : V
time : s

background noise of the circuit
Qmax ≤ 1pC

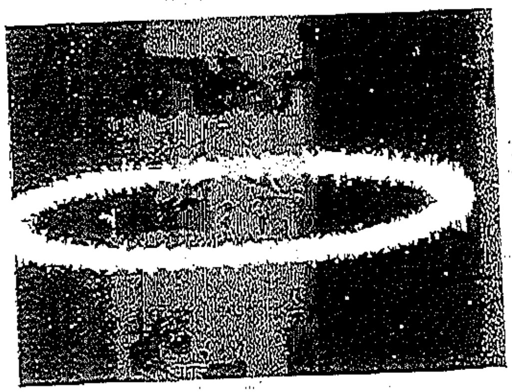


Oscillogram no. 07

Channel 1 :
voltage : 100 mV/div.
time : s

Channel 2 :
voltage : V
time : s

calibration of the test circuit
50 pC/250 mV = 0,2 pC/mV

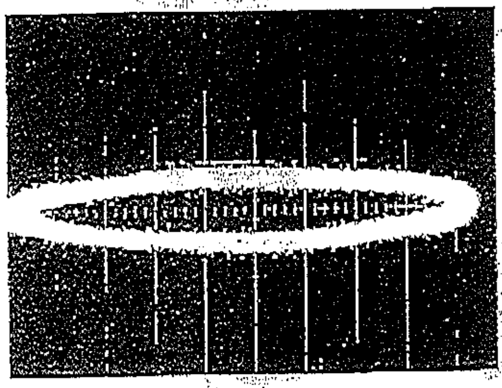


Oscillogram no. 08

Channel 1 :
voltage : 5 mV/div.
time : s

Channel 2 :
voltage : V
time : s

Sample no. 01 before the test
U = 31,5 kV
Qmax ≤ 1 pC

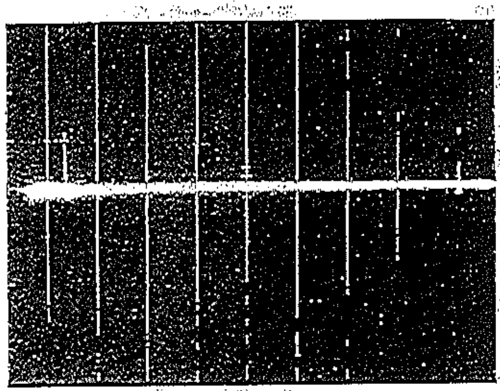


Oscillogram no. 03

Channel 1 :
voltage : 5 mV/div.
time : s

Channel 2 :
voltage : V
time : s

background noise of the circuit
Qmax ≤ 1pC

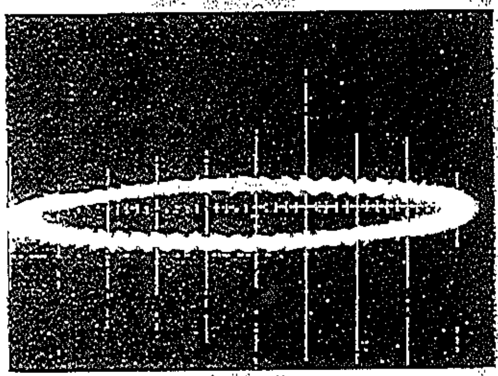


Oscillogram no. 04

Channel 1 :
voltage : 100 mV/div.
time : s

Channel 2 :
voltage : V
time : s

calibration of the test circuit
50 pC/250 mV = 0,2 pC/mV



Oscillogram no. 05

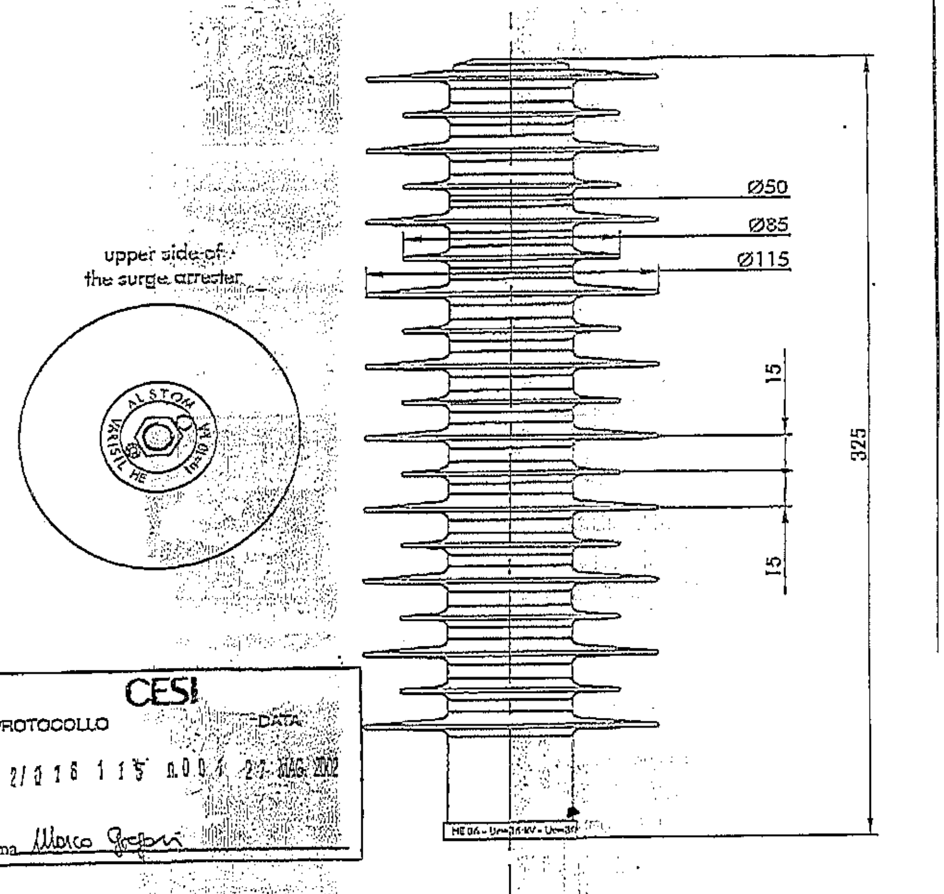
Channel 1 :
voltage : 10 mV/div.
time : s

Channel 2 :
voltage : V
time : s

Sample no. 01 before the test
U = 31,5 kV
Qmax ≤ 1 pC

ВЯРНО С ОРИГИНАЛА

653



CESI
PROTOCOLLO DATA
A 2/016115 n.004 27 MAG 2002
Firma Marco Grefori

Modification:	Dessinateur:	Date:	Vérification:
Tolérances générales:			
Matière:			
Traitement:			
Echelle :	Dessinateur: HS	Date: 03/05/02	Vérification:

Accessibilité du plan:
Confidentiel ☐
Libre ☒

Ce plan est propriété de ALSTOM Parafoudres SA; il ne peut être ni reproduit ni communiqué sans autorisation préalable.

VARISIL Type HE 36
Surge Arrester

ALSTOM
TRANSMISSION & DISTRIBUTION
Parafoudres
B.P 256
65202 Bagnères-de-Bigorre

A4	APF	W 8997 01 36	Folio : 1 / 1 Ind : 02

ВЯРНО С
ОРИГИНАЛА

CESI

Vs. rif.

Ns. rif. PeC – A3/001926

Data 21-01-2002

Messrs.
ALSTOM transmission & distribution
Parafoudres
65202 Bagnères-de-Bigorre
Att. Mr. Frederic Malpiece

Subject: Weather ageing test according to IEC standard 60099-4 (2001-12) on one polymer housed surge arrester type HE 24

Dear Sirs,

With reference to your request and awaiting to get ready the test report relevant to the subject we wish to send you here below a summary of the test carried out and of the relevant results

1. TEST OBJECTS

One polymer housed surge arrester type HE 24 (drawing W 8997 01 24)

The following ratings were assigned by the manufacturer:
- *Rated voltage: 24 kV*
- *Continuous operating voltage: 20 kV*
- *Nominal discharge current: 10 kA*

2. NORMATIVE REFERENCES

IEC 600994 (2001-12): "Surge arresters – metal oxide surge arresters without geps for a.c. systems"

CESI
Centro Elettrotecnico Sperimentale Italiano Giacinto Motta SpA
Via R. Rubattino 54
20134 Milano - Italia
Telefono +39 022125.1
Fax +39 0221255440
www.cesi.it

Capitale sociale 8 550 000 Euro interamente versato
Codice fiscale e numero iscrizione CCIAA 00793580150
Registro Imprese di Milano
Sezione Ordinaria
N. R.E.A. 429222
P.I. IT00793580150

ВЯРНО С ОРИГИНАЛА

660

CESI

3. TEST PLAN

The test was carried according to IEC 60099-4 at item 9.7.10 test series B
The surge arrester, mounted in vertical position, was energized at a power frequency voltage equal to 13.9 kV for 5000 hours while submitted to the various environmental stresses as specified in figure 9 of the standard.
Before and after the test the partial discharges and the reference voltage were measured for comparison.
Note that, according to Alstom request, the test voltage was $24/\sqrt{3} = 13.9$ kV while the continuous operating voltage specified for the surge arrester is 20 kV

4. TEST RESULTS

No overcurrent trip-out occurred during the test.
No tracking, shed puncture, deep erosions or other significant damages were observed at the end of the test.
The partial discharge level measured before and after the test was less than 1 pC
The reference voltage measured before and after the test were respectively 23.16 kV and 22.93 kV with a decreasing of about 1%.

5. CONCLUSION

All the acceptance criteria specified by the standard at item 9.7.10.3 are satisfied and therefore the test result is to be considered positive.

ВЯРНО С
ОРИГИНАЛА

client	ALSTOM Parafoudres S.A. - Bagneres de Bigorre (France)
equipment under test	Polymer housed metal-oxide surge arrester type VARISIL HE 24
tests performed	Weather ageing test - Test series B
normative documents	IEC 60099-4 (2001-12) edition 1.2
receipt date of the sample	02 May, 2002
test date	from 15 May, 2002 to 15 December, 2002

the test results relate only to the sample tested
this document shall not be reproduced except in full without the written approval of CESI

no. of pages	23	no. of pages annexed	4
issue date	27 March 2003		
prepared	PeC/TEST - M. Bonomelli	M. Bonomelli	
verified	PeC/TEST - A. Sironi	Albert. Si	
approved	PeC/TEST - V. Scarioni		

CESI
CENTRO ELETTROTECNICO SPERIMENTALE ITALIANO
Business Unit
Prove e Componenti
Il Responsabile del Laboratorio

ВЯРНО С ОРИГИНАЛА

tests witnessed by: /

Identification of the object: The manufacturer guarantees that the tested object is manufactured according to the submitted drawings.
CESI checked that drawing adequately represents in shape and dimension the essential detail and the parts of the tested object.
The drawing identified by CESI and numbered A3/011332 is annexed to this document.

The measurement uncertainties of the test results reported in this document are the following:
- dielectric tests with impulse voltage : peak voltage: ± 3 % ; time parameters: ± 10 %
- dielectric tests with impulse current : peak value: ± 3 % ; time parameters: ± 10 %
- dielectric tests with alternating voltage : voltage (rms): ± 3 %

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to a confidence level of about 95 %) and have to be considered as maximum values.

laboratory information

CESI testing team: Mr. Bonomelli
Mr. M. Gregori - Mr. L. Podovitto

test laboratory: P177 - surge arrester laboratory
test laboratory: P189 - weather ageing laboratory
activity code: 33618J
keywords: 12015R, 22360O, 31020W, 44060J, 53001D, 62570N

ВЯРНО С ОРИГИНАЛА

199

contents	page	test date
Test object characteristics	4	
Reference standard	5	
Test procedure	6	
Summary of test result	9	20.05.2002 ÷ 15.12.2002
Initial measurement	10 ÷ 11	03.07.2002
Visual examination	12	
Final measurement	13 ÷ 14	09.12.2002
Photos	15 ÷ 23	

Page annexed: oscillogram n. 04.

Reference document annexed: ALSTOM drawing A1/011332 n. 1

Test object characteristics

type: Metal-oxide surge arrestor type VARISIL HE 24

electrical characteristics (claimed by the client)

manufacturer's name	ALSTOM Parafoudres S.A.
nominal discharge current - I_n [kA]	10,0
rated voltage - U_r [kV]	24
continuous operating voltage - U_c [kV]	20
rated frequency - [Hz]	50 - 60

geometrical characteristics (measured on the test sample)

total height [mm]	245
number of large sheds	7
number of small sheds	7
shed large diameter [mm]	110
shed small diameter [mm]	80
shed spacing [mm]	30 (large-large); 15 (large-small)
core diameter [mm]	50
creepage distance [mm]	800

other characteristics

housing material	silicon
housing color	grey

MOD.A13/0/0

ВЯРНО С ОРИГИНАЛА

Reference Standard

IEC 60099-4 (2001-12) edition 1.2 at clause 9.7.10
" Metal-oxide surge arrester without gaps for a.c. system"

Test carried out

test carried out	number of sample tested
initial measurements	One sample identified as sample #5
weather test series B - 5000 hours	
final measurements and visual inspection	

A view of the test object is shown at page 16.

ВЯРНО С ОРИГИНАЛА

Test procedure

Initial measurement

- The reference voltage have been measured at reference current equal to 1 mA_{pk}
- Internal partial discharge have been measured.
  The application voltage has been increased up to rated voltage (U_r) and maintained for 10 sec. Then the voltage has been decreased to 1,05 times the continuous operating voltage (U_c) and the partial discharge level has been measured according to the reference standard.

Test series A - 5000 hours

The test specimen has been installed in the test chamber in vertical position.
The test specimen has been kept energized at the voltage U_{test} = 13.9 kV_{rms} while submitted to the daily multi-stress environmental cycle as specified below.
The multi-stress environmental cycle was repeated 208 times for a total duration of 5000 hours.
The main characteristics of the different environmental stresses applied during the test are reported in the following table:

environmental stress	daily duration [h]	total duration [h]	severity
salt fog	8	1664	7 g/l - 0,4 l/h/m³
humidification	4	832	98 %
rain	2	416	100 Ωm - 1,5 mm/min
U.V. radiation	12	2496	50 mW/cm²
heating	10	2080	50 °C

A scheme of the daily cycle is shown at page 7.
A scheme of the test configuration is shown at page 8.
A view of the test configuration is shown on page 17.

