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UNIDO Contract No. 87/134
Project No. DP/VIE/85/010
Activity Code: J13313

DP/VIE/85/010

TECHNOLOGY TRANSFER FOR DESIGN TEST AND PILOT MANUFACTURE OF HIGH VOLTAGE POWER CAPACITORS IN THE SOCIALIST REPUBLIC OF VIET NAM

****

FINAL REPORT

According to point 2.18 f) of Contract 87/134

Monza, September the 1st 1990

DP/VIE/85/010

FINAL REPORT

This report covers the activities subsequent to the commissioning stage and the testing of capacitors in site and at international laboratory according to point 2.18 f) of contract 87/134 and to the section 2.4.b) ii) and iii) of "Terms of reference".

Assistance

The post commissioning operational assistance and on-site training were performed by:

Mr. P. Scarafiotti: ICAR HV components production Manager, in charge of the technical and executive direction of the project.

Mr. G. Borelli : ICAR HV components, field engineer of the project.

Mr. P. Scarafiotti re-visited the pilot plant in Ho Chi Minh City

on 10 - 14 January 1990

Mr. G. Borelli re-visited the pilot plant in Ho Chi Minh City

on 18 - 25 August 1989
9 - 19 November 1989
7 - 23 January 1990
20 - 30 April 1990
5 - 19 August 1990

During these visits ICAR engineers integrated the previous trainings with discussions on all the aspects of the technology transfer :

a) production on process
b) testing
c) quality control
d) rejection examination and rework
e) production management

and they also verified that the pilot plant is managed properly and is working at full scale production.

After the commissioning stage, from August 1989 and February 1990, 310 capacitors of 100 Kvar - 8.66 KV were manufactured in full autonomy by the personell of the implementing agency, Power Company No. 2.

All the capacitors manufactured passed the routine tests carried out in the factory laboratory and then they were installed.

Until now only 1 unit was rejected from service.
The examination of the failed unit showed that the breakdown was casual and did not depend by a production mistake.

Type tests

Four capacitors, randomly chosen from production, were tested at ICAR HV laboratory under the supervision and witnessed by an ispector from the international laboratory:

CESI - Centro Elettrotecnico Sperimentale Italiano",

which has provided to certify the tests, according to point 2.18 f) of the contract 87/134.

The tests were witnessed also by:

Mr. Y. Shibata, CTA of the project
Mr. Vo Minh Bon from PC2 and NPD of the project
Mr. Ngo Duc Quang from PC2
Mr. Le Dinh Dan from PC2
Mr. To Cong Thanh Loc from PC2

The type test certificate issued by CESI is enclosed, annex 1.

Study tour

Finally a study group composed by:

Mr. Vo Minh Bon from PC2 and NPD of the project
Mr. Ngo Duc Quang from PC2
Mr. Le Dinh Dan from PC2
Mr. To Cong Thanh Loc from PC2

under the supervision and the assistance of the CTA of the project:

Mr. Y. Shibata

carried out a 2 week stage at ICAR factory to study:

1) the possibility of expanding the existing pilot plant into full-scale production plant

2) the possibility of adding a production line for low-voltage capacitors for diversification of the existing plant

3) the ICAR experiences in making customers aware of economic advantage of power factor improvement.

The report of the study group is enclosed, annex 2.


CESI

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CENTRO ELETTROTECNICO SPERIMENTALE ITALIANO

inspection report

CESI **inspection report** AT-90/012033

client ICAR s.p.a. - Monza - MI ITALY

object N° 4 Power-factor correction capacitors, manufactured by POWER COMPANY N° 2 - HO CHI MINH CITY - VIETNAM

purpose Routine tests and type tests

place and inspection date ICAR HV Laboratory Monza, 2-6/7/1990

this document is composed by 8 pages, 1 annexe of 13 pages

milan, 20 july 1990

responsible of the inspection

keywords: 12020V 22525Z 54550D 62001C 62050A

CONTENTS

1. TEST OBJECT

Power-factor correction capacitors of a.c. power systems.

The main characteristics are the following:

- Manufacturer	:	Power Company N. 2 HO CHI MINH CITY - VIETMAN
- Model	:	PL-1 100/8.66
- Rated output	:	100 kVAr
- Rated voltage	:	8,66 kV
- Rated frequency	:	50 Hz
- Series number	:	070989-030989-090989-010989
- Capacitance	:	4,29 µF 4,33 µF 4,26 µF 4,26 µF
- Type	:	Single phase capacitor
- Insulation level	:	38/95
- Temperature category	:	- 25 + 45 ^{o}C
- Service	:	outdor
- Dielectric		all polipropylene film
- Electrodes	:	alluminium foils
- Impregnant	:	Pxe
- Discharge resistor	:	internal
- Internal connection	:	6 series groups, 3 paralleled elements/series
- Weight	:	31 Kg
- Year of manufacture	:	1989

2. TESTS PERFORMED

Tests are performed according to IEC standard, Publication 871-1, 1987

The following tests are performed:

- Routine tests
- Type tests

3. ROUTINE TEST

3.1 Voltage test between terminals

The test was performed applying for 10 S a sinusoidal test voltage.

U_t = 18,62 kV r.m.s. 50 Hz

During the test no flashovers or other appreciable phenomena occured.
Test results : Favourable
Test procedure and results are reported in the annexe 1 page 4 (ICAR Test Report N. 2515).

3.2 A.C. voltage test between terminals and container

The test was performed applying the test voltage for 10 s between the terminals (joined together) and the container.