Note: The test was carried out in parallel with other specimens with different design

Note: According to client request the test voltage was 24/√3 = 13.9 kV while the specified continuous operating voltage is 20 kV

Final measurement

- The reference voltage have been measured at reference current equal to 1 mA_{pk}
- Internal partial discharge have been measured.
  The application voltage has been increased up to rated voltage (U_r) and maintained for 10 sec. The voltage has been decreased to 1,05 times the continuous operating voltage (U_c) and the partial discharge level has been measured according to the reference standard.
- The test samples have been visually inspected

Au

ВЯРНО С ОРИГИНАЛА

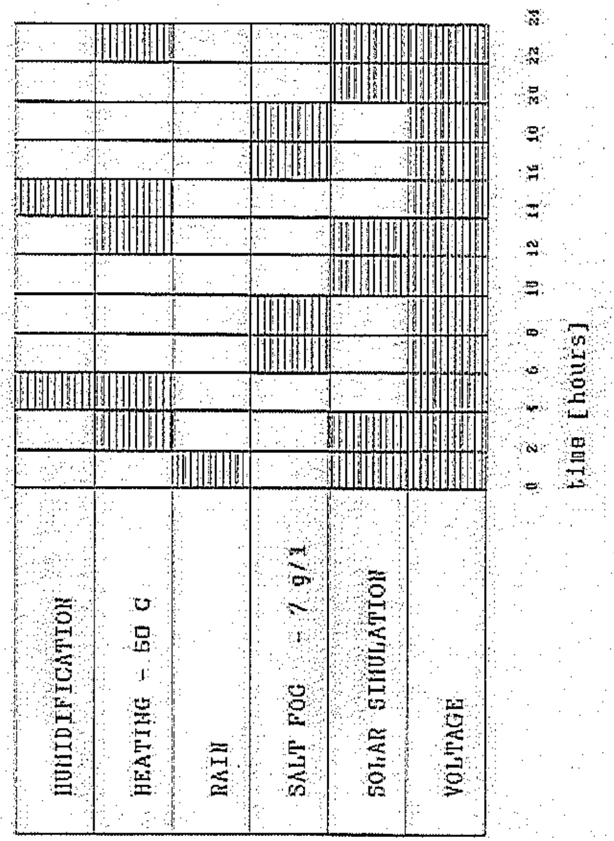


Fig. 4 - Daily cycle

ВЯРНО С ОРИГИНАЛА

663

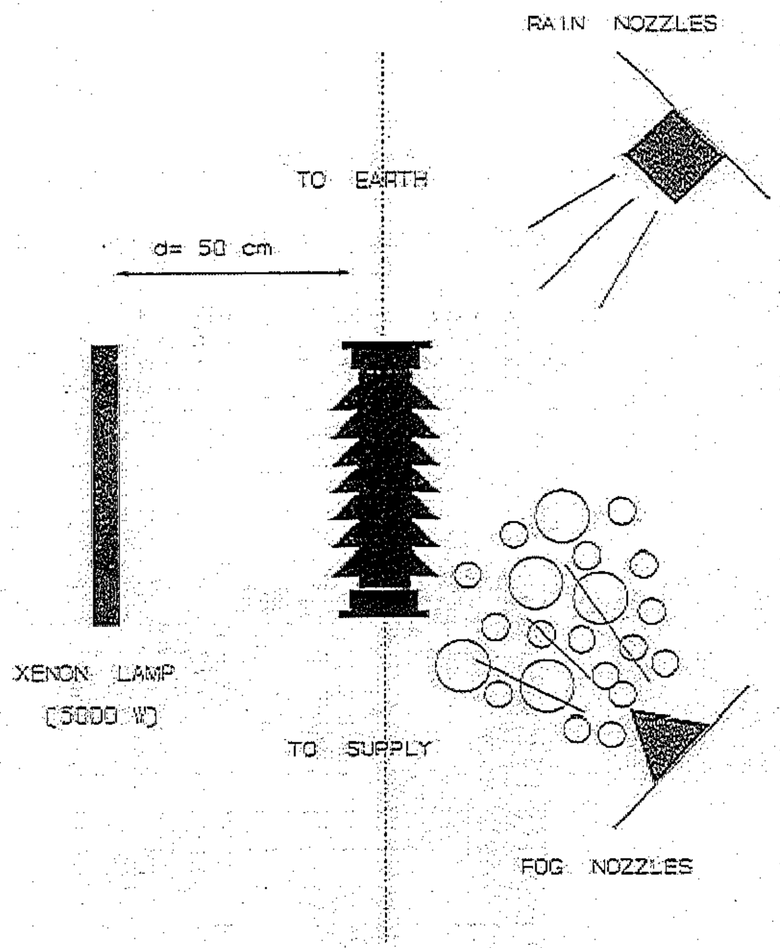


Fig. 5 - Scheme of the test configuration

ВЯРНО С
ОРИГИНАЛА

Summary of test result

Test series B - 5000 hours

No flashover occurred during the test.

Visual inspection

No tracking, shed puncture, erosion or any significant deterioration has been evidenced by the visual inspection carried out at the end of the test.

Variation of the reference voltage

	before test	after test	variation
	kV	kV	%
sample #5	23,15	22,93	-1,0

Acceptance criteria: variation before/after less than 5 %

Partial discharge level

	before test	after test
	pC	pC
sample #5	< 1	< 1

Acceptance criteria: partial discharge level less than 10 pC

All acceptance criteria according to the reference standard are satisfied and therefore the results is to be considered positive.

ВЯРНО С ОРИГИНАЛА

Measurement of the reference voltage - initial

test object: Metal-oxide surge arrester

date: 03 March, 2002

			sample #5			
oscill.	voltage	current	current	current	power	3rd harmonic amplitude
no.	kV	+ mA	− mA	mA	W	µA
1	23,16	1,0	0,98	0,59	7,78	1,76

672

ВЯРНО С ОРИГИНАЛА

Measurement of partial discharges - initial

test object: Metal oxide surge arrester

arrangement: ---

atmospheric conditions		
b	t	h
kPa	°C	g / m³

date: 03 March 2002

test	applied	duration of	temperature	partial discharge measurement				oscillogram	note
				voltage increase		voltage decrease			
condition	voltage	voltage application	of the test object	CRO readout	Q max	CRO readout	Q max		
	kV_{rms}	sec	°C	mV	pC	mV	pC	no.	
sample #5	24		20	≤5	≤1				
	21					≤5	≤1	05	

Note: background noise ≤ 1 pC, see oscillogram n. 03.

Visual examination

The housing of the specimen has been inspected visually.
No tracking, shed puncture, erosion or any significant deterioration has been evidenced by the visual inspection carried out at the end of the test.
See photos from page 18 to 23.

ВЯРНО С ОРИГИНАЛА

Measurement of the reference voltage - final

test object: Metal-oxide surge arrester

date: 09 December, 2002

sample no. #5

oscill.	voltage	current	current	current	power	3rd harmonic amplitude
no.	kV	+ mA	- mA	mA	W	µA
2	22,93	0,85	1,04	0,55	—	—

Measurement of partial discharges - final

test object: Metal-oxide surge arrester

arrangement: ---

atmospheric conditions		
b	t	h
kPa	°C	g / m³

date: 09 December, 2002

test	applied	duration of	temperature	partial discharge measurement				oscillogram	note
				voltage increase		voltage decrease			
condition	voltage	voltage application	of the test object	CRO readout	Q max	CRO readout	Q max		
	kV_{rms}	sec	°C	mV	pC	mV	pC	no.	
	24		19	≤5	≤1				
	21					≤5	≤1	00	

Note: background noise ≤ 1 pC.

ВЯРНО С ОРИГИНАЛА

DAkkS
Deutsche
Akkreditierungsstelle

Deutsche Akkreditierungsstelle GmbH

Anlage zur Akkreditierungsurkunde D-PL-11195-01-00 nach DIN EN ISO/IEC 17025:2005

Gültigkeitsdauer: 16.01.2013 bis 15.01.2018

Urkundeninhaber:

SCUS GmbH Service Center Umweltsimulation
Heidelberger Straße 20, 01189 Dresden

Prüfungen in den Bereichen:

mechanische und klimatische Umweltsimulationsprüfungen an Packstoffen, Packmitteln, Packstücken (Bereich Verpackung) und technischen Produkten, wie Klima-, Schock- und Vibrations- sowie Stoßprüfungen und deren Kombination

verwendete Abkürzungen: siehe letzte Seite

*Innerhalb der mit * gekennzeichneten Prüfbereiche ist dem Laboratorium, ohne dass es einer vorherigen Information und Zustimmung der DAkkS bedarf, die freie Auswahl von genormten oder ihnen gleichzusetzenden Prüfverfahren gestattet.*

Die aufgeführten Prüfverfahren sind beispielhaft. Das Laboratorium verfügt über eine aktuelle Liste aller Prüfverfahren im flexiblen Akkreditierungsbereich

1 Umweltsimulationsprüfungen Bereich Verpackung

DIN EN 13054 2001-05	Verpackung - Versandfertige Packstücke - Prüfung zur Bestimmung des Schwerpunktes eines Packstückes
DIN EN 14149 2003-11	Verpackung - Versandfertige Packstücke und Ladeeinheiten - Vertikale Stoßprüfung durch Kippen
DIN EN 22248 1993-02	Verpackung; Versandfertige Packstücke; Vertikale Stoßprüfung (freier Fall)
DIN EN 28768 1993-02	Verpackung; Versandfertige Packstücke; Umsturzprüfung

ВЯРНО С ОРИГИНАЛА

DIN ISO 10531 2000-03	Verpackung - Versandfertige Packstücke - Festigkeitsprüfung von Ladeeinheiten
DIN EN ISO 2234 2002-12	Verpackung - Versandfertige Packstücke und Ladeeinheiten - Stapelprüfung unter statischer Last
DIN EN ISO 2244 2002-12	Verpackung - Versandfertige Packstücke und Ladeeinheiten - Horizontale Stoßprüfung
DIN EN ISO 3037 2007-06	Wellpappe - Bestimmung des Kantenstauchwiderstandes (Verfahren für ungewachste Kanten)
DIN EN ISO 12048 2001-04	Verpackung - Versandfertige Packstücke - Kompressions- und Stapelprüfung unter Verwendung einer Kompressionsprüfmaschine
DIN EN ISO 2247 2002-12	Verpackung - Versandfertige Packstücke und Ladeeinheiten - Schwingprüfung mit niedriger Festfrequenz
DIN EN ISO 8318 2002-12	Verpackung - Versandfertige Packstücke und Ladeeinheiten - Schwingprüfung mit variabler sinusförmiger Frequenz
DIN EN ISO 13355 2003-10	Verpackung - Versandfertige Packstücke und Ladeeinheiten - Schwingprüfung mit vertikaler rauschförmiger Anregung
DIN EN 15552 2008-11	Verpackung - Versandfertige Packstücke und Ladeeinheiten - Prüfpläne für gewöhnliche Transportketten
DIN EN 22206 1993-02	Verpackung - Versandfertige Packstücke - Bezeichnung von Flächen, Kanten und Ecken für die Prüfung
DIN EN ISO 4180 2010-12	Versandfertige Packstücke - Allgemeine Regeln für die Erstellung von Prüfplänen
DIN EN 60721-3-6/A2 1997-07	Klassifizierung von Umweltbedingungen - Teil 3: Klassen von Umwelteinflußgrößen und deren Grenzwerte - Einsatz auf Schiffen
DIN EN ISO 2233 2001-11	Verpackung - Versandfertige Packstücke und Ladeeinheiten - Klimatische Vorbehandlung für die Prüfung
DIN EN ISO 2759 2003-11	Pappe - Bestimmung der Berstfestigkeit (ISO 2759:2001)

ВЯРНО С ОРИГИНАЛА

DIN EN ISO 2873 2002-12	Verpackung - Versandfertige Packstücke und Ladeeinheiten – Unterdruckprüfung (ISO 2873:2000)
DIN 53142-1 2004-12	Prüfung von Pappe - Durchstoßprüfung - Teil 1: Prüfung mit dem Pendelschlagwerk
DIN 55440-1 1991-11	Packmittelprüfung - Stauchprüfung - Prüfung mit konstanter Vorschubgeschwindigkeit
DIN EN ISO 527-3 2003-07	Kunststoffe - Bestimmung der Zugeigenschaften - Teil 3: Prüfbedingungen für Folien und Tafeln
DIN EN ISO 1924-2 2009-05	Papier und Pappe - Bestimmung von Eigenschaften bei zugförmiger Belastung - Teil 2: Verfahren mit konstanter Dehngeschwindigkeit
ISTA Ressource Book 2012	Guideline Transport
ASTM D 642-00 2010-08	Standard Test Method for Determining Compressive Resistance of Shipping Containers, Components and Unit Loads
ASTM D 4169-09 2009-11	Standard Practice for Performance Testing of Shipping Containers and Systems
ASTM 6653-01 2010-10	Standard Test Methods for Determining the Effects of High Attitude on Packaging Systems by vacuum Method

2 Umweltsimulationsprüfungen Bereich technische Produkte

DIN EN 61373 2011-04	Bahnanwendungen - Betriebsmittel von Bahnfahrzeugen - Prüfungen für Schwingen und Schocken
DIN EN 60068-2-1 2008-01	Umgebungseinflüsse - Teil 2-1: Prüfverfahren - Prüfung A: Kälte (IEC 60068-2-1:2007)
DIN EN 60068-2-2 2008-05	Umweltprüfungen - Teil 2-2: Prüfverfahren - Prüfung B: Trockene Wärme (IEC 60068-2-2: 2007)

ВЯРНО С ОРИГИНАЛА

DIN EN 60068-2-6 2008-10	Umweltprüfungen - Teil 2-6: Prüfverfahren - Prüfung Fc: Schwingen, sinusförmig (IEC 60068-2-6: 2007)
DIN EN 60068-2-27 2010-02	Umweltprüfungen - Teil 2-27: Prüfverfahren - Prüfung Ea und Leitfaden: Schocken (IEC 60068-2-27: 2008)
DIN EN 60068-2-30 2006-06	Umgebungseinflüsse - Teil 2-30: Prüfverfahren - Prüfung Db: Feuchte Wärme, zyklisch (12 + 12 Stunden) (IEC 60068-2-30:2005)
DIN EN 60068-2-32 1995-03	Umweltprüfungen - Teil 2-32: Prüfverfahren - Prüfung Ed: Frei Fallen (IEC 60068-2-32:1975 + A1:1982 + A2:1990)
DIN EN 60068-2-64 2009-04	Umweltprüfungen - Teil 2-64: Prüfverfahren - Prüfung Fh: Schwingen, Breitbandrauschen (digital geregelt) und Leitfaden (IEC 60068-2-64: 2008)
DIN EN 60068-2-78 2010-10	Umweltprüfungen - Teil 2-78: Prüfverfahren - Prüfung Cab: Feuchte Wärme, konstant (IEC 104/523/CD: 2010)

1 Umweltsimulationsprüfungen Bereich Verpackung *

Prüfart	*Messgröße / Prüfparameter*	*Mess- und Prüfbereich*	*Kleinste erreichbare Messunsicherheit K=2*	*Beispielhafte Prüfverfahren*
Druckprüfung, Stauchprüfung, Stapelprüfung	Kraft	max. 50 N max. 500 N max. 10 kN max. 50 kN	1 %	DIN 55440-1 DIN EN ISO 12048 ASTM D642-00 ASTM 4169-09
	Stauchweg	0,01 bis 1.800 mm	1 %	
	Dehnung	0,001 bis 1.200 mm	1 %	
Zugprüfung, Zugeigenschaften von Kunststoffen	Kraft	max. 50 N max. 500 N max. 10 kN	1 %	DIN EN ISO 527-3 DIN EN ISO 1924-2

ВЯРНО С ОРИГИНАЛА

DAkkS
Deutsche
Akkreditierungsstelle

Prüfart	*Messgröße / Prüfparameter*	*Mess- und Prüfbereich*	*Kleinste erreichbare Messunsicherheit K=2*	*Beispielhafte Prüfverfahren*
Berstfestigkeit	Druck	4000 kPa	3 %	DIN EN ISO 2759
Durchstoßarbeit	Energie	48 J	2 %	DIN 53142-1
Schwingprüfung, Vibrationsprüfung, Schockprüfung, Prellen	Kraftvektor	Sinus: max. 56 kN Rauschen: max. 56 kN Schock: 166 kN	-	DIN EN ISO 8318 DIN EN ISO 13355 ASTM 4169-09
	Schwingweg-amplitude Spitze-Spitze	max. 63,5 mm	-	
	Schwing-geschwindigkeit	Standard max. 2,0 m/s	-	
	Beschleunigung	max. 1.750 m/s^2	3 %	
	Frequenzbereich	3 Hz bis 3000 Hz	0,1 %	
Klimaprüfung	Temperatur	+5 °C bis +90 °C	0,5 K	ISTA Series
	Relative Luftfeuchte	10 % bis 98 %	2 % r. F.	
Temperatur-prüfung	Temperatur	-60 °C bis +180 °C	0,5 K	ISTA Series
horizontaler Stoß	Geschwindigkeit	0 bis 5 m/s	3,5 %	DIN EN ISO 2244
Fallprüfung	Freifall	0 bis 2000 mm	1 %	DIN EN 22248
Unterdruck-prüfung	Unterdruck	188 bis 1013 mbar	1 %	DIN EN ISO 2873

ВЯРНО С ОРИГИНАЛА

DAkkS
Deutsche
Akkreditierungsstelle

2 Umweltsimulationsprüfungen Bereich technische Produkte*

Prüfungsart	*Messgröße / Prüfparameter*	*Mess- und Prüfbereich*	*Kleinste erreichbare Messunsicherheit K=2*	*Charakteristische Prüfverfahren*
Schwingprüfung, Vibrationsprüfung, Schockprüfung	Kraftvektor	Sinus: max. 56 kN Rauschen: max. 56 kN Schock: 166 kN	-	DIN EN 60068-2-6 DIN EN 60068-2-27 DIN EN 60068-2-64
	Schwingweg-amplitude Spitze-Spitze	max. 63,5 mm	-	
	Schwing-geschwindigkeit	Standard max. 2,0 m/s	-	
	Beschleunigung	max. 1.750 m/s^2	3 %	
	Frequenzbereich	3 Hz bis 3000 Hz	0,1 %	
Klimaprüfung	Temperatur	+5 °C bis +90 °C	0,5 K	DIN EN 60068-2-30 DIN EN 60068-2-78
	Relative Luftfeuchte	10 % bis 98 %	2 % r. F.	
Temperatur-prüfung	Temperatur	-60 °C bis +180 °C	1 K	DIN EN 60068-2-1 DIN EN 60068-2-2
Fallprüfung	Freifall	10 bis 2000 mm	1 %	DIN EN 60068-2-32

verwendete Abkürzungen:

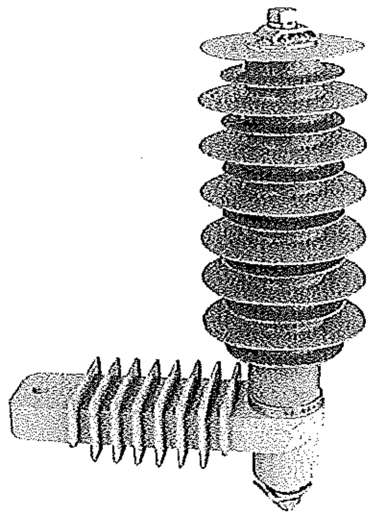
ASTM	American Society for Testing and Materials
DIN	Deutsches Institut für Normung
EN	Europäische Norm
ISO	International Organization for Standardization
ISTA	International Safe Transit Association
TGL	Technische Güte- und Lieferbedingungen

ВЯРНО С ОРИГИНАЛА

TRIDELTA Parafoudres S.A.

Вентилни отводи за разпределителни системи

VARISIL™ тип HE



ОБЩО ТЕХНИЧЕСКО ОПИСАНИЕ ИНСТРУКЦИЯ ЗА МОНТАЖ, ЕКСПЛОАТААЦИЯ И ОБСЛУЖВАНЕ. УКАЗАНИЯ ЗА СЪХРАНЕНИЕ НА СКЛАД СПИСЪК НА ВСИЧКИ ОСНОВНИ СТАНДАРТИ, ИЗПОЛЗВАНИ ПРИ РАЗРАБОТВАНЕТО И ИЗПИТВАНЕТО НА ВЕНТИЛНИТЕ ОТВОДИ

Януари 2010

TRIDELTA Parafoudres S.A.

Съдържание

TRIDELTA Parafoudres S.A.

654

TRIDELTA Parafoudres S.A.

ВЕНТИЛНИ ОТВОДИ VARISIL™ тип НЕ

ПРЕДГОВОР

Каквото и да е системното напрежение, електрическите мрежи са подложени на краткотрайни свръхнапрежения, които често повреждат оборудването (силови трансформатори, подземни кабели, ...), поради високото им ниво.

Съществуват два основни типа свръхнапрежения:

- свръхнапрежения от вътрешен произход, т.е. причинени от оперирането или схемата на мрежата (комутационно пренапрежение, резонансни явления, ...);

- свръхнапрежения от външен произход, т.е. генерирани от външни явления, сред които най-важна е мълнията.

Доказано е, че при средноволтажни мрежи (разпределителни мрежи), свръхнапреженията, породени от удари на мълния са най-често срещаните енергийни натоварвания, независимо от това дали са причинени от преки удари (свръхнапрежения, дължащи се на галванична връзка) или в по-малка степен от непреки удари (свръхнапрежения, дължащи се на кондензаторна и/или индукционна връзка).

Тяхното ниво може да достигне няколко стотин киловолта и да надхвърли много изолационната издръжливост на оборудването. Тези свръхнапрежения могат след това да предизвикат искрене или/и пробив на изолацията на оборудването, ако преди това предварително не е било инсталирано подходящо защитно устройство на разрядника.

В случай, че действително възникне подобен проблем, операторите вероятно ще съжаляват, че не са инвестирали във вентилни отводи, чиято цена е много по ниска от тази на повреденото оборудване.

TRIDELTA Parafoudres S.A.

1 ВЕНТИЛНИ ОТВОДИ

1.1 Защитни устройства

Съществуват два основни типа защитни устройства за разпределителните мрежи: въздушни искроразрядници и вентилни отводи.
Те обикновено се включват между фазата и земята, така че да се създаде слаба точка в изолацията на системата и така да се осигури защита на оборудването от свръхнапрежение срещу индуктивно или пряко пренапрежение

Искроразрядниците все още широко се използват за защита на въздушно изолирано оборудване или когато не е необходимо ниско изолационно ниво.
Обаче, за да се подобри качеството на обслужването се изискват по-високи характеристики и тогава са необходими вентилните отводи. На разположение са две технологии за вентилните отводи:

- **вентилни отводи SiC** : техният активен комплект е съвкупност от елементарни въздушни междини и нелинейни силициево-карбидни резистори, които са свързани в серии;
- **вентилни отводи МО** : техният активен комплект е изработен само от нелинейни метало-оксидни резистори.

Технологията на МО е възникнала в началото на 70-те години и осигурява по-добри експлоатационни качества от SiC. Поради това вентилните отводи SiC постепенно са били заменени с вентилни отводи МО, чиито последен дизайн с полимерен корпус сега се използва широко по света.

1.2 Въздушни искроразрядници

Въздушният искроразрядник е по-старото, по-простото и по--евтиното устройство за защита от пренапрежение.

<u>Дизайн</u>

Обикновено той се изработва от два електрода: първият се свързва с линейната страна на оборудването, което следва да бъде защитено, а вторият се заземява.

<u>Принцип на действие</u>

Въздушната междина между тези два електрода е слаба точка в изолацията на мрежата. Въздушното разстояние може да бъде настроено, за да се регулира пробивното напрежение до исканата стойност.

Защитно ниво

Защитното ниво на искровия разрядник е максимумът на пробивното напрежение при стандартно 1.2/50 импулсно напрежение при удар от мълния.

TRIDELTA Parafoudres S.A.

Предимства и недостатъци

Въпреки, че искроразрядниците са много евтини, много здрави и могат да бъдат лесно монтирани те притежават редица недостатъци, по-важните от които са:

- при възникване на искров пробив, електрическата дъга не може спонтанно да се загаси и затова трябва да се включи прекъсвачът, за да се елиминира късото съединение;
- искровият пробив води до формиране на вълна със заден фронт, което може да причини повреда на близкото намотъчно устройство;
- пробивното напрежение зависи от климатичните условия (температура, влажност...),а също и от предното нарастване на свръхнапрежението. При стръмен фронт на вълната, в действителност напрежението, приложено към оборудването може да бъде много по-голямо от самото пробивно напрежение (време на реакция), което също би могло да доведе до неочаквана повреда.

1.3 Силициево-карбидни вентилни отводи с междини (SiC)

При вентилните отводи SiC са премахнати някои от недостатъците на въздушните искроразрядници. Принципът бе да се използва нелинейно съпротивление в серии заедно с въздушна междина, за да се предотврати протичането на силен ток по време на работа. Силициевият карбид бе първият материал с висок нелинеен фактор, подходящ за подобно приложение. Нелинейните резистори са изработени от SiC гранули, които са пресовани като дискове с метализирана повърхност за по-добър електрически контакт.

Дизайн

Тъй като силициевият карбид има нелинейни свойства в ограничен обхват спрямо стойностите на плътността на електрическия ток, то едно устройство без междини би се повредило веднага при нормално напрежение фаза-земя. Въздушните междини са задължителни, за да се изолират дисковете при нормални условия.
Поради това, сърцевината на силициево карбидни вентилни отводи е изработена от SiC резистори в серии с няколко елементарни въздушни междинни. Тази сърцевина е поместена в порцеланов корпус, напълнен със сух въздух или азот. Подходяща уплътнителна система предотвратява проникването на влага, тъй като експлоатацията и надеждността са много чувствителни към влажност.

Принцип на действие

При номинално напрежение фаза-земя, въздушните междини изолират вентилния отвод. В случай на свръхнапрежение, надвишаващо пробивното напрежение на междините, токовият импулс преминава през SiC резисторите, чието съпротивление се намалява с увеличаването на тока (нелинейно свойство), което ограничава действителното ниво на свръхнапрежение. След като енергията на пренапрежение бъде абсорбирана, вентилният отвод остава проводим докато приложимото

напрежение достигне нула : съпротивлението на SiC резисторите е достатъчно високо, за да елиминира тока и за да изолира отново вентилния отвод.
Благодарение на нелинейното съпротивление на SiC резисторите, силициево-карбидните вентилни отводи могат да ограничат свръхнапреженията, при което се спазват изискванията за непрекъснатост на електроснабдяването.

TRIDELTA Parafoudres S.A.

Защитно ниво
Защитното ниво на силициево-карбидния вентилен отвод се определя като максимална стойност в т.ч.:
- 1,2/50 импулс при удар от мълния максимално пробивно напрежение ;
- максимално пробивно напрежение на фронта на вълната, разделено на 1.15;
- максимално остатъчно напрежение при номинален разряден ток.

Останали недостатъци
Независимо от това, че позволяват да се избегнат повечето от недостатъците на единичните искроразрядници, вентилните отводи SiC все още имат някои недостатъци:
- след като свръхнапрежението бъде ограничено, все още протича ток с промишлена честота (наричан „остатъчен ток", който може да достигне сто или повече ампера) докато прилаганото напрежение стигне нула, като в най- лошия случай това става в продължение на половин цикъл;
- въпреки, че сериите от въздушни междини са поставени в плътен корпус, пробивното напрежение е чувствително към външното разпределение на напрежението по порцелановия корпус, което се променя под въздействия на околната среда (дъжд, сол, мъгла, ...).

1.4 Метало-оксидни вентилни отводи в цялостен корпус (MOSA)

През 60-те години нелинейните резистори, изработени от метални оксиди са били проектирани за защита на електронно оборудване. Десет години по-късно бяха внедрени МО вентилни отводи, предназначени за средноволтово приложение.
Те се характеризират с две основни предимства:
- много висок нелинеен фактор при разширен обхват на стойностите за плътност на тока;
- много по-висока способност за поглъщане на енергия отколкото при вентилните отводи SiC .

Дизайн
Високата нелинейност при разширен обхват на тока позволява да се премахнат въздушните междини. Резисторите МО са вградени в плътен корпус, който обикновено е от порцеланов тип. Порцелановият корпус трябва да бъде снабден със система за освобождаване на налягане, за да се избегне разрушаване поради вътрешна повреда (например вследствие на много силен удар от мълния).
Наскоро производителите заместиха този традиционен порцеланов корпус с полимерен корпус с подходящи свойства, така че да издържа на климатични въздействия и да осигурява трекинг устойчивост. За да се получи изискваната механична якост на вентилния отвод (която преди това бе постигана от самия порцеланов корпус), понастоящем метало-оксидните резистори се обвиват със смола, усилена чрез фибростъкло.

Производственият процес на МО резисторите (наричани също "MOV блокове") изисква голям опит, за да се постигне очакваното действие и надеждност. По време на производствения процес се изисква особено голямо внимание. Един блок се прави от цинков оксид (90 %) смесен с други метални оксиди (бисмут, кобалт, манган, ...). Формулата (химичният състав) и процесите (особено цикъла на спичане) се контролират внимателно, за да се гарантират високи нива на качество и надеждност.

TRIDELTA Parafoudres S.A.

Принцип на действие

Основното предимство на един МО резистор е високата нелинейна характеристична крива на тока спрямо напрежението (виж кривата на стр. 13).
При номинално напрежение фаза-земя, импедансът на един МО вентилен отвод е много висок, тъй че утечката на тока е много ниска (обикновено по-малко от 0.1 mA). Когато възникне свръхнапрежение, омното съпротивление намалява много бързо, така че ударният ток да протече към земята и нивото на свръхнапрежение се ограничава. Нелинейният фактор е толкова висок, че между 0.1 mA и 10 kA напрежението само се удвоява.

Защитно ниво

Защитното ниво на метало-оксидния вентилен отвод се определя като максимално остатъчно напрежение при номинален разряден ток .

Определяне н а параметрите

Изборът на подходящ вентилен отвод (т.е. дефиниране на съответното разчетно напрежение) се основава на съображения, имащи противоположни тенденции:

- да се оптимизира предоставената защита, но колкото по-ниско е защитното ниво, толкова по-ниско е разчетното напрежение;
- да се осигури издържане на прилаганите напрежения, но колкото по-висока е устойчивостта на напрежение, толкова по-високо е разчетното напрежение.

Пълната процедура за избор е дадена в раздел 4.

Във всички случаи, вентилният отвод променя електрическата енергия в топлинна енергия. При електрическо натоварване вътрешната температура на МО резисторите може да се повиши много бързо. Ако поетата енергия е по-висока от способността за топлинно разсейване, то могат да възникнат повреди поради явление на топлинен пробив.

Категории на разряд по линията

Енергията при комутационните пренапрежения зависи от волтажа на системата. Колкото по-висок е волтажа на системата, толкова по-висока е акумулираната енергия поради капацитета на мрежата. При високоволтажни мрежи енергията на някои пренапрежения дори може да надвиши тази от удари при мълния.
Поради това, стандартът IEC 60099-4 определя категории на разряд (от 1 до 5), отговарящи на повишената способност за поглъщане на енергия при комутационни пренапрежения. При разпределителните мрежи обикновено се използва категория 1. Категориите 2 и 3 преди всичко се прилагат за волтажи на системи в диапазон от 60 до 245 kV, а категориите 4 и 5 над това.

Забележки :

1. Категория на разряд по линията се прилага само към вентилни отводи, които имат номинален разряден ток от 10 kA (категории от 1 до 3) и от 20 kA (категории 4 и 5).

2. Вентилни отводи от категория 2 или 3 на разряд по линията могат да бъдат необходими за средноволтажни подстанции в случай на висока реактивна мощност (наличие на кондензаторни батерии за компенсаторна цел).

TRIDELTA Parafoudres S.A.

Основни характеристики на вентилен отвод MO

- Разчетното напрежение (Ur) е максимално допустимата rms стойност на напрежение с промишлена честота, което може да бъде приложено към вентилния отвод в продължение на 10 s (т.е. временно) след поглъщане на разчетната енергия.

- Постоянното оперативно напрежение (Uc) е максималното напрежение, което може да бъде прилагано непрекъснато към вентилния отвод при дадени външни условия.

- Номиналният разряден ток (In) е най-високата стойност на стандартния 8/20 токов импулс при мълния, който се използва за класифициране на един вентилен отвод. Той може да бъде или 5 kA, 10 kA или дори 20 kA : защитното ниво на вентилния отвод срещу мълния се определя при тази стойност на тока.

- Способността за поглъщане на енергия може да бъде зададена за устойчивост към висок токов импулс (4/10 токов импулс при мълния) или за устойчивост към много продължителен токов импулс (продължителност и най-висока стойност съгласно изискванията за категории на разряд по линията).

Предимства на MO вентилни отводи спрямо SiC вентилни отводи

Благодарение на високата нелинейност и способността за поглъщане на енергия при MO резисторите, метало-оксидните вентилни отводи имат много предимства пред предишната силициево-карбидна технология:

- не се абсорбира остатъчен ток ;
- защитното ниво се контролира по-добре, тъй като то вече не зависи от стойността на пробивно напрежение, което се подлага на флуктуации;
- остатъчното напрежение при високи стойности на тока е много по-ниско;
- режимът на работа при сурови климатични условия е много подобрен;
- размерът и теглото са много по-малки.