Ut = 38 kV r.m.s. 50 Hz

During the test no flashovers or other appreciable phenomena occured.
Test results : Favourable
Test procedure and results are reported in the annexe 1 page 4.

3.3 Capacitance and tan δ measurement.

The capacitance and tan δ measurement after the a.c. voltage tests were made at:

- Un = 8.66 kV r.m.s. 50 Hz
- Ambient temperature = 27 °C

Capacitance tolerance admitted - 5 to + 10%.
Test results : Favourable
Test procedure and results are reported in the annexe 1 page 4.

3.4 Test of internal discharge device

The resistance measurement of the internal discharge device was performed with a megaohm meter.

- Voltage measurement 500 V D.C.
- Resistance : 8,24 ÷ 8,26 (megaohm)
- Maximum value allowed : 12,56 (megaohm)

Test results: Favourable
Test procedure and results are reported in the annexe 1 page 5.

3.5 Sealing test

The capacitor units n. 030989 and 010989 was heated for 3 hours in an oven for 3 hours.

- Temperature 80 ± 5 °C

No leakage occured.
Test results : Favourable
Test procedure and results are reported in the annexe 1 page 5.

4. TYPE TESTS

4.1 Thermal stability test

The test capacitor n. 070989 was placed in a heated enclosure, with the air temperature of 45 °C.
The capacitor was subjected for a period of 58 hours to a sinusoidal voltage of:

- 10,4 kV r.m.s. 50 Hz

Test results: Favourable
Test procedure and results are reported in the annexe 1 page 6.

4.2 Capacitor losses measurement at elevated temperature.

The tan δ was measured on the capacitor n. 070989 at the end of the termal stability test.
The tan δ was made at:

- 10,4 kV r.m.s 50 Hz
- capacitor temperature 49 °C

Maximum tan δ admissible : $0.2\ 10^{-3}$.
Test results : Favourable
Test procedure and results are reported in the annexe 1 page 5.

4.3 A.C. voltage test between terminals and container.

The test was performed applying the test voltage for 1 min between the terminals (joined together) and the container.

- U_t = 38 kV r.m.s. 50 Hz

During the test no flashovers or other appreciable phenomena occured.
Test results : Favourable
Test procedure and results are reported in the annexe 1 page 7.

4.4 Short-circuit discharge test

The capacitor 030989 was subjected to 5 such discharges within 10 min.
The unit was charged at D.C. voltage of:

- U_t = 2,5 Un = 21,7 kV d.c.

Within 5 min after this test, the capacitor was subjected to a voltage test between terminals.

- U_t = 2,15 Un = 18,62 kV r.m.s. 50 Hz

The capacitance was measured before the dicharge test and after the voltage test.
Maximum change of capacitance admissible : 2%.
Test results: Favourable
Test procedure and results are reported in the annexe 1 page 7.

4.5 **Lightning impulse test between terminals and container.**

The lightning impulse test was made with a wave-shape of 1.02/45 μs having a crest value of:

- U_t = 95 kV

For each polarity 15 impulse voltage are applied
During the test no flahovers other appreciable phenomena occured.
Test results : Favourable
Test procedure and results are reported in the annexe 1 page 8-11.

5. CONCLUSIONS

The test are performed according to IEC Standard, Publication 871-1, 1987 and test results are favourable.

A N N E X E 1

ICAR	TEST REPORT N. 2515	Sheet 1 of 11

TEST OBJECT: Capacitors for Power Factor Correction model PL-1 100/8.66

manufactured by:

POWER COMPANY N° 2
HO CHI MINH CITY
VIETNAM

TEST SPECIFICATION: The tests were carried out in accordance with IEC 871-1 edition 1987.

OVERALL RESULTS OF TESTS: The capacitor passed all the tests in full compliance with the above mentioned specifications.

TEST DATE: July 2nd - July 6th 1990

TEST PERFORMED AT: ICAR SpA H.V. Laboratory

WITNESSED BY: Mr. A. TULIPANO, Inspector from C.E.S.I. Centro Elettrotecnico Sperimentale Italiano.

Mr. Y. SHIBATA, CTA of UNIDO project DP/VIE/85/010

Mr. VO MINH BON
Mr. NGO DUC QUANG
Mr. LE DINH DAN
Mr. TO CONG THANH LOC
from POWER COMPANY N.2

Mr. L. POZZI
Mr. A. MAGNI
from ICAR SpA (Q.C. Division)

This report is composed by 11 pages and 1 drawing.

Monza, July the 11th 1990.

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C O N T E N T S

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1. PURPOSE OF THE TESTS

The purpose of the test was the type qualification of power factor correction capacitors model PL-1 100/8.66, manufactured by POWER COMPANY N°2 - HO CHI MINH CITY - VIETNAM, according to IEC 871-1.

2. CHARACTERISTICS OF THE TESTED CAPACITORS

Model	:	PL-1 100/8.66
Rated output	:	100 kvar
Rated voltage	:	8660 V
Rated frequency	:	50 Hz
Identification number	:	070989-030989-090989-010989
Type	:	single phase capacitor
Insulation level	:	38/95
Temperature category	:	-25 +45°C
Service	:	outdoor
Dielectric	:	all polypropylene film
Electrodes	:	aluminium foils
Impregnant	:	PXE
discharge resistor	:	internal
Internal connection	:	6 series groups 3 paralleled elements/series group
Weight	:	31 Kg
Year of manufacture	:	1989

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3. TEST METHODS

The tests were performed in accordance with IEC 871-1 edition 1987 the corresponding clause of each test is indicated in brackets.