Предимства на MOSA в полимерен корпус

Последната технология се възползва както от MO резисторите, така и от изработване на полимерен корпус. Подобни вентилни отводи все още предлагат повече предимства пред конвенционалните метало-оксидни вентилни отводи:

- теглото е почти наполовина от подобните вентилни отводи в порцеланов корпус, което улеснява както транспортирането, така и обработката;

- диелектричната здравина е подобрена;

- сигурността е повишена в случай на повреда, тъй като силно раздробяване на корпуса не може да възникне;

- режимът на работа при сурови климатични условия е много по-добър, благодарение на естествената хидрофобност и устойчивост към UV на полимерния корпус, особено ако е изготвен от силиконов каучук;

- намаленият размер позволява да се извърши монтаж по-близо до оборудването и във всяко положение, така че да се подобри защитата от свръхнапрежение.

Благодарение на горните важни предимства MOSA в полимерен корпус са доказали, че са идеалните устройства за защита при пренапрежения на оборудването в разпределителната мрежа.

TRIDELTA Parafoudres S.A.

2 ОБХВАТ НА РАЗПРОСТРАНЕНИЕ ОТ TRIDELTA НА МЕТАЛО-ОКСИДНИ ВЕНТИЛНИ ОТВОДИ В ПОЛИМЕРЕН КОРПУС

2.1 Продуктова номенклатура на VARISIL™ тип HE

Продуктите VARISIL™тип HE са 10 kA метало-оксидни вентилни отводи за разпределителни мрежи, специално предназначени за райони, подложени на силни удари от мълния и са с високо ниво на замърсяване на околната среда.
Обхватът включва системни напрежения от 5.5 kV до 36 kV. В таблицата на стр. 14 са представени основните характеристики на вентилните отводи VARISIL™ тип HE.
Номенклатурата включва четири различни размера, които съответно се използват за разчетни напрежения до 12 kV, 18 kV, 24 kV и 36 kV.

2.2 Дизайн на VARISIL™ тип HE

Активната част е изработена от MOV блокове обвити със синтетична смола, усилена чрез фибростъкло, чийто дизайн е патентован.
Това ядро осигурява механичната издръжливост и е покрито с полимерен корпус, изработен от силиконов каучук, подходящ за райони с високо ниво на замърсяване на околната среда.

<u>MOV блокове на TRIDELTA</u>
TRIDELTA произвежда своите блокове в добре известни цехове.
Формулата (химичният състав) и процесите (особено цикълът на спичане) се контролират внимателно, за да се гарантират високи нива на качество и надеждност.

<u>Композитна обвивка</u>
Тялото на вентилния отвод е изработено от синтетична смола, усилена чрез фибростъкло, чийто дизайн е патентован. Тази рамка осигурява перфектно капсуловане на MOV блоковете и надежден режим на работа при условия на повреда.

<u>Корпус от силиконов каучук</u>
Силиконовият каучук, използван за външна изолация е показал задоволителни характеристики при високоволтово приложение.
Най-важният довод за успеха на силиконовия каучук при тези приложения е неговата способност да поддържа хидрофобна повърхност дори при замърсяване, както и да възвръща хидрофобността, ако тя е била временно изчезнала по време на изключителна електрическа активност.
Хидрофобността фактически е улавяне на вода при разпръснати капки вода, като се избягват големи зони на повърхностна проводимост. В замърсена околна среда

691

силиконовият каучук показва съществени предимства пред керамични материали, като порцелан, по отношение на работния режим при електрически разряд (виж диаграмата на стр. 12).

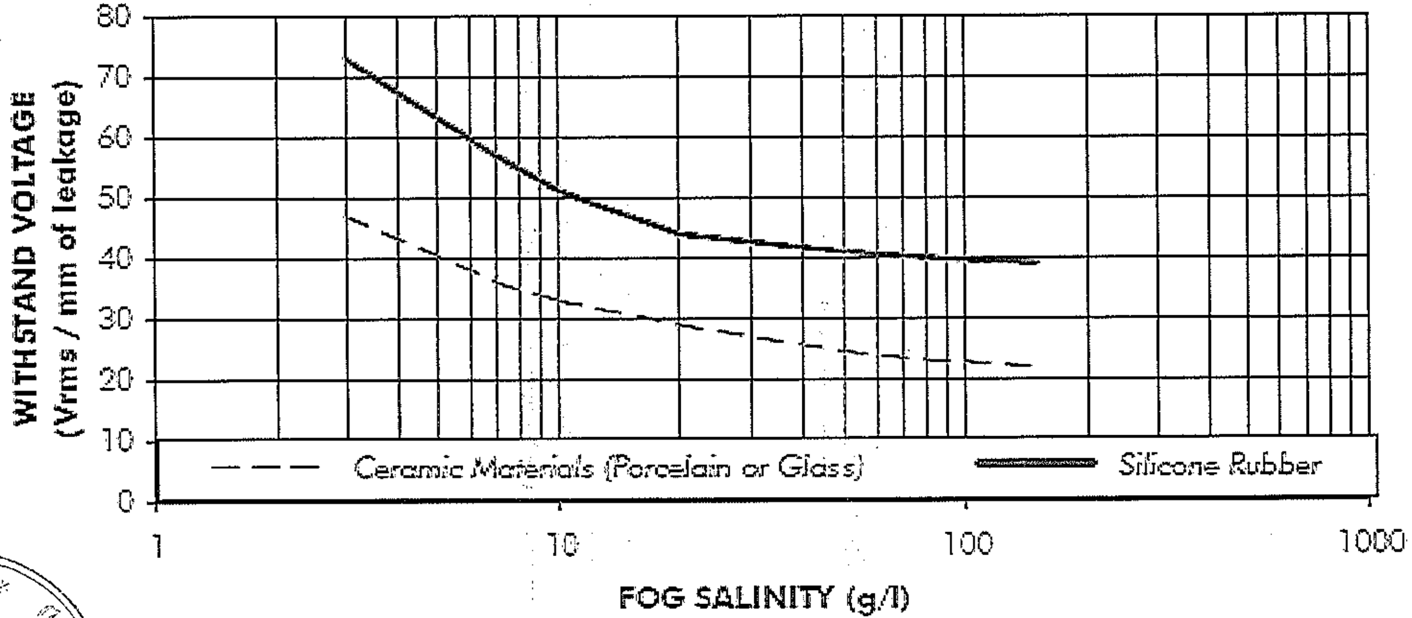
TRIDELTA Parafoudres S.A.

В допълнение, изключителната устойчивост на силиконовия каучук към ултравиолетови лъчи, окисляване и озон осигурява, че материалът ще остане функционален при дълго влияние на околната среда. Това се дължи предимно на факта, че силиконовият каучук е неорганичен материал с молекулярни връзки силиций - кислород (Si - O) и с много по-малка чувствителност към UV радиация, отколкото молекулярните връзки въглерод - въглерод - при EPM, EPDM и XLPE (полиетилен с междумолекулярни връзки).

692

TRIDELTA Parafoudres S.A.

COMPARISON OF FLASHOVER PERFORMANCE OF SILICONE RUBBER & CONVENTIONAL CERAMIC MATERIALS

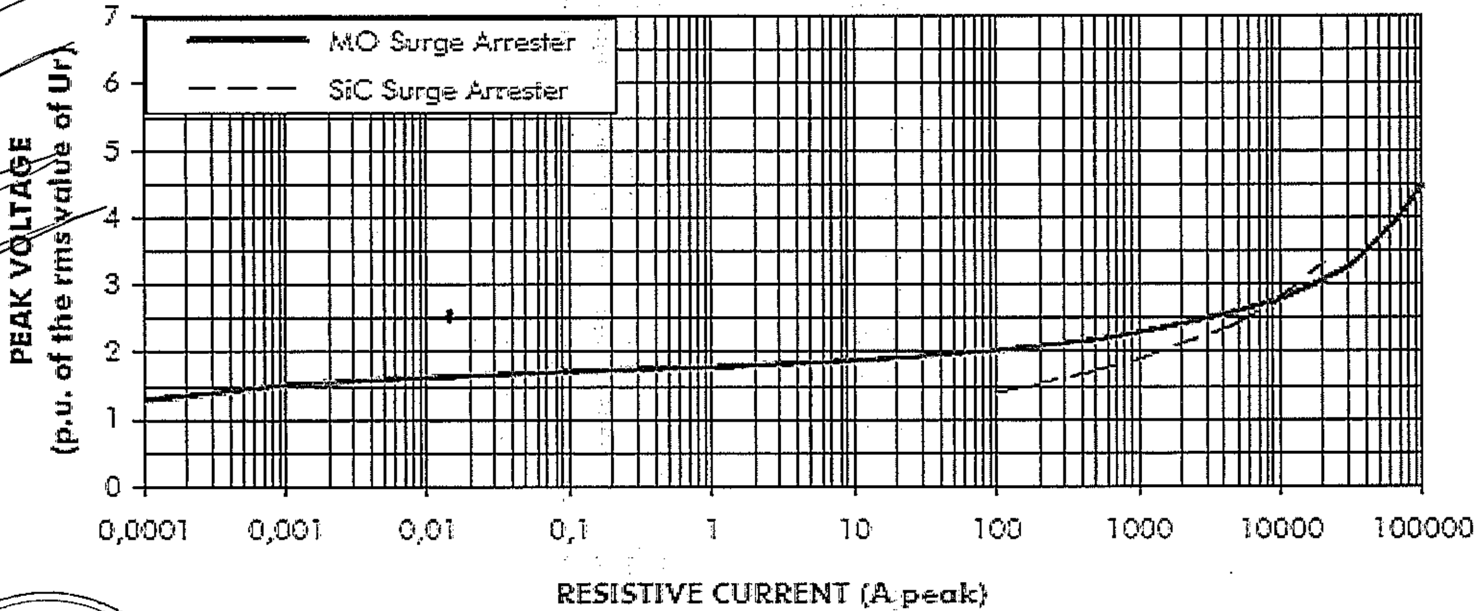


cyf

693

TRIDELTA Parafoudres S.A.

COMPARISON OF CURRENT vs VOLTAGE CHARACTERISTIC CURVES for MO and SiC SURGE ARRESTERS having the same protective level



694

TRIDELTA Parafoudres S.A.

CHARACTERISTICS OF TRIDELTA VARISIL™ Type HE SURGE ARRESTERS

TYPE	HE 05	HE 06	HE 09	HE 10	HE 12	HE 15	HE 18	HE 21	HE 24	HE 27	HE 30	HE 33	HE 36
Rated voltage Ur (kV rms)	5	6	9	10	12	15	18	21	24	27	30	33	36
Continuous Operating Voltage Uc (kV rms)	4.25	5.1	7.65	8.4	10.2	12.7	15.3	17.5	20	22.5	25	27.5	30
Maximum residual voltage at In (kV)	15.2	16.4	28.1	29.3	32.8	43.3	49.1	59.7	65.1	76.8	81.1	92.8	97.5
Nominal discharge current In	10 kA with 8/20 bi-exponential waveshape												
High current impulse withstand (Energy absorption capability)	100 kA with 4/10 bi-exponential waveshape (4.0 kJ/kV of Ur)												
Long duration current impulse withstand (Energy absorption capability)	300 A with 2000 µs rectangular waveshape (2.0 kJ/kV of Ur)												
Short circuit withstand	20 kA / 0.2 s - 600 A / 1 s												
Leakage distance	480 mm					650 mm		800 mm		1200 mm			

TRIDELTA Parafoudres S.A.

3 ДОПЪЛНИТЕЛНИ ЧАСТИ ЗА ВЕНТИЛНИ ОТВОДИ VARISIL™ тип HE

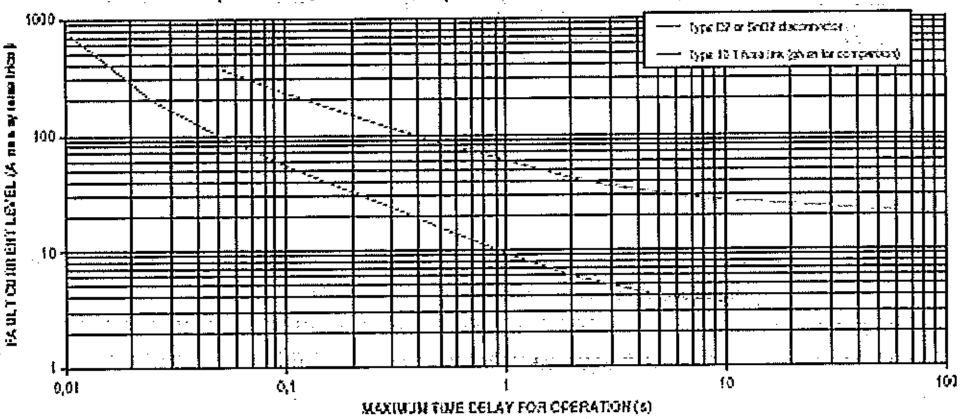
3.1 Прекъсвач или индикатор за повреда

Прекъсвач

Прекъсвачът е устройство, позволяващо автоматично да се отвори връзката на вентилния отвод към земята.

В случай на повреда на вентилния отвод, вътрешното пиротехническо устройство сработва заради възникналия електрически и термален ток при късо съединение. Модулът изключва и така прекъсва връзката на вентилния отвод към земята, предотвратявайки поддържане на повредата. Благодарение на това устройство се осигурява непрекъснатост на работата.

OPERATION CHARACTERISTIC CURVE of Type D2 or SnD2
DISCONNECTING DEVICE Intended for VARISIL surge arresters
(also refer to CESI Test Report ref. A5/020072 dated April 27, 2005)



Техническо усъвършенстване :

Отсега нататък ние ще интегрираме функцията на прекъсване в изолационната поддържаща конзола, за да се оптимизира монтажа и функционирането на вентилния отвод.

В частност, повишено е нивото на устойчивост към импулсния ток.

TRIDELTA Parafoudres S.A.

Характеристики на прекъсвач SnD2 :

Гаранция за функциониране под 20 mm лед.

Чувствителност към ток при късо съединение:

20 A eff. / 0,4 s maximum
10 A eff. / 1 s maximum
5 A eff. / 3 s maximum

Устойчивост към импулсен ток :

Вълна на мълния *4/10* :	**> 2 последователни импулса от 100 kA**
Вълна на превключване *30/80* :	**> 2 последователни импулса от 35 kA**
Правоъгълна вълна *2000 µs* :	**> 5 последователни импулса от 300 A**

Приложения :

При стандартна доставка с модел S1D2 се оборудват VARISIL ™ HE, HEL и HE-S при разчетно напрежение до 18 kV, а с модел S3D2 се оборудва от 21 kV.

TRIDELTA Parafoudres S.A.

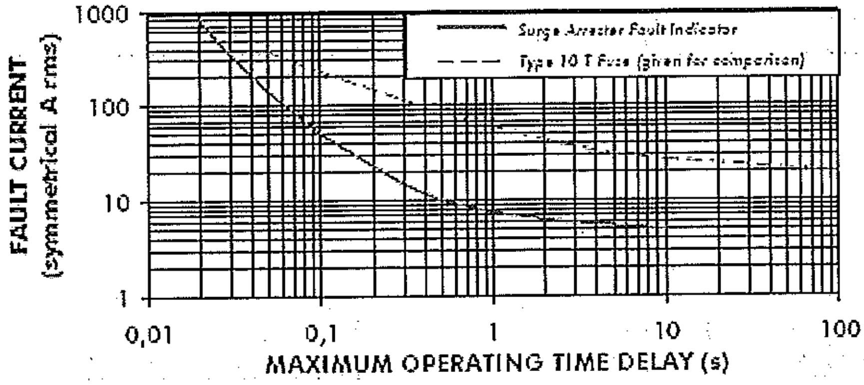
Индикатор за повреда

Когато операторът иска непрекъснатост на защитата, то всеки повреден вентилен отвод трябва да остане включен в мрежата, за да се поддържа защитата.

Опцията "IF" включва модул на индикатор за повреда. В случай на натоварване, надвишаващо способността на вентилния отвод за поглъщане на енергия, токът във веригата на късо съединение предизвиква появата на червен сигнал. Така всеки повреден вентилен отвод може да бъде лесно открит от значително разстояние.

Чувствителността е 10 A / 0.5 s. Тази опция се препоръчва за мрежи с ниски токове на късо съединение (условия на заземяване с изолирана или компенсирана неутрална точка).

SENSITIVITY OF THE FAULT INDICATOR INTENDED FOR VARISIL Type HE Version IF SURGE ARRESTERS



3.2 Конзола и накрайници

3.2.1 Конзола

<u>*-Индивидуална конзола*</u> (по 1 елемент за всеки вентилен отвод) : стандартна конзола NEMA за монтиране върху траверса.

3.2.2 Накрайници

<u>- опция *"NO" и "SnD2"*</u> : M12 болт, пружинна шайба и скоба от страната на линията / M12 болт, пружинна и плоска шайба от страната на земята;

<u>- опция *"IF"*</u> : M12 болт, пружинна шайба и стяга от страната на линията / M16 щифт, пружинна и плоска шайба от страната на земята.

TRIDELTA Parafoudres S.A.

4 ПРОЦЕДУРА ЗА ИЗБОР НА ВЕНТИЛЕН ОТВОД VARISIL™ тип HE

Изборът на подходящ вентилен отвод се базира върху четири параметъра:

- Номинален разряден ток ;
- Защитно ниво ;
- Постоянно напрежение фаза-земя на мрежата;
- Временно свръхнапрежение в мрежата при условия на повреда.

4.1 Номинален разряден ток

Стандартите IEC 60099-4 и IEEE C62.11 дефинират два основни типа вентилни отвода за разпределители мрежи: :

- 5 kA / нормален режим на работа, отнасящ се до върхова стойност на токовия импулс от 65 kA ;
- 10 kA / тежък режим на работа, отнасящ се до върхова стойност на токовия импулс от 100 kA.

Изборът на съответен тип зависи от нивото на гръмотевичните бури в района на монтаж, т.е. от честотата на мълниите и нивото на тока при удари от мълния. В тропическите райони има по-високо ниво на гръмотевични бури, поради това там се нуждаят от вентилни отводи 10 kA. За умерените райони обикновено са подходящи вентилни отводи 5 kA, но при по-сурови местни условия може да са необходими от тип 10 kA (например при планини).

В следващия пример ние ще изберем вентилен отвод VARISIL™ тип HE, който е от тип 10 kA / тежък режим на работа.

4.2 Защитно ниво

Предназначението на вентилния отвод е да се предотврати възпламеняване или пробив на изолацията на оборудването. За да се провери дали това изискване действително е изпълнено, трябва да се сравнят две стойности:

- устойчивост на изолацията на оборудването при 1.2/50 импулсно напрежение при удар от мълния (BIL или LIWL);
- остатъчно напрежение на вентилния отвод при номинален разряд (Up).

За да се имат предвид възможни по-високи разрядни токове, както и дължината на свързващите проводници, препоръчва се да има минимално съотношение от 1.4 между тези две стойности, т.е. да се поддържа коефициента на надеждност над 40 %.

<u>1-ви критерий</u>
Up < BIL / 1,4

Всички вентилни отводи, отговарящи на това изискване могат да бъдат взети от таблицата на стр. 14.

Примерът се отнася до мрежа с 11 kV системно напрежение и BIL от 75 kV. Първият критерий се отнася до всички вентилни отводи VARISIL™ тип HE, които имат защитно ниво по-ниско от 75 / 1.4 = 53 kV, т.е. с разчетно напрежение Ur <= 18 kV.

4.3 Постоянно напрежение фаза-земя на мрежата

При нормални условия, постоянното оперативно напрежение Uc на вентилния отвод трябва да бъде по-високо от максималното напрежение фаза-земя в мрежата.
Трябва да се знае максималното системно напрежение Um .

<u>2-ри критерий</u>
Uc > Um / 1,732

В нашия пример максималното системно напрежение е 12 kV, което води до максимално напрежение фаза-земя от 12 / 1.732 = 6.9 kV.
Всички вентилни отводи VARISIL™ тип HE, които имат Ur >= 9 kV отговарят на това изискване.

4.4 Временни условия на свръхнапрежение

При условие на повреда на една фаза, напреженията фаза-земя са небалансирани. Способът на заземяване в неутрална точка в подстанцията оказва влияние върху действителните напрежения, прилагани към вентилни отводи, които са свързани със здрави фази.

4.4.1 Способ на заземяване в неутрална точка

Могат да се използват 4 способа на заземяване в неутрална точка:

- твърд;
- импедансен (резисторен и/ или индукционен);
- изолиран;
- компенсиран (бобина на Петерсен).

Факторът на заземяване Kd характеризира небалансираното въздействие. Това е съотношението между максималното напрежение фаза-земя, прилагано към здрави фази при повреда на една фаза и максималното напрежение фаза-земя при нормални условия (Um / √3).

Той може да бъде установен от характеристики на мрежата като например: мощност на веригата при късо съединение, съпротивление на земята, импеданс на трансформаторите и линията и т.н.

TRIDELTA Parafoudres S.A.

Типичните стойности на този фактор са дадени в таблицата по-долу:

Свързване в неутрална точка	Kd
твърдо заземяване	< 1.4
чрез импеданс	1.4 à 1.73
изолирано	1.6 à 1.8
чрез бобина на Петерсен	1.73 à 1.9

Операционното време на закъснение на прекъсвача на веригата също трябва да се има предвид.
В долната таблица са дадени типичните данни за прекъсване:

Свързване в неутрална точка	Време на реакция
твърдо заземяване	0.1 до 0.5 s
чрез импеданс	0.2 до 1 s
изолирано	0.5 до 8 h
чрез бобина на Петерсен	0.5 s постоянно

Временното свръхнапрежение (TOV), прилагано към вентилните отводи ще бъде различно в зависимост от способа на заземяване в неутрална точка.
Производителите трябва да предоставят крива за устойчивост към временно свръхнапрежение TOV, която характеризира работата на вентилните отводи при подобни натоварвания.
Кривата на стр. 21 се отнася до вентилните отводи VARISIL™ тип HE.

Подходящите вентилни отводи трябва да бъдат избрани както следва:

3-и критерий
• Умножете максималното напрежение фаза-земя в мрежата (Um/1.732) по фактора Kd.
• От кривата TOV, определете напрежението, което трябва да се издържи (k x Ur) при максимална продължителност на състоянията на повреда.
• Изчислете необходимия минимум на разчетното напрежение Ur.

В примера неутралната точка е свързана към земята чрез импеданс, с фактор на заземяване 1.55 и максимална продължителност на повредата 1 s.
- *Kd = 1.55 : временно свръхнапрежение = 6.9 x 1.55=10.7 kV*
- *k за 1 s : k = 1.14 m.e. Ut = 1.14 x Ur*

Критерий за избор : 1.14 x Ur > 10.7 m.e. Ur > 9.4 kV.
Минималното разчетно напрежение, необходимо за вентилия отвод е Ur = 10 kV.

701

TRIDELTA Parafoudres S.A.

4.4.2 Долно съпротивление на опората

Ако съпротивлението на земята на някои места е високо, то поведението на системата е като че ли неутралната точка е била заземена чрез висок импеданс. Тогава изчисленията трябва да се направят със съответно завишен фактор Kd (виж точка 5.2 за повече информация).

<u>Краен избор</u>

Ако повече от един отвод отговаря и на трите критерия, то тогава трябва да бъде предпочетен вентилният отвод с най-ниско разчетно напрежение, за да се подобри работата по защитата.

Само специални местни условия (високо долно съпротивление, явления на феророзонанс) биха могли да оправдаят избора на по-високо разчетно напрежение.

В примера :

1-ви критерий : Ur <= 18 kV
2-ри критерий : Uc > 6.9 kV
3-ти критерий : Ur > 9.4 kV

Могат да бъдат използвани 4 модела : разчетни напрежения от 10 kV, 12 kV, 15 kV или 18 kV.
Вентилен отвод 10 kV следва да бъде предпочетен, тъй като осигурява най-ниско защитно ниво.

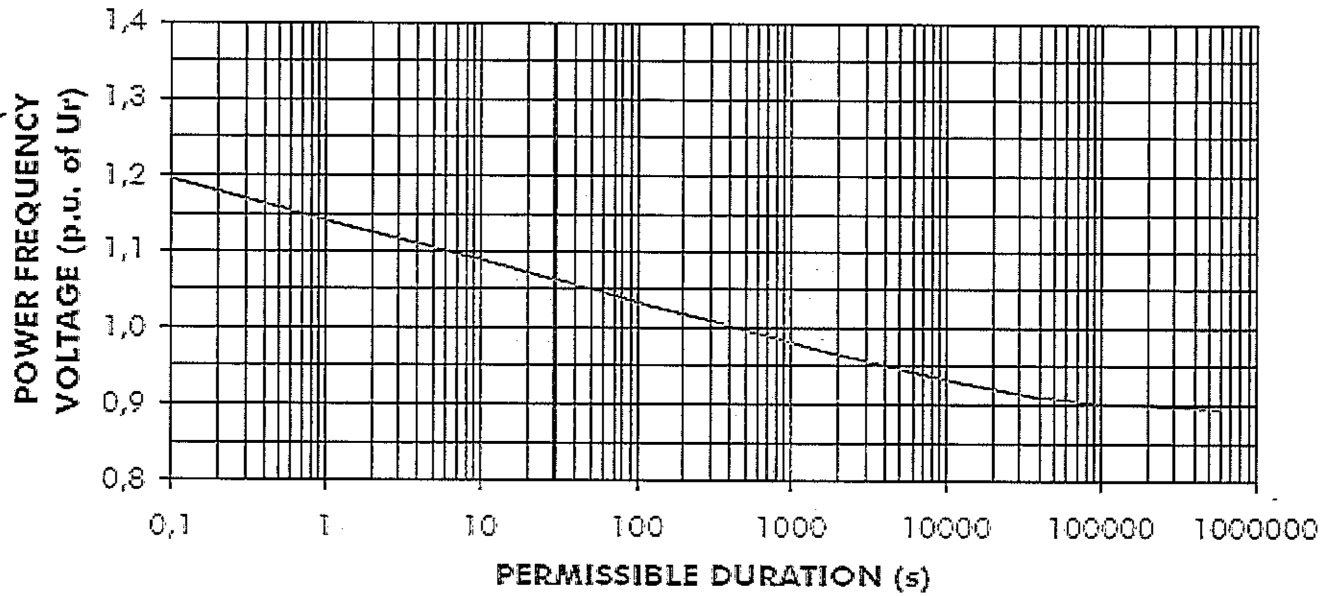
<u>Забележка</u> : За разпределителна мрежа с високо локално земно съпротивление (фактор на заземяване 1.732), критерият за избор по-скоро ще насочи към разчетно напрежение 12 kV.

В таблицата на стр. 23 са посочени типичните разчетни напрежения, които се използват при най-често срещаните системни напрежения.

702

TRIDELTA Parafoudres S.A.

MINIMUM OVERVOLTAGE WITHSTAND CAPABILITY of VARISIL Type HE SURGE ARRESTERS according to Annex D of IEC 60099-4



703

TRIDELTA Parafoudres S.A.

SIMPLIFIED GUIDE for the selection of the rated voltage Ur of VARISIL™ Type HE surge arresters

Depending on the neutral point grounding conditions, the more severe stresses are either of continuous or temporary type.

Nominal system voltage Un (kV)	6	10	11	13.8	15	20	22	30	33
Maximum system voltage Um (kV)	7.2	11	12	15	17.5	22	24	33	36
Solidly earthed neutral point	6	9	10	12	15	18	21	27	30
Grounding through impedance	9	*10 / 12*	12	15	18	*21 / 24*	24	33	36
Isolated neutral point	9	12	15	*15 / 18*	18	24	27	36	—
Grounding through Petersen coil	9	12	15	18	21	*24 / 27*	27	—	—

Забележка : Стойностите в червено е необходимо да бъдат проверени в съответствие с действителния фактор на заземяване или / и с максималната продължителност на повредата.

704

TRIDELTA Parafoudres S.A.

5 ПРЕПОРЪКИ ЗА ИНСТАЛИРАНЕ

За да се получи ефективна защита срещу свръхнапрежение, необходимо е да се поддържа минимално съотношение от 1.4 между изолационното ниво (BIL или LIWL) на оборудването и защитното ниво (Up) на вентилния отвод като се имат предвид дължината на свързващите проводници и възможните по-високи разрядни токове.

5.1 Дължина на свързващите проводници

Обикновено се счита, че специфичната индуктивност на кабелите е около 1 μH/m.

При 40 kA (средна стойност) на токов импулс при мълния с форма на вълната 4/10 индукционното напрежение Ui е :

$U_i = L \times di/dt = 1\ \mu H/m \times 40\ kA / 4\ \mu s$ т.е. $U_i = 10\ kV/m$ от дължината на кабела.

При по-висока степен на повишаване или при върхови стойности (например 100 kA), тази стойност би могла да бъде много по-голяма (до 25 kV/m или дори повече).

Препоръки

Дължината на свързването, която трябва да се има предвид представлява общата дължина, където протича разрядния ток, т.е. дължината на проводниците между вентилния отвод и точката на свързване към линията, както и между вентилния отвод и общата точка на свързване към земята.

Обичайна практика е при монтаж на опората е да се свърже заземената страна на вентилния отвод към клемата за заземяване на корпуса на трансформатора, който се инсталира отдолу. Това би следвало да се избягва, за да се подобри ефективността на защитата срещу свръхнапрежение. Вместо това силно се препоръчва клемата за заземяване на корпуса на трансформатора директно да се свърже към заземената точка на закрепване на вентилния отвод. Най-малко 10 kV могат да бъдат спестени при този способ на свързване към земята.

Колкото по-къси са свързващите проводници, толкова по-добра е защитата срещу свръхнапрежение.

5.2 Долно съпротивление на опората

Условия при мълния

Ако омното съпротивление на местната почва е доста голямо (минерални характеристики на пръстта, липса на влага), напрежението в общата точка на заземяване между трансформатора и вентилния отвод достига много висока стойност при токови импулси от мълния.

705

TRIDELTA Parafoudres S.A.

В този случай, основната опасност е да се получи искрене между корпуса на трансформатора и вторичните намотки (ниско напрежение с твърдо заземена неутрална точка и подлежащо на разпределение). Независимо от номиналното напрежение, вентилните отводи за разпределителни мрежи не са предназначени да се справят с подобно явление. Все пак, един въздушен искроразрядник, свързан между неутралната точка на ниското напрежение и корпуса трансформатора може да реши този проблема.

Условия на повреда

При условия на повреда в самата система (повреда в заземяването или изолацията), стойността на тока при късо съединение остава доста ниска, тъй като се ограничава от високото омно съпротивление на земята.

В този конкретен случай, вентилните отводи свързани към здрави фази ще бъдат много повече натоварени от гледна точка на напрежение. Тогава следва да се предпочете възможно най-високото разчетно напрежение (фактор на заземяване в по-висок диапазон на стойностите, виж точка 4.4.2).

В заключение се препоръчва съпротивленията на заземяване да бъдат възможно най-ниски. В конкретния случай, при монтиране на опората, долното съпротивление не трябва да надвишава 30 Ω.

5.3 Отстояния

При етапа на инсталиране трябва така да се отчитат луфтовете, че да се гарантира правилна работа на вентилните отводи VARISIL™ тип HE .

Разстоянията между активните части на вентилните отводи и който и да е заземен елемент (разстояние d) както и между активните части на вентилните отводи, свързани към близките фази (разстояние D) следва да бъдат внимателно проверявани.

В долната таблица са препоръчани отстояния в съответствие с разчетното напрежение.

Type HE	05	06	09	10	12	15	18
d (mm)	46	50	86	89	100	132	150
D (mm)	50	54	92	96	108	143	163

Type HE	21	24	27	30	33	36
d (mm)	182	199	234	247	283	297
D (mm)	199	217	258	272	313	330

TRIDELTA Parafoudres S.A.