4. TESTS AND RESULTS

4.1 Routine tests

4.1.1. Voltage test between terminals (Sub-clause 9.1)

The test was performed applying an a.c. voltage of 18620 V 50 Hz for 10 seconds.

No breakdown occurred.

4.1.2. A.C. Voltage test between terminals and container (Clause 10)

The test was performed applying an A.C. Voltage of 38 KV 50 Hz for 10 seconds between the terminals (joined together) and the casing.

No Dielectric breakdown or flashover occurred.

4.1.3. Measurement of the capacitance and tan δ between terminals (clause 7 and 8)

The capacitance and the loss angle tangent were measured at 27°C after the a.c. voltage tests in order to check the behaviour of the capacitor during the voltage test.
The measurements were made with a schering bridge at 8660V - 50Hz.
The results obtained were:

Capacitor (n°)	Capacitance (µF)	Loss angle (tan δ)
070989	4.330	0.190 · 10^{-3}
030989	4.343	0.189 · 10^{-3}
090989	4.304	0.192 · 10^{-3}
010989	4.300	0.192 · 10^{-3}

Capacitance tolerance admitted -5 +10 %

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4.1.4. Checking of discharge device (clause 11)

The check was performed with a megaohm meter with a d.c. voltage output of 500 V. Maximum value allowed: 12.56 megaohm.

Capacitor (n°)	Resistance (megaohm)
070989	8.24
030989	8.25
090989	8.26
010939	8.24

4.1.5. Sealing test (clause 12)

The capacitors 030989 - 010989 were placed in an oven having constant temperature of 80 ± 5°C for 3 hours.

No leakage occurred.

4.2 TYPE TESTS

4.2.1. Capacitor losses measurement at high temperature (clause 14)

The capacitor losses were measured at the end of the thermal stability test at 49°C - 10400 V - 50Hz.
The following results were obtained:

Capacitor (n°)	Capacitance (μF)	Loss angle ($\tan\delta$)
070989	4.307	$0.156 \cdot 10^{-3}$

Maximum $\tan\delta$ admitted: $0.2 \cdot 10^{-3}$

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4.2.2. Thermal stability test (clause 13)

The capacitor 070989 was placed between two dummy capacitors, each containing resistors, in a heated enclosure where the air temperature was 45°C.
The dissipation in the resistors of the two dummy capacitors was adjusted to a value such that the case temperature of the dummy capacitors near the top opposing faces was equal or higher than the test capacitor.
Throughout the test the air temperature was checked by means of a thermometer.
During the whole test the difference between the measured air temperature and the specific test temperature was in the range of tolerance ± 2 %.
After all parts of the capacitor had attained the temperature of the ambient air, the capacitor was subjected for a period of 58 hours to a voltage of 10400 V at rated frequency.
During the test the temperature of the container near the top was measured and recorded, during the last 6 hours no significant change was noted.
Record of the ambient temperature and of the above container temperature are available.
Before and after the test, the capacitance was measured at a temperature of 27°C. The following results were obtained:

MEASUREMENTS AT 27°C BEFORE THE TEST		MESUREMENTS AT 27°C AFTER THE TEST	
C µF	Tan δ	C µF	Tan δ
4.330	$0.190 \cdot 10^{-3}$	4.341	$0.162 \cdot 10^{-3}$

Maximum change of capacitance admitted: 2%

Hour		53rd	54th	55th	56th	57th	58th
Ambient temperature	T4	47.2	46.4	44.1	47.0	45.4	45.1
	T5	46.1	45.2	42.9	46.4	44.8	44.3
	T6	45.9	45.3	42.9	46.2	44.7	44.3
Dummy capacitor temperature	T3	51.3	50.2	49.3	52.2	50.9	52.0
Capacitor temperature	T1	49.7	48.6	47.1	49.7	48.3	49.1
	T2	49.0	48.0	46.4	49.4	47.8	49.0

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4.2.3. A.C. Voltage test between terminals and container (clause 15)

The test modalities were the same indicated in clause 4.1.2. but the test duration was 1 minute.

No dielectric breakdown or flashover occurred.

4.2.4 Discharge test (clause 17)

The capacitor 030989 was charged by means of a d.c. voltage equal to 21700 V and then discharged through a gap situated as close as possible to the capacitor. It was subjected to 5 such discharges in about 10 minutes. Five minutes after this test, the capacitor was subjected to a voltage test between terminlas, the test modalities were the same indicated in clause 4.1.1.
The capacitance was measured before the discharge test and after the voltage test.
The following results were obtained:

BEFORE THE TEST		AFTER THE TEST	
C μF	Tan δ	C μF	Tan δ
4.343	$0.189 \cdot 10^{-2}$	4.345	$0.187 \cdot 10^{-2}$

Maximum change of capacitance admitted: 2 %

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4.2.5. Lightning impulse test between terminals and container (clause 16)

The lightning impulse test was made in accordance with IEC publications 60 but with a wave-shape of 1.2/50 µsec having a crest value of 95 kV.

Fifteen impulses of positive polarity followed by fifteen impulses of negative polarity was supplied between bushing joined together and the container.

See the pictures of pages 9-10-11.
The pictures of page 9 show the wave-shape of 64 % of test voltage.
The pictures of page 10 show the 15 positive impulses.
The pictures of page 11 show the 15 negative impulses.

No puncture, no flashover and no irregularities on the impulse wave-shape occured.

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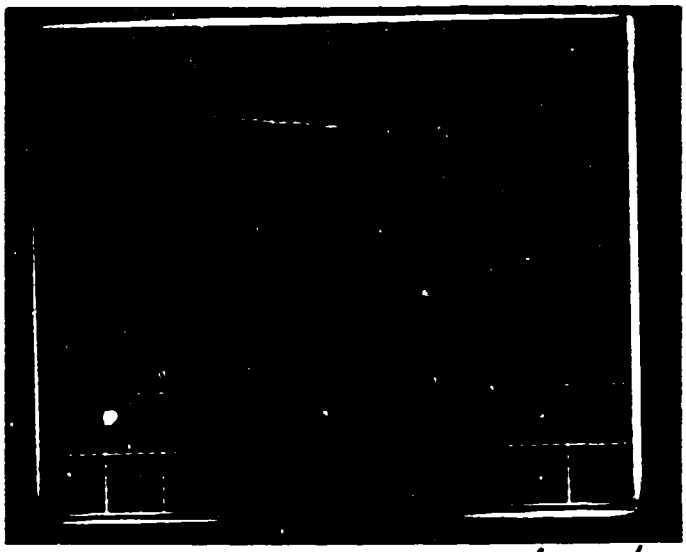

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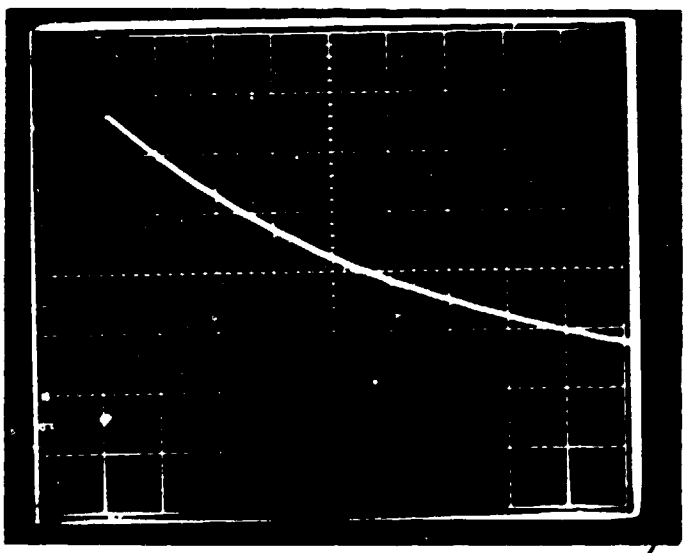

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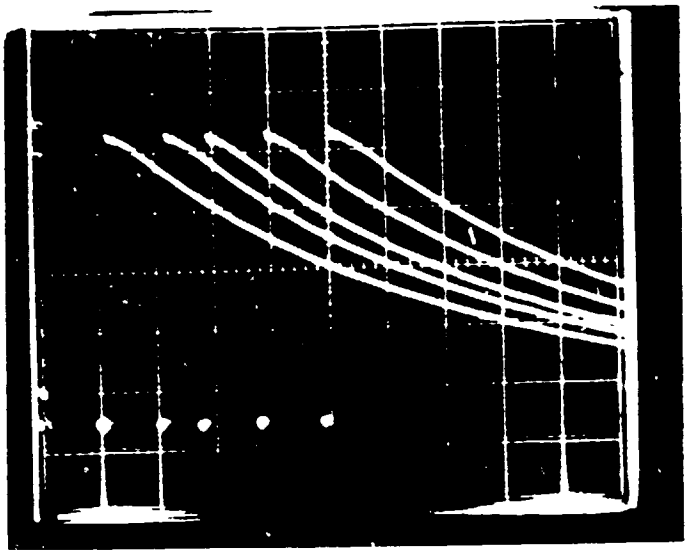

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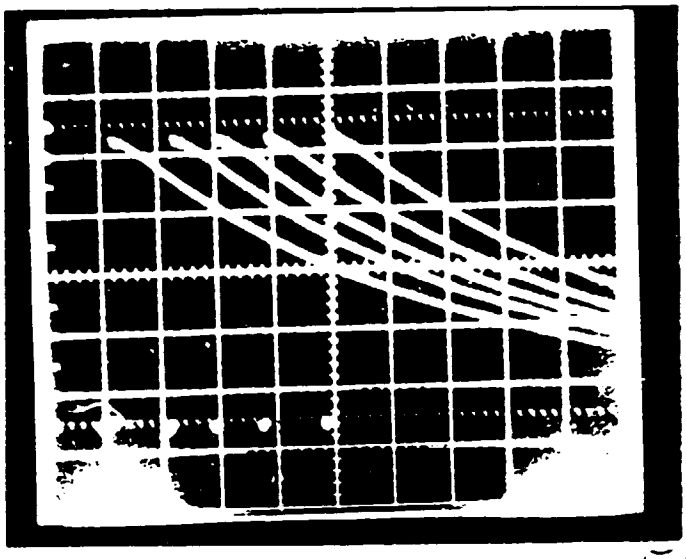