5.4 Електрически връзки

5.4.1 Свързване към земята

При вентилните отводи VARISIL™ тип HE, които са снабдени с разединително устройство (опция "SD"), трябва да се използва меден кабел (гол или изолиран) с минимум напречно сечение 16 mm² за свързване към земята. Кабел без кабелен накрайник може да се използва при условие, че диаметърът не надвишава 15 mm : при това положение той може директно да се закрепи като се използва доставената метална скоба.
Този кабел трябва да бъде гъвкав и достатъчно дълъг, за да се осигури необходимия луфт в случай, че разединителят работи. Важно е също така да се провери, че никой елемент не може да попречи на движението на кабела при подобни условия.
При вентилните отводи VARISIL™ тип HE имащи или опция "NO" или опция "IF", свързването към земята следва да се извърши чрез заземяване на монтажната конзола.

5.4.2 Свързване към линията

Свързването на вентилните отводи VARISIL™ тип HE към линията трябва да се извърши или чрез меден или чрез алуминиев кабел (голи или изолирани) с минимум напречно сечение 16 mm². Този кабел следва да се свърже към линейния извод M12 на вентилния отвод. Кабел без кабелен накрайник може да се използва при условие, че диаметърът не надвишава 15 mm : при това положение той може директно да се закрепи като се използва доставената метална скоба.
Препоръчва се също така, към вентилния отвод да не се прилага значителен механичен натиск чрез повишено натоварване на линейния кабел.

5.4.3 Сили на затягане

Силите, прилагани за затягане на болтовете и/или гайките на вентилните отводи VARISIL™ тип HE, никога не трябва да надвишават :

- **20 N.m** за M12 накрайници (приложими към всички опции);
- **30 N.m** за M16 накрайници (опция "IF")

5.5 Опаковка

Вентилните отводи VARISIL™ тип HE са опаковани в отделни сандъци, които могат лесно да се отворят без да са необходими инструменти.

707

5.5.1 Обработка и транспорт

Благодарение на мекия полимерен корпус на вентилните отводи VARISIL™ тип НЕ с тях може да се борави с по-малка предпазливост от тази, която се изисква за устройствата с порцеланов корпус. Все пак, трябва да се обърне внимание да се избягва повреждане на:

- полимерния корпус (срязване или разкъсване с остри предмети);
- свързващите болтове и шпилките с резба;
- допълнителните части, ако има такива (изолационна конзола, прекъсвач или индикатор за повреда).

Ако бъдат повредени тези части те могат да попречат на правилния монтаж и/или работа. Препоръчва се, вентилните отводи да останат в оригиналния им сандък до тяхното инсталиране.

5.5.2 Съхранение

Преди употреба вентилните отводи трябва да се държат в тяхната оригинална опаковка. Сандъците следва да се съхраняват в закрити помещения при температура на въздуха в границите на – 20 °C ÷ + 70 °C.

5.5.3 Поддръжка

VARISIL ™ тип НЕ вентилните отводи не изискват техническа поддръжка.

Ако се използват вентилни отводи с разединително устройство (опция "SnD2"), препоръчва се на оператора да извършва периодични проверки на самия терен, за да открие някой вентилен отвод, който може да се е изключил (падане на заземяващия кабел) и да го подмени колкото е възможно по-скоро.
В случай на изключване, следва да се подмени целият комплект (елементът на вентилния отвод / изолационната конзола / модулът за разединяване).

TRIDELTA Parafoudres S.A.

6 СТАНДАРТИ И ТЕСТОВЕ

Номенклатурата на VARISIL™ тип HE вентилни отводи изпълнява всички съответни изисквания на IEC.

6.1 Еталонен стандарт

IEC 60099-4 : "Вентилни отводи / Част 4 : Метало-оксидни вентилни отводи без междини за системи с променлив ток „– 2-ро издание.

6.2 Други приложими стандарти

ANSI/IEEE C62.11 : "IEEE стандарт за метало-оксидни вентилни отводи за енергийни вериги с променлив ток."

IEC 60071-1 : "Свързване на изолацията / Част 1 : Дефиниции, принципи и правила".

IEC 60099-5 : " Вентилни отводи / Част 5 : Препоръки за избор и приложение".

IEC 60270 : "Измервания на частичния разряд".

IEC 60507 : "Тестове при изкуствено замърсяване на високоволтови изолатори, които ще се използват в системи с променлив ток".

IEC 60815 : "Ръководство за избор на изолатори във връзка с условията на замърсяване".

IEC 61109 : "Комбинирани изолатори за надземни проводници с променлив ток с номинално напрежение над 1000 V – Дефиниции, методи за тестване и критерии за приемане".

6.3 Типови тестове

Всички типови тестове са извършени в CESI (Centro Elettrotecnico Sperimentale Italiano), независима лаборатория, намираща се в МИЛАНО - Италия.

Таблица с проведените типови тестове и съответните тестове са на разположение при поискване.

709

TRIDELTA Parafoudres S.A.

6.4 Тестове за приемане на стандарт

В таблицата по-долу са дадени тестовете за приемане на стандарт, които се изискват по IEC 60099-4 :

Test description	Clause of IEC 60099-4	Test samples
Measurement of the reference voltage at 1 mA peak AC	§ 9.2.1.a	Surge Arresters
Measurement of the lightning residual voltage at 10 kA	§ 9.2.1.b	MOV blocks
Measurement of the partial discharge level	§ 9.2.1.c	Surge Arresters

6.5 Рутинни тестове

В таблицата по-долу са посочени рутинните тестове, които се извършват при производството на вентилните отводи VARISIL™ тип HE :

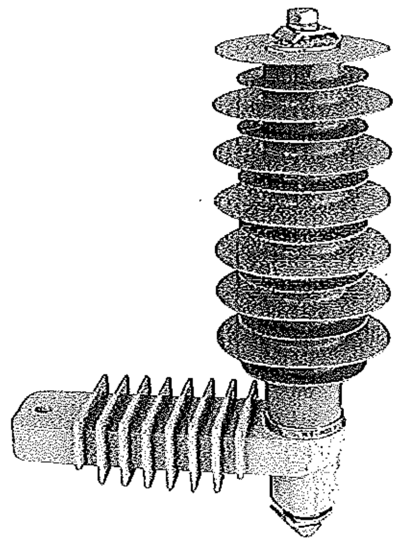
Test description	Clause of IEC 60099-4	Test samples
Measurement of the voltage at 1 mA	Not required	MOV blocks
Measurement of the lightning residual voltage at 10 kA	§ 9.1.b	MOV blocks
Verification of the energy absorption capability (2 shots at 300 A / 2000 µs)	Not required	MOV blocks
Measurement of the reference voltage at 1 mA peak AC	§ 9.1.a	Surge arresters
Verification of the absence from partial discharge and contact noise (1)	§ 9.1.c	Surge arresters

(1) Този тест се провежда в същото време, когато се измерва еталонното напрежение.

TRIDELTA Parafoudres S.A.

Surge Arresters for Distribution Systems

VARISIL™ Type HE



Presentation and Technical Guide

January 2010

TRIDELTA Parafoudres S.A.

Contents

713

TRIDELTA Parafoudres S.A.

VARISIL™ Type HE SURGE ARRESTERS

FOREWORD

Whatever the system voltage, power supply networks are stressed by transient overvoltages which often damage the equipment (power transformers, underground cables, ...) because of their high level.

There are two main types of overvoltages :

- overvoltages with internal origin, i.e. caused by operation or layout of the network (switching surges, resonance phenomena, ...)
- overvoltages with external origin, i.e. generated by external phenomena among which lightning is the most important.

On power Medium Voltage networks (Distribution networks), overvoltages due to lightning strokes prove to be the most energetic stresses, whether they are caused by direct strokes (overvoltages due to galvanic coupling) or, at a lower rate, indirect strokes (overvoltages due to capacitive and/or inductive coupling).
Their level may reach several hundreds of kilovolts and then far exceed the insulation withstand of the equipment. These overvoltages may then cause the equipment insulation to flashover or/and to puncture if no suitable surge protection device has been previously installed.

In case such a problem actually occurs, operators might regret not to have invested in surge arresters whose cost is far less than that of damaged equipment.

TRIDELTA Parafoudres S.A.

1 SURGE ARRESTERS

1.1 Protective devices

There are two main types of protection devices for Distribution networks : air spark gaps and surge arresters.
These are generally connected between phase and earth so as to create a weak point in the system insulation and thus ensure the overvoltage protection of the equipment against induced or direct surges.

Spark gaps are still widely used to protect air insulated equipment or when a low insulation level is not needed.
However, to improve quality of service, higher performance is required and surge arresters are necessary. Two technologies of surge arresters are available :

- **SiC surge arresters** : their active stack is an assembly of elementary air gaps and non linear silicon carbide resistors which are connected in series
- **MO surge arresters** : their active stack is only made of non linear metal oxide resistors.

The MO technology appeared in the early 70's and provides better performance than SiC. Therefore SiC surge arresters have been progressively replaced by MO surge arresters whose latest polymer housed design is now widely used throughout the world.

1.2 Air spark gaps

The air spark gap is the elder, the simpler and the cheaper surge protection device.

Design
It is generally made of two electrodes : the first one is connected to the line side of the equipment to be protected and the second one is earthed.

Operating principle
The air gap between these two electrodes is a weak point in the network insulation. The air distance can be set in order to adjust the sparkover voltage to the required value.

Protective level
The protective level of a spark gap is the maximum sparkover voltage under the standard 1.2/50 lightning voltage impulse.

Advantages and drawbacks

Even though spark gaps are very cheap, very strong and can be easily set, they suffer from a lot of disadvantages whose main are :

- once sparkover occurs, the power arc is not able to extinguish spontaneously, so that the circuit breaker has to operate in order to clear the fault current
- sparkover leads to a waveshape with cut tail, which may cause close winding equipment to fail.
- the sparkover voltage depends on climatic conditions (temperature, humidity, ...) and also on the front rise of the overvoltage. In case of steep front of wave, the voltage actually applied to the equipment may be much greater than the sparkover voltage itself (response time), which could also lead to unexpected failure.

1.3 Gapped Silicon Carbide Surge Arresters (SiC)

SiC surge arresters have got rid of some of the drawbacks of the air spark gaps. The principle was to use a non linear resistance in series with the air gap in order to prevent a high power current to flow during operation. Silicon carbide was the first material with a high non linear factor suitable to such an application.
Non linear resistors are made of SiC grains, pressed into discs with metallised faces for improved electric contact.

Design

Because silicon carbide has non-linear properties on a limited range of current density values, a gapless device would fail immediately under the normal phase-to-earth voltage. Air gaps are compulsory to isolate the discs under normal conditions.
Therefore, the core of silicon carbide surge arresters is made of SiC resistors in series with several elementary air gaps. This core is enclosed in a porcelain housing filled with dry air or nitrogen. An appropriate sealing system prevents moisture ingress as performance and reliability are very sensitive to humidity.

Operating principle

Under the nominal phase-to-earth voltage, the air gaps isolate the surge arrester. In case of overvoltage exceeding the sparkover voltage of the gaps assembly, a current impulse flows through the SiC resistors whose resistance decreases as the current increases (non linear property), which limits the actual overvoltage level. Once the surge energy has been absorbed, the surge arrester remains conductive till the applied voltage reaches zero at the latest : the resistance of SiC resistors is then high enough to clear the current and to re-isolate the surge arrester.
Thanks to the non linear resistance of their SiC resistors, silicon carbide surge arresters are able to limit overvoltages while respecting the continuity of supply requirements.

716

Protective level
The protective level of a silicon carbide surge arrester is defined as the maximum value among :
- 1,2/50 lightning impulse maximum sparkover voltage
- front-of-wave maximum sparkover voltage divided by 1.15
- maximum residual voltage at the nominal discharge current.

Remaining disadvantages
Even though they allow to avoid most of the drawbacks of single spark gaps, SiC surge arresters still have some :
- once the overvoltage has been limited, a power frequency current still flows (called "follow current", which can reach a hundred amps or more) till the applied voltage reaches zero, that is during half a cycle in the worst case.
- although the series air gaps are enclosed in a tight housing, the sparkover voltage is sensitive to external voltage distribution along the porcelain housing which is modified by environment stresses (rain, salt fog, ...).

1.4 Gapless Metal Oxide Surge Arresters (MOSAs)

In the 60's, non linear resistors made of metal oxides were designed for the protection of electronic equipment. Ten years later, MO surge arresters intended for Medium Voltage applications were intoduced.
These were characterized by two main advantages :
- a very high non linear factor on an extended range of current density values
- a far higher energy absorption capability than SiC surge arresters

Design
The high non-linearity on an extended range of current allows to remove the air gaps. The MO resistors are enclosed into a tight housing which used to be of porcelain type. The porcelain housing must be equipped with a pressure relief system to avoid shattering in case of internal failure (subsequent to a very high lightning stress for instance).
More recently, manufacturers have replaced this traditional porcelain housing by a polymeric housing with appropriate properties so as to withstand climatic stresses and ensure tracking resistance. To get the required mechanical strength for the surge arrester (which was formerly obtained by the porcelain housing itself), the metal oxide resistors are now wrapped in a fibreglass reinforced resin.
The manufacturing process of the MO resistors (also called "MOV blocks") requires a strong experience to get the expected performance and reliability. A particular care is necessary during the manufacture processes. A block is made of zinc oxide (90 %) mixed with others metal oxides (Bismuth, Cobalt, Manganese, ...). The formula (chemical composition) and the processes (especially the sintering cycle) are carefully checked in order to guarantee high quality and reliability levels.

Operating principle
The main advantage of a MO resistor is the highly non linear current vs voltage characteristic curve (see curve on page 13).
Under the nominal phase-to-earth voltage, the impedance of a MO surge arrester is very high so that the leakage current is very low (typically less than 0.1 mA).
When an overvoltage appears, the ohmic resistance decreases very quickly in order that the surge current flows to the earth and the overvoltage level is limited. The non-linear factor is so high that between 0.1 mA and 10 kA the voltage is only doubled.

Protective level
The protective level of a metal oxide surge arrester is defined as the maximum residual voltage at the nominal discharge current.

Dimensioning
Selection of an appropriate surge arrester (i.e. define the suitable rated voltage) is based on considerations having opposite trends :

- optimize the protection provided, but the lower the protective level the lower the rated voltage
- ensure the withstand to applied voltages, but the higher the voltage withstand the higher the rated voltage

The complete procedure for selection is exposed in section 4.

In any case, the surge arrester changes electrical energy into thermal energy. When electrically stressed, the internal temperature of MO resistors may increase very quickly. If the absorbed energy is higher than the heat dissipation capability, failure may occur by a thermal runaway phenomenon.

Line discharge class
The energy of switching surges depends on the system voltage. The higher the system voltage, the higher the stored energy due to capacitive behaviour of the network. In high voltage networks, the energy of some switching surges can even exceed that of lightning strokes.
Therefore, IEC 60099-4 standard defines line discharge classes (from 1 to 5) corresponding to increased energy absorption capability under switching surges. For Distribution networks, class 1 is usually used. Classes 2 and 3 are more commonly specified for system voltages ranging from 60 to 245 kV and classes 4 and 5 above.

Notes :

1. Line discharge class is only applicable to surge arresters having a nominal discharge current of 10 kA (classes 1 to 3) and 20 kA (classes 4 and 5).
2. Line discharge class 2 or 3 surge arresters may be required in Medium Voltage sub-stations in case of high reactive power (presence of capacitor banks for compensation purpose).

Main characteristics of a MO surge arrester

- The rated voltage (Ur) is the maximum permissible rms value of power frequency voltage which can be applied to the surge arrester during 10 s (i.e. temporarily) after absorption of the rated energy.
- The continuous operating voltage (Uc) is the maximum voltage which can be applied continuously to the surge arrester under given ambient conditions.
- The nominal discharge current (In) is the peak value of the standard 8/20 lightning current impulse which is used to classify a surge arrester. It can be either 5 kA, 10 kA or even 20 kA : the lightning protective level of the surge arrester is defined at this current value.
- The energy absorption capability can be given for the high current impulse withstand (4/10 lightning current impulse) or for the long duration current impulse withstand (duration and peak value according to line discharge class requirements).

Advantages of MO vs SiC surge arresters

Thanks to the high non-linearity and energy absorption capability of MO resistors, metal oxide surge arresters have many advantages over former silicon carbide technology :

- no follow current is absorbed
- the protective level is better controlled because it no longer depends on a sparkover voltage value which is submitted to fluctuations
- the residual voltage at high current values is much lower
- the behaviour under severe climatic conditions is well improved
- size and weight are far less.