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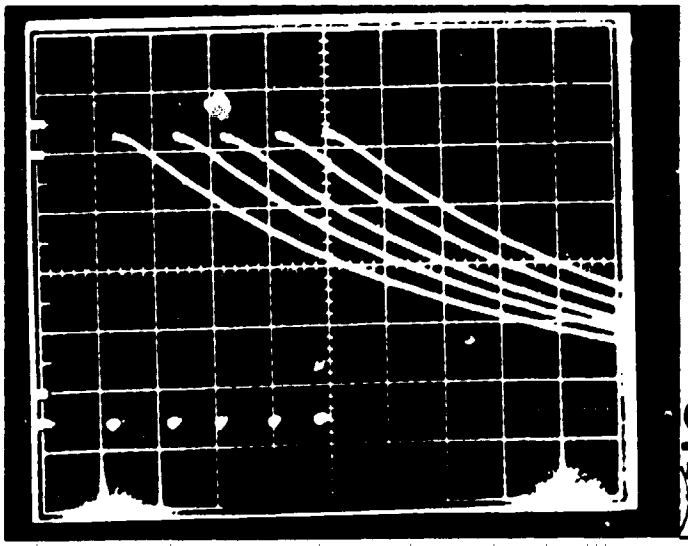

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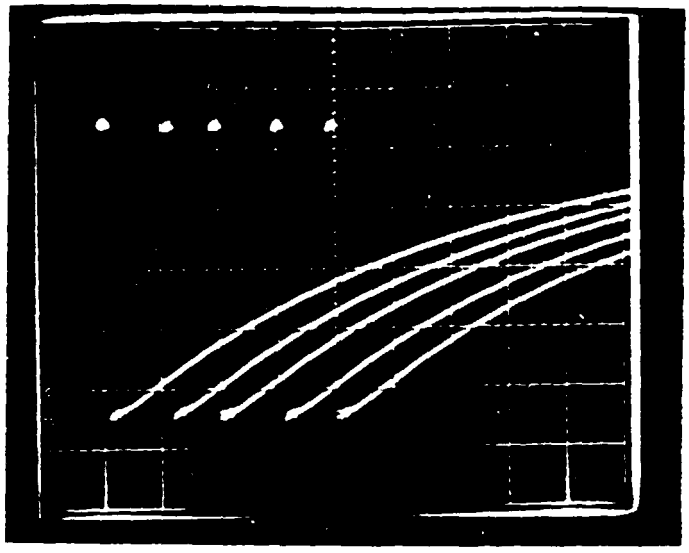

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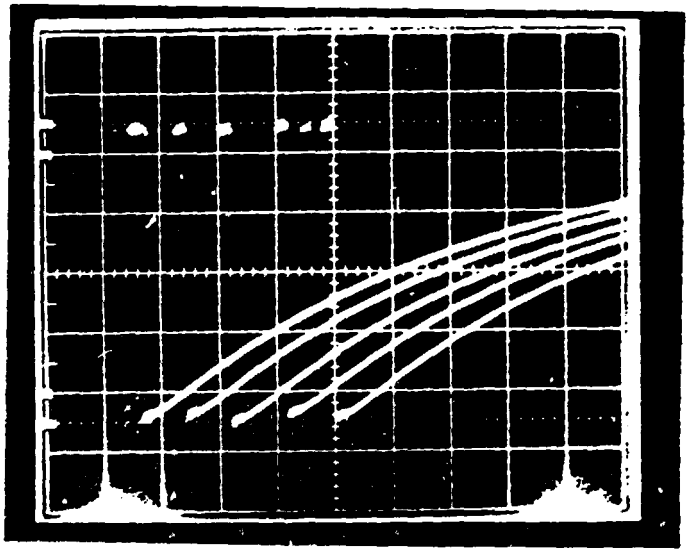

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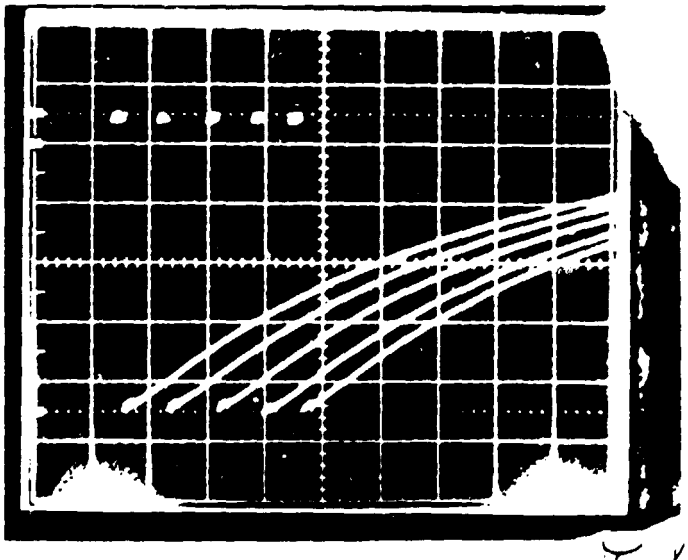

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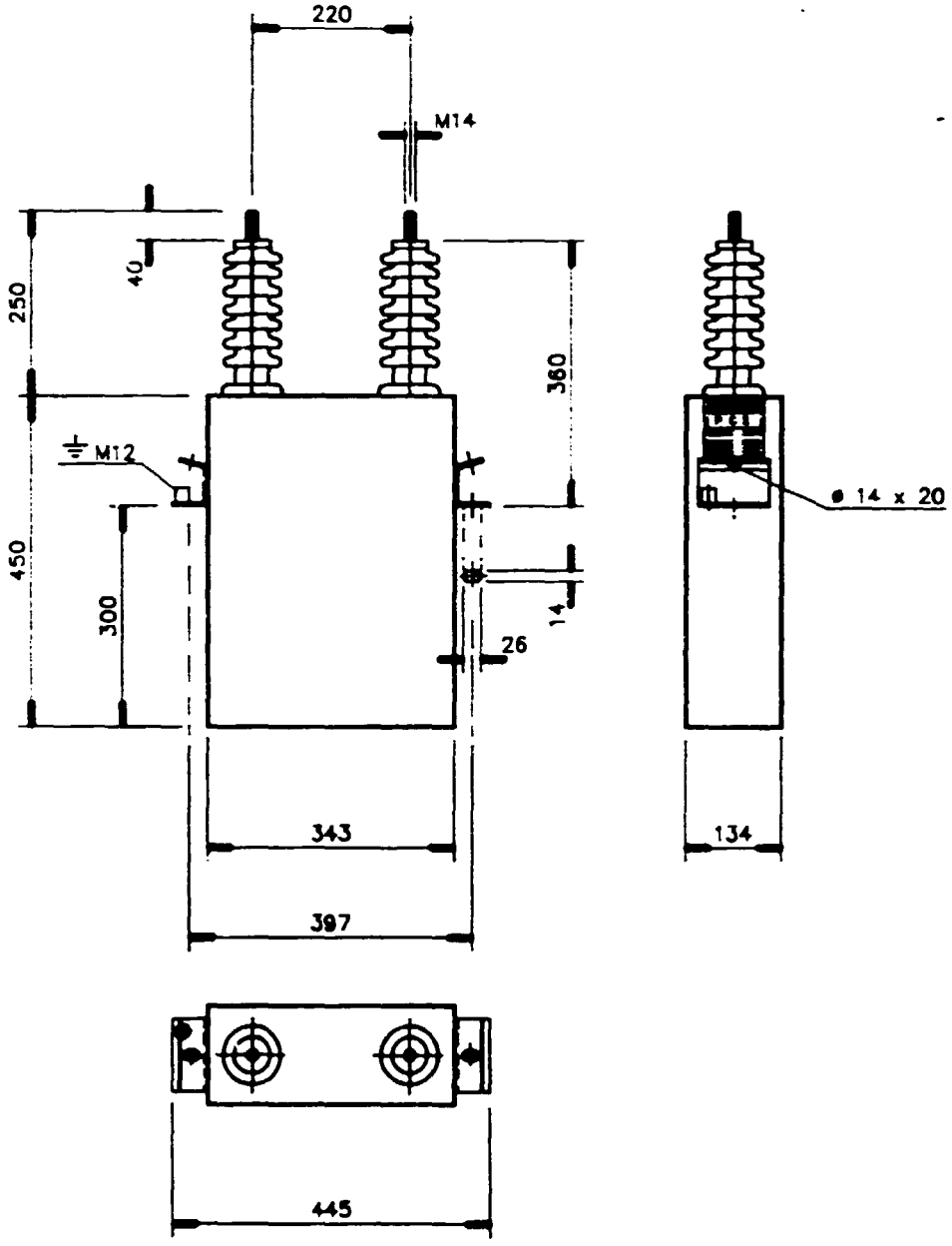

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U N I D O

REPORT OF THE STUDY TOUR

VIETNAM – DP/VIE/85/010

TRANSFER OF TECHNOLOGY FOR THE DESIGN , TEST AND PILOT MANUFACTURE OF LOW VOLTAGE POWER CAPACITORS

Report of the study tour

Carried out from 24 June - 7 July 1990

VO MINH BON

NGO DUC QUANG

LE DINH DAN

TO CONG THANH LOC

1. INTRODUCTION

1.1 A study tour group from Power Company N°2, Vietnam (PC-2) consisting of

Mr. VO MINH BON , NPD;
Mr NGO DUC QUANG ,
Mr LE DINH DAN ,
Mr TO CONG THANH LOC

visited ICAR Company (Italy) from June 25 to July 7,1990 within the framework of Project DP/VIE/85/010.

1.2 The Project entitled DP/VIE/85/010 (Technology Transfer for the Design,Test and Pilot Manufacture of High Voltage Power Capacitors) was approved and became operational in August 1986. Messrs ICAR Company were selected among 19 leading capacitor manufacturers for the technology transfer, and PC-2 was the project executing agency. A pilot plant for menufacturing H.V. capacitors was established and operational in Ho Chi Minh City for the above-mentioned purpose.

1.3 The objectives of the study tour was to revisit and discuss with ICAR Company about the following points:

(a) The possibility of expanding existing pilot plant into full-scale production;

(b) To witness the type test of the H.V.power capacitors samples;

(c) The possibility of adding a production line for Low voltage capacitors for diversification of the existing plant;

(d) To study experiences in making customers aware of economic advantage of power factor improvement.

2. PROGRAMME OF THE STUDY TOUR

During the study tour,the following activities were carried out:

24 June 1990,Sunday : Departure from Vietnam.

25 June 1990,Monday : Arrival in Milan.
Courtesy visit to ICAR Head Office,
Discussion about working plan.
Check in at Collodi Residence.

26 June 1990,Tuesday : First visit to the HV capacitor plant at Monza (conducted by Messrs Scarafiotti and Borelli)

Visit to ADVIL (Mr Pennati)
Particular attention to metallization process and equipment.
Visit the production line for plastic can,metallized film low voltage capacitors.

27 June 1990,Wednesday: Free, in view of a general strike of metal industry workers

28 June 1990,Thursday : Visit to the production line for L.V. metallized film capacitors at Monza (conducted by Mr.Beretta)

Discussion on the production process of metallized film, aluminium can type capacitors and construction of power factor correction units.
(Particular attention to conditions in Vietnam)

Visit the assembly line for energy saving cabinets.