Advantages of polymer housed MOSAs

This latest technology benefits by both the MO resistors and the polymeric housing performance. Such surge arresters still provide more advantages than conventional metal oxide surge arresters :

- the weight is about half the weight of the equivalent porcelain housed surge arresters, which facilitates both transportation and handling
- the dielectric strength is improved
- the safety is increased in case of failure since a violent shattering of the housing cannot occur
- the behaviour under very severe climatic conditions is much better thanks to the natural hydrophobicity and UV resistance of the polymer housing, especially if made of silicone rubber
- the reduced size allows installation closer to the equipment and in any position so as to improve the overvoltage protection.

Thanks to above significant advantages, polymer housed MOSAs prove to be ideal devices for surge protection of Distribution equipment.

2 TRIDELTA RANGE OF DISTRIBUTION METAL OXIDE POLYMER HOUSED SURGE ARRESTERS

2.1 VARISIL™ Type HE product range

VARISIL™ Type HE products are 10 kA metal oxide surge arresters for Distribution networks, specifically designed for areas with strong lightning exposure and high pollution level.
The range covers system voltages from 5.5 kV to 36 kV. Table on page 14 gives the main features of VARISIL™ Type HE surge arresters.
The range includes four different sizes which are respectively used for rated voltages up to 12 kV, 18 kV, 24 kV and 36 kV.

2.2 VARISIL™ Type HE design

The active part is made of MOV blocks wrapped in a fiberglass reinforced synthetic resin whose design is patented.
This core provides the mechanical resistance and is covered by a polymeric housing made of silicone rubber suitable to areas with high pollution level.

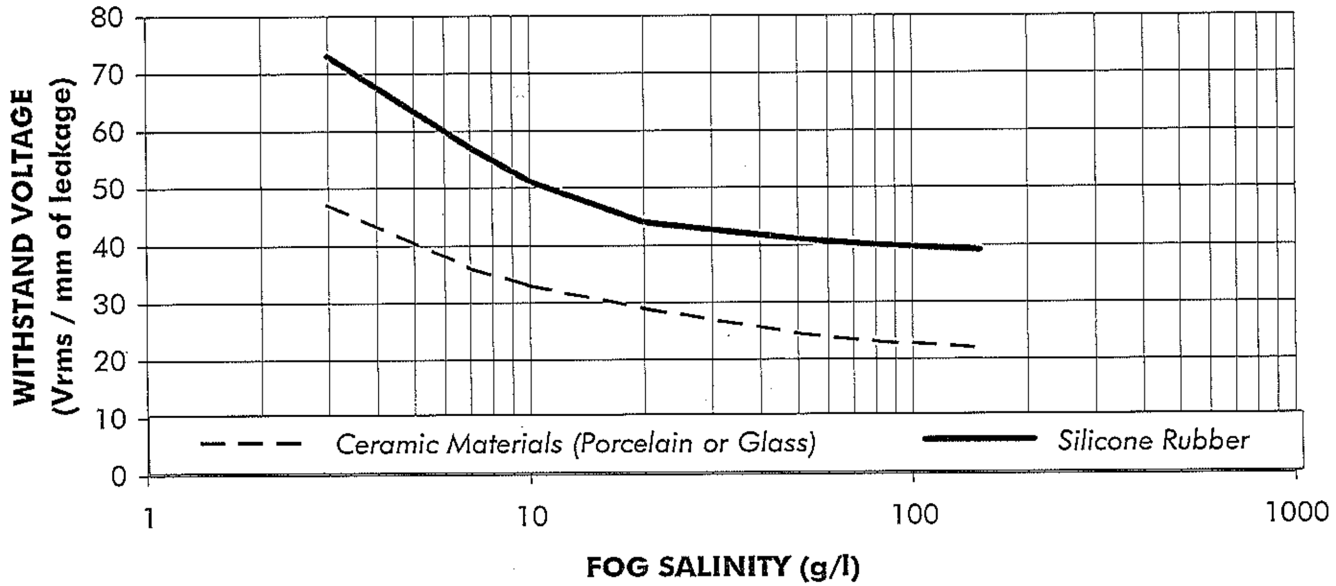
TRIDELTA MOV blocks
TRIDELTA manufactures its own blocks in recognized workshops.
The formula (chemical composition) and the processes (especially the sintering cycle) are carefully checked in order to guarantee a high quality and reliability levels.

Composite wrapping
The surge arrester body is made of a fiberglass reinforced synthetic resin whose design is patented. This frame ensures a perfect encapsulation of the MOV blocks and a safe behaviour under fault conditions.

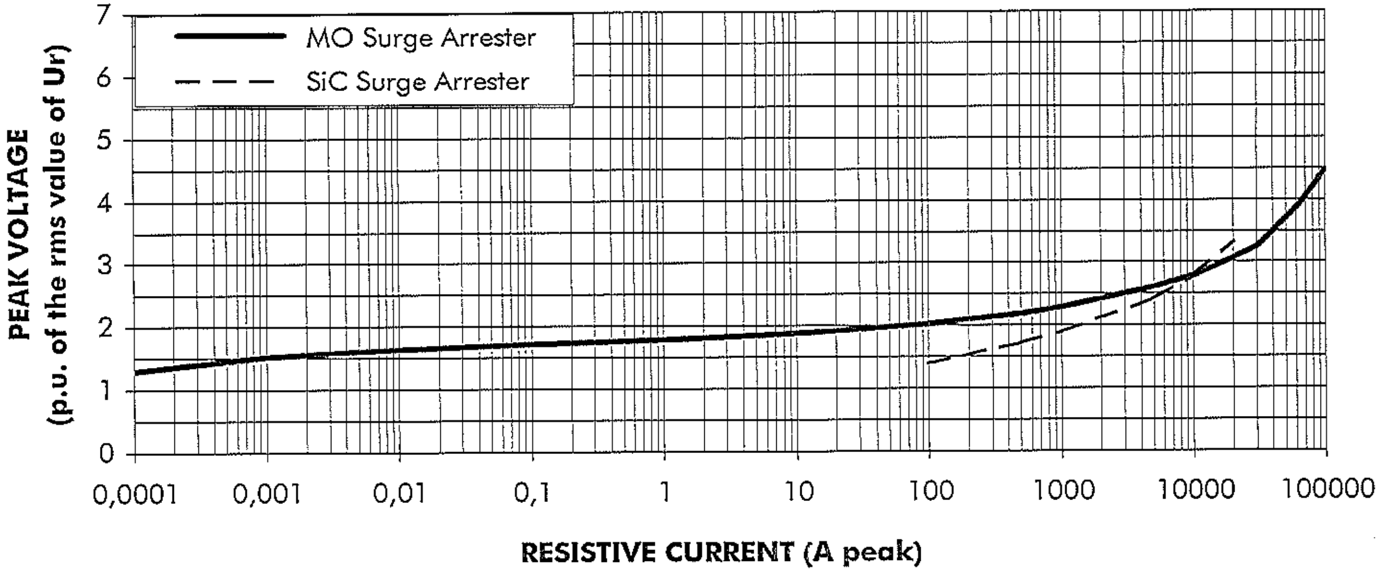
Silicone rubber housing
The silicone rubber used for external insulation has shown satisfactory performance in high voltage applications.
The key point to silicone rubber success in these applications is its ability to maintain a hydrophobic surface, even when contaminated, and to recover hydrophobicity if it is temporarily lost during periods of extreme electrical activity.
Hydrophobicity is the fact to capture water under spread drops of water avoiding any large surface conductive areas. In contaminated environments, silicone rubber has demonstrated significant advantages over ceramic materials such as porcelain with respect to flashover performance (see figure on page 12)

In addition, the outstanding resistance of silicone rubber to ultraviolet radiation, oxidation and ozone ensures that the material will remain functional through prolonged environmental exposure. This is mainly due to the fact that silicone rubber is an inorganic material with Silicon-Oxygen (Si-O) molecular links far less sensitive to UV radiation than carbon – carbon molecular links of EPM, EPDM and XLPE (Cross-linked Polyethylene).

COMPARISON OF FLASHOVER PERFORMANCE OF SILICONE RUBBER & CONVENTIONAL CERAMIC MATERIALS



COMPARISON OF CURRENT vs VOLTAGE CHARACTERISTIC CURVES for MO and SiC SURGE ARRESTERS having the same protective level



TRIDELTA Parafoudres S.A.

CHARACTERISTICS OF TRIDELTA VARISIL™ Type HE SURGE ARRESTERS

TYPE	HE 05	HE 06	HE 09	HE 10	HE 12	HE 15	HE 18	HE 21	HE 24	HE 27	HE 30	HE 33	HE 36
Rated voltage Ur (kV rms)	5	6	9	10	12	15	18	21	24	27	30	33	36
Continuous Operating Voltage Uc (kV rms)	4.25	5.1	7.65	8.4	10.2	12.7	15.3	17.5	20	22.5	25	27.5	30
Maximum residual voltage at In (kV)	15.2	16.4	28.1	29.3	32.8	43.3	49.1	59.7	65.1	76.8	81.1	92.8	97.5
Nominal discharge current In	10 kA with 8/20 bi-exponential waveshape												
High current impulse withstand (Energy absorption capability)	100 kA with 4/10 bi-exponential waveshape (4.0 kJ/kV of Ur)												
Long duration current impulse withstand (Energy absorption capability)	300 A with 2000 µs rectangular waveshape (2.0 kJ/kV of Ur)												
Short circuit withstand	20 kA / 0.2 s - 600 A / 1 s												
Leakage distance	480 mm					650 mm		800 mm		1200 mm			

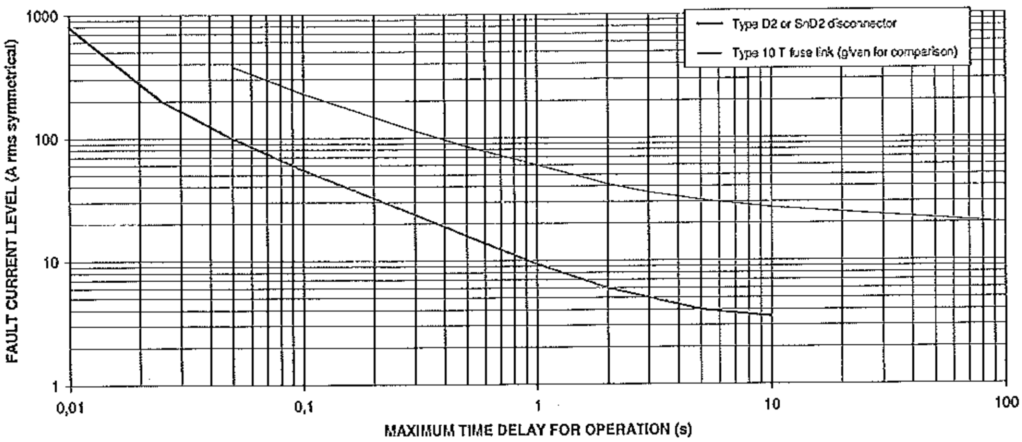
3 ACCESSORIES FOR VARISIL™ Type HE SURGE ARRESTERS

3.1 Disconnector or fault indicator

Disconnector

The disconnector is a device permitting to automatically open the connexion of the surge arrester to the earth .
In case of failure of the surge arrester, the internal pyrotechnic device operates due to the electrical and the thermal fault current which occurs. The module breaks and disconnects so the connexion of the surge arrester to the earth, avoiding the maintain of the fault. Thanks to this device, the continuity of service is favoured.

OPERATION CHARACTERISTIC CURVE of Type D2 or SnD2 DISCONNECTING DEVICE intended for VARISIL surge arresters (also refer to CESI Test Report ref. A5/020072 dated April 27, 2005)



Technical evolution :

Henceforth, we shall integrate the disconnecting function inside the insulating support bracket to optimize the installation and the functioning of the surge arrester
In particular, the immunity level to the impulse current has been increased.

TRIDELTA Parafoudres S.A.

Performances of the disconnector SnD2 :

Guarantee of functionning under 20 mm of ice

Sensitivity to fault current

20 A eff. / 0,4 s maximum
10 A eff. / 1 s maximum
5 A eff. / 3 s maximum

Immunity to impulse current :

Lightning wave *4/10* :	> **2 consecutive impulses of 100 kA**
Switching wave *30/80* :	> **2 consecutive impulses of 35 kA**
Rectangular wave *2000 µs* :	> **5 consecutive impulses of 300 A**

Applications :

As standard supply, the S1D2 model equips the VARISIL™ HE, HEL and HE-S with rated voltage up to 18 kV and the S3D2 model equips from 21 kV.

726

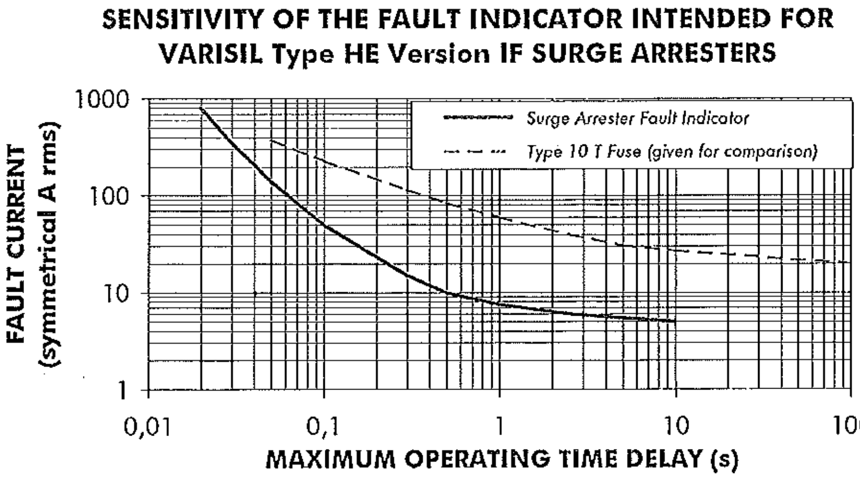
TRIDELTA Parafoudres S.A.

Fault indicator

Whenever the operator requests continuity of protection, each failed surge arrester has to remain connected to the network in order to maintain the protection.

The "IF" option includes a fault indicator module. In case of stress exceeding the energy absorption capability of the surge arrester, the short circuit current causes a red flag to appear. Any failed surge arrester can then be easily detected at a significant distance.

The sensitivity is 10 A / 0.5 s. This option is recommended for networks with low fault currents (isolated or compensated neutral point grounding conditions).



3.2 Bracket and terminals

3.2.1 Bracket

- *Individual bracket* (1 unit per surge arrester) : standard NEMA bracket for mounting on crossarm

3.2.2 Terminals

- *"NO" and "SnD2" option* : M12 bolt, spring washer and clamp at the line side / M12 bolt, spring and flat washers at the earth side
- *"IF" option* : M12 bolt, spring washer and line clamp at the line side / M16 stud, spring and flat washers at the earth side.

TRIDELTA Parafoudres S.A.

4 PROCEDURE TO SELECT A VARISIL™ Type HE SURGE ARRESTER

The selection of an appropriate surge arrester is based on four parameters :

- Nominal discharge current
- Protective level
- Continuous phase-to-earth voltage of the network
- Temporary overvoltage of the network under fault conditions

4.1 Nominal discharge current

IEC 60099-4 and IEEE C62.11 standards define two main types of Distribution surge arresters :

- 5 kA / Normal Duty relating to a high current impulse peak value of 65 kA
- 10 kA / Heavy Duty relating to a high current impulse peak value of 100 kA

Selection of the type depends on the keraunic level of the installation area i.e. the frequency and the current level of lightning strokes. Tropical regions have a higher keraunic level, thus needing 10 kA surge arresters. For temperate regions, 5 kA surge arresters are generally suitable, but more severe local conditions may require a10 kA type (mountains for instance).

In the following example, we will choose a VARISIL™ Type HE surge arrester which is of 10 kA / Heavy Duty type.

4.2 Protective level

The purpose of the surge arrester is to avoid flashover or puncture of the equipment insulation. To check that this requirement is actually fulfilled, two values must be compared :

- insulation withstand of the equipment under 1.2/50 lightning voltage impulse (BIL or LIWL)
- residual voltage of the surge arrester at the nominal discharge (Up)

In order to take into account possible higher discharge currents and length of connection leads, it is recommended to get a minimum ratio of 1.4 between these two values, i.e. keep the safety margin above 40 %.

<u>1st criterion</u> :

Up < BIL / 1,4

723

All surge arresters meeting this requirement can then be extracted from the table given on page 14.

The example is a network with 11 kV system voltage and a BIL of 75 kV.
The first criteron then leads to all VARISIL™ Type HE surge arresters having a protective level lower than 75 / 1.4 = 53 kV, i.e. with a rated voltage Ur <= 18 kV.

4.3 Continuous phase-to-earth voltage of the network

Under normal conditions, the continuous operating voltage Uc of the surge arrester shall be higher than the maximum phase-to-earth voltage of the network.

The maximum system voltage Um must then be known.

2nd criterion :
Uc > Um / 1,732

In our example, the maximum system voltage is 12 kV, which leads to a maximum phase-to-earth voltage of 12 / 1.732 = 6.9 kV.
All VARISIL™ Type HE surge arresters with Ur >= 9 kV then meet the case.

4.4 Temporary overvoltage conditions

Under single phase fault conditions, the phase-to-earth voltages are unbalanced. The neutral point grounding mode in the substation influences the actual voltages applied to the surge arresters connected to healthy phases.

4.4.1 Neutral point grounding mode

Four modes of neutral point grounding can be used :
- solid
- impedant (resistive and or inductive)
- isolated
- compensated (Petersen coil)

The earth fault factor Kd characterizes the unbalanced effect. It is the ratio between the maximum phase-to-earth voltage on healthy phases under single phase fault conditions and maximum phase-to-earth voltage under normal conditions (Um/√3).

It can be derived from the network features like short circuit power, earth resistances, transformer and line impedances, etc.

729

Typical values for this factor are given in table below :

Neutral point connection	Kd
Solidly grounded	< 1.4
Through impedance	1.4 à 1.73
Isolated	1.6 à 1.8
Through Petersen coil	1.73 à 1.9

The operation time delay of the circuit breaker must also be considered.
The table below gives typical tripping values :

Neutral point connection	Response time
Solidly grounded	0.1 to 0.5 s
Through impedance	0.2 to 1 s
Isolated	0.5 s to 8 h
Through Petersen coil	0.5 s to continuous

The temporary overvoltage (TOV) applied to the surge arresters will then be different according to the neutral point grounding mode.
Manufacturers should provide a TOV withstand curve which characterizes the performance of the surge arresters under such stresses.
The curve on page 21 relates to VARISIL™ Type HE surge arresters.

Appropriate surge arresters shall then be selected as follows :

3rd criterion :
• Multiply the maximum phase-to-earth voltage of the network (Um/1.732) by the Kd factor • From the TOV curve, determine the withstand voltage (k x Ur) for the maximum duration of fault conditions • **Calculate the required minimum rated voltage Ur**

In the example, the neutral point is connected to earth through an impedance with an earth fault factor of 1.55 and a maximum fault duration of 1 s.

- *Kd = 1.55 : Temporary overvoltage = 6.9 x 1.55=10.7 kV*
- *k for 1 s : k = 1.14 i.e. Ut = 1.14 x Ur*

Selection criterion : 1.14 x Ur > 10.7 i.e. Ur > 9.4 kV.
The minimum rated voltage required for the surge arrester is then Ur = 10 kV.

7 10

4.4.2 Foot resistance of the pole

If the earth resistance is locally high, the system behave as if the neutral point was grounded through a high impedance. The calculations must then be made with a Kd factor increased accordingly (see clause 5.2 for more information).

<u>Final selection</u> :

**If more than one single arrester fulfil all 3 criteria,
the surge arrester with the lowest rated voltage shall be preferred
so as to improve the protection performance.**

Only particular local conditions (high foot resistance ,ferroresonance phenomena) might justify the selection of a higher rated voltage.

In the example : 1st criterion : Ur <= 18 kV
2nd criterion : Uc > 6.9 kV
3rd criterion : Ur > 9.4 kV

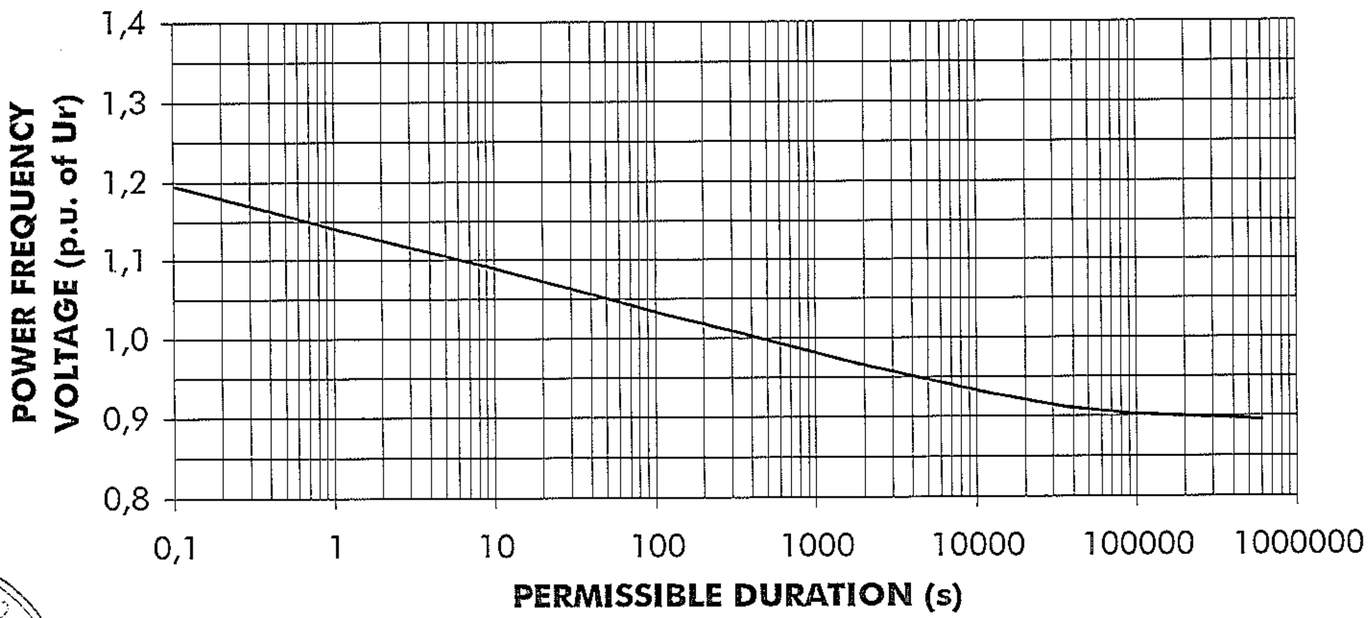
4 models could then be used : rated voltage of 10 kV, 12 kV, 15 kV or 18 kV.
The 10 kV rated surge arrester shall be preferred as it provides the lowest protective level.

<u>Note</u> : for a Distribution network with high local earth resistances (earth fault factor of 1.732), the selection criteria would rather lead to a rated voltage of 12 kV.

The table on page 23 indicates the typical rated voltages to be used for common system voltages.

TRIDELTA Parafoudres S.A.

MINIMUM OVERVOLTAGE WITHSTAND CAPABILITY of VARISIL Type HE SURGE ARRESTERS according to Annex D of IEC 60099-4



732

TRIDELTA Parafoudres S.A.

SIMPLIFIED GUIDE for the selection of the rated voltage Ur of VARISIL™ Type HE surge arresters

Depending on the neutral point grounding conditions, the more severe stresses are either of continuous or temporary type.

Nominal system voltage Un (kV)	6	10	11	13.8	15	20	22	30	33
Maximum system voltage Um (kV)	7.2	11	12	15	17.5	22	24	33	36
Solidly earthed neutral point	6	9	10	12	15	18	21	27	30
Grounding through impedance	9	*10 / 12*	12	15	18	*21 / 24*	24	33	36
Isolated neutral point	9	12	15	*15 / 18*	18	24	27	36	---
Grounding through Petersen coil	9	12	15	18	21	*24 / 27*	27	---	---

Note : values in italics red need to be validated according to the actual earth fault factor or/and maximum fault duration.

5 RECOMMENDATIONS FOR INSTALLATION

To obtain an effective overvoltage protection, a minimum ratio of 1.4 shall be kept between the insulation level (BIL or LIWL) of the equipment and the protective level (Up) of the surge arrester so as to take into account the length of connection leads and possible higher discharge currents.

5.1 Length of connection leads

It is generally considered that the specific inductance of cables is around 1 µH/m.

Under a 40 kA (moderate value) lightning current impulse with 4/10 waveshape, the induced voltage Ui is then :

$Ui = L \times di/dt = 1\ \mu H/m \times 40\ kA / 4\ \mu s$ i.e. $Ui = 10$ kV/m of cable length

For higher rates of rise or peak values (100 kA for instance), this value could be much greater (up to 25 kV/m or even more).

<u>Recommendations</u>

The connection length to be considered is the total length where the discharge current flows, i.e. the length of leads between the surge arrester and the connection point to the line, as well as between the surge arrester and the common connection point to earth.

In case of pole mounting, a usual practice is to connect the earth side of the surge arrester to the earth terminal of the transformer tank which is installed below. This shall be avoided in order to improve the efficiency of the overvoltage protection.

Instead, it is strongly recommended to connect the earth terminal of the transformer tank directly to the earthed fixing point of the surge arrester. At least 10 kV can be saved through this mode of connection to earth.

The shorter the connection leads, the better the overvoltage protection.

5.2 Foot resistance of the pole

<u>Lightning conditions</u>

If the ohmic resistance of the local earth is pretty high (mineral characteristics of the soil, lack of humidity), the voltage at the common earthing point of the transformer and the surge arrester reaches a very high value under lightning current impulses.

In this case, the major risk is flashover between the transformer tank and secondary windings (low voltage neutral point solidly earthed and distributed). Whatever the voltage rating, Distribution surge arresters are not intended to deal with such a phenomenon. However, an air spark gap connected between the LV neutral point and the transformer tank can solve this problem.

Fault conditions

In case of fault conditions due to the system itself (earth fault or insulation damage), the fault current value remains pretty low as limited by the high ohmic resistance of the earth.

In such a particular case, the surge arresters connected to the healthy phases will be more stressed on the voltage point of view. The highest possible rated voltage shall then be preferred (earth fault factor in the higher range of values, see clause 4.4.2).

As a conclusion, it is recommended that earthing resistances be as low as possible. In the particular case of pole mounting, the foot resistance shall not exceed 30 Ω.

5.3 Clearances

At the installation stage, clearances shall be respected so as to guarantee correct operation of VARISIL™ Type HE surge arresters.

The distances between the live parts of surge arresters and any earthed element (distance d) and between the live parts of surge arresters connected to adjacent phases (distance D) shall be carefully checked.

The table below advises clearances according to the rated voltage :

Type HE	05	06	09	10	12	15	18
d (mm)	46	50	86	89	100	132	150
D (mm)	50	54	92	96	108	143	163

Type HE	21	24	27	30	33	36
d (mm)	182	199	234	247	283	297
D (mm)	199	217	258	272	313	330

5.4 Electric connections

5.4.1 Connection to earth

For VARISIL™ Type HE surge arresters equipped with a disconnecting device ("SD" option), a copper lead (bare or insulated) with minimum cross section of 16 mm² must be used for connection to earth. A cable without terminal lug can be used on condition that the diameter does not exceed 15 mm : if so, it can be directly clamped using the metal clamp supplied.
This cable has to be flexible and long enough to provide the required clearance in case the disconnector operates. It is also important to check that no element can interfere with the cable movement under such conditions.

For VARISIL™ Type HE surge arresters fitted with either "NO" option or "IF" option, connection to earth shall be made through earthing of the mounting bracket.

5.4.2 Connection to line

Line connection of VARISIL™ Type HE surge arresters must be achieved with either a copper or an aluminium cable (bare or insulated) with minimum cross section of 16 mm². This cable shall be connected to the M12 line terminal of the surge arrester. A cable without terminal lug can be used on condition that the diameter does not exceed 15 mm : if so, it can be directly clamped using the metal clamp supplied.
It is also recommended that no significant mechanical stress be applied to the surge arrester through excessive tension of the line cable.

5.4.3 Tightening torques

Torques applied to secure bolts and/or nuts of VARISIL™ Type HE surge arresters shall never exceed :

- **20 N.m** for M12 terminals (applicable to all options)
- **30 N.m** for M16 terminals ("IF" option)

5.5 Packaging

VARISIL™ Type HE surge arresters are packed inside individual boxes which can be easily opened with no need of tool.

736

5.5.1 Handling and transport

Thanks to the soft polymer housing, VARISIL™ Type HE surge arresters can be handled with less care than required for porcelain housed devices. However, attention must be paid to avoid damage to :

- the polymeric housing (cut or tear by sharp objects)
- connecting bolts and threaded studs
- accessories if any (insulating bracket, disconnector or fault indicator)

If damaged, those parts may prevent correct mounting and/or operation.
It is then recommended that the surge arresters remain inside their original box till installation.

5.5.2 Storage

Before use, the surge arresters shall be kept inside their original packaging. The boxes shall be stored in sheltered premises with ambient air temperature in the range –20 °C ÷ + 70 °C.

5.5.3 Maintenance

VARISIL ™ Type HE surge arresters are maintenance free.

If surge arresters with disconnecting device are used ("SnD2" option), the operator is advised to perform periodical inspections on site in order to detect any surge arrester which would have disconnected (drop of the earth lead) and replace it as soon as possible.
In case of disconnection, the complete assembly (surge arrester element/insulating bracket/disconnection module) shall be changed.

732

6 STANDARDS AND TESTS

The VARISIL™ Type HE range fulfils all relevant IEC requirements.

6.1 Reference standard

IEC 60099-4 : "Surge Arresters / Part 4 : Metal-oxide surge arresters without gaps for a.c. systems" – 2nd edition.

6.2 Other applicable standards

ANSI/IEEE C62.11 : "IEEE standard for metal-oxide surge arresters for alternating current power circuits"

IEC 60071-1 : "Insulation co-ordination / Part 1 : Definitions, principles and rules"

IEC 60099-5 : "Surge Arresters / Part 5 : Selection and application recommendations"

IEC 60270 : "Partial discharge measurements"

IEC 60507 : "Artificial pollution tests on high-voltage insulators to be used on a.c. systems"

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

IEC 61109 : "Composite insulators for a.c. overhead lines with a nominal voltage greater than 1000 V – Definitions, test methods and acceptance criteria"

6.3 Type tests

All type tests have been performed in CESI (Centro Elettrotecnico Sperimentale Italiano) independent laboratory located in MILANO - Italy.

The table of the type tests which have been carried out and the corresponding tests are available upon request).

TRIDELTA Parafoudres S.A.

6.4 Standard acceptance tests

The table below reminds the standard acceptance tests which are required by IEC 60099-4 :

Test description	Clause of IEC 60099-4	Test samples
Measurement of the reference voltage at 1 mA peak AC	§ 9.2.1.a	Surge Arresters
Measurement of the lightning residual voltage at 10 kA	§ 9.2.1.b	MOV blocks
Measurement of the partial discharge level	§ 9.2.1.c	Surge Arresters

6.5 Routine tests

The table below indicates the routine tests which are performed during the manufacture of VARISIL™ Type HE surge arresters :

Test description	Clause of IEC 60099-4	Test samples
Measurement of the voltage at 1 mA	Not required	MOV blocks
Measurement of the lightning residual voltage at 10 kA	§ 9.1.b	MOV blocks
Verification of the energy absorption capability (2 shots at 300 A / 2000 µs)	Not required	MOV blocks
Measurement of the reference voltage at 1 mA peak AC	§ 9.1.a	Surge arresters
Verification of the absence from partial discharge and contact noise (1)	§ 9.1.c	Surge arresters

(1) This test is performed at the same time than the measurement of the reference voltage

739