29 June 1990,Friday : Visit to CESI - an independent testing laboratory (conducted by Mr.Umberto Zanaboni, Mr Enrico Bertani)

2 July 1990,Monday : Witness the preparation and conduct of the type test of 4 samples sent from PC-2 previously.(CESI Inspector,Mr Antonio Tulipano and ICAR engineers conducted the testing)

3 July 1990, Tuesday: Discussion about quality standards (acceptability range) for incoming raw materials ,components and subcontracted parts.
Discussion about quality control practice (Mr Pozzi, Mr Scarafiotti)

4 July 1990,Wednesday: Discussion about PC-2 low voltage capacitor project. Review of the project pre-feasibility study prepared by PC-2 (Mr Folli, Mr Beretta)

5 July 1990, Thursday: Mr Picci talked about Power factor correction with capacitors.
Discuss with Messrs Folli, Beretta, Borelli about the production line for L.V. capacitors (types of product,production flow chart, equipment, extent of automation)

6 July 1990, Friday: Discussion about maintenance management
Studying about experience in promoting the company product (pricing,selling, customer service)

Discuss about result of the type test.

7 July 1990,Saturday: Departure for Rome.

3. CONCLUSIONS AND RECOMMENDATIONS

The Study tour group had opportunities to visit several ICAR plants,including its subsidiary metallization and plastic can capacitor plant ADVIL; and discussed the relevant issued with the Company management.

(1) The visits and discussions were very helpful and made it possible for the study tour participants to gain some insight to a technology that never before existed in Vietnam and to be convinced that it is possible to expand the existing high voltage power capacitor plant with a low voltage production line for the need of power factor correction capacitors; and later on A.C. capacitors for general applications.

The types of product that are suitable for conditions in Vietnam are low voltage metallized polypropylene film, can (Aluminium can) with overpressure disconnector

(1) Due to the high investment versus added value, also environmental conditions,space availability and non-homogeneous technology with respect to the previous project, it is not advisabe to set up a metallization plant for local production. Importing metallized films is viable as many low voltage capacitor producers nowadays do not meta-llize,therefore metallized film is available in the market from several sources.

(2) In view of the high humidity in Vietnam,the metallized film L.V. capacitors that are to be manufactured in Vietnam should be impregnated.

(3) In view of the prevailing conditions in Vietnam,a fully automatic plant does not seem very viable as the investment is too high,and less job opportunities are provided.
A semi-automatic production line may be more suitable.
However, emphasis should be placed on winding,spraying and testing process which necessarily have to be fully automatic.

(4) The 4 sample capacitors dispatched from Vietnam for type test were unpacked on 2 July 1990 and were found to be in good condition. The tests (routine and type test) carried out afterwards by ICAR engineers and CESI Inspector,witnessed by representatives of PC-2 and the Project CTA- Mr Y.SHIBATA, proved to be satisfactory (See Attachment)

(5) For transferring from pilot manufacture to full-scale production, another impregnating machine will be needed to improve the productivity. However special attention should be paid in maintenance of equipment and quality control.
Quality should be built into the process;rather than relying on inspection.
Managers and workers should be provided with the training they need to fully participate in the improvement process.
Long-term ties should be established with selected suppliers rather than awarding contracts on price tag alone.

I have read this report, prepared by the PC-2 study tour group, and find it satisfactory.

Monza, July the 6th 1990

Y. SHIBATA

CHIEF TECHNICAL ADVISER
DP/VIE/85/010

4. LIST OF PERSONS CONTACTED

This report will not be completed without a note of special thanks to the following persons,whose patience,kind attendance and hospitality are gratefully appreciated:

ICAR Spa

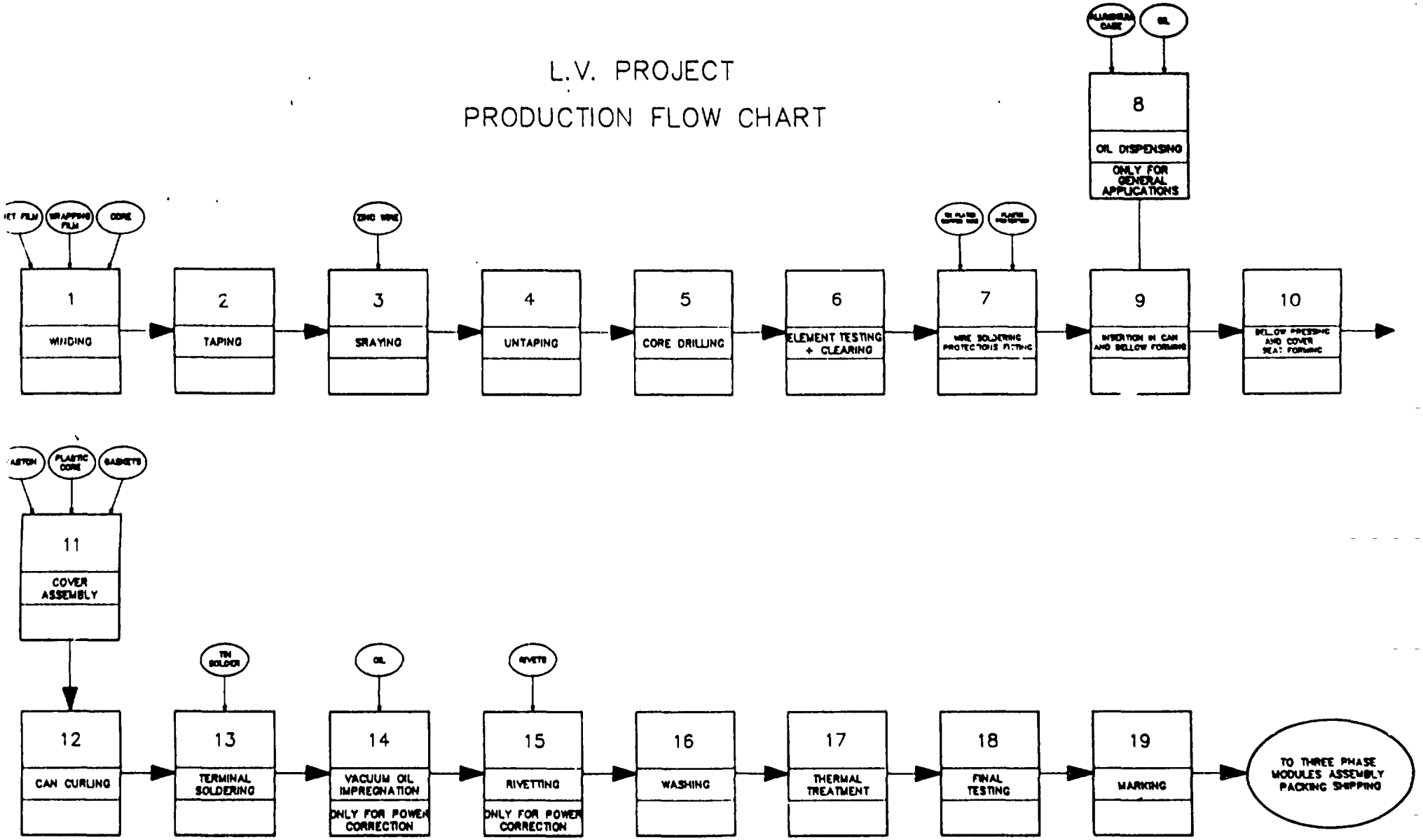
Mr F.FOLLI	Director General
Mr. SCARAFIOTTI	Production Manager/ HV Capacitors
Mr. BORELLI	Chief Designer/ HV Capacitos
Mr. BERETTA	Production Manager/ LV Capacitors
Mr. POZZI	Quality Control Manager
Mr. PICCI	Technical Manager
Mr. MAGNI	HV capacitor Inspector
Mr. PENNATI	Production Manager /LV Capacitors

CESI

Mr U.ZANABONI	Tecnical-Commercial Direction
Mr. A.TULIPANO	Inspector / H.V. Division
Mr. E.BERTANI	Inspector/ H.V. Division

L.V. PROJECT

PRODUCTION FLOW CHART



ICAR **PROVE INDIVIDUALI** (e = 27 °C)

Ponte di Misura Tettex tipo 2811

DATA / Matricola	Prova di tensione 10 sec. c.a. tra armature a 18,6 kV	60 sec. c.a. verso massa a 38 kV	Misure al ponte Differenziale kV CN = 10004 pF. K = 10 lettura per calcolo C_x	C_x (µF)	100 tg δ	
2.7.90						
(µF)						
4,19 070989	OK	OK	420,15	4,330	0,0190	6,4
4,33 030989	OK	OK	421,51	4,343	0,0189	8,1
4,26 090989	OK	OK	417,75	4,304	0,0194	8,4
4,26 010989	OK	OK	417,33	4,300	0,0194	8,1
Misura dopo prova di scarica in c.c a 2,5 V_n						
26650 V_{cc} S scarica in 10 min e prova di:						
Resistenza a 2,15 V_n 10 °C.						
030989			421,73	4,345	0,018F	

Prova superficiale 3 ore ind numeri 03 - 01
temperatura 20°C : OK

NOTE: MOD. PL - 1 100 Kvar 266 Kv

ICAR

Condensatori in prova

n° 090989

9. TARATURA DEL CIRCUITO DI MISURA

Condizioni ambientali: temperatura 27 °C

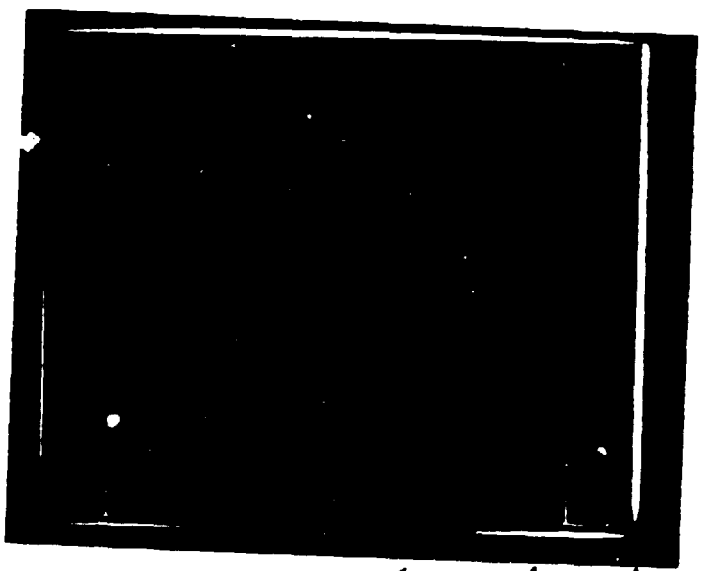
pressione 746 mmHg a - °

pressione 744,7 mmHg a 0°C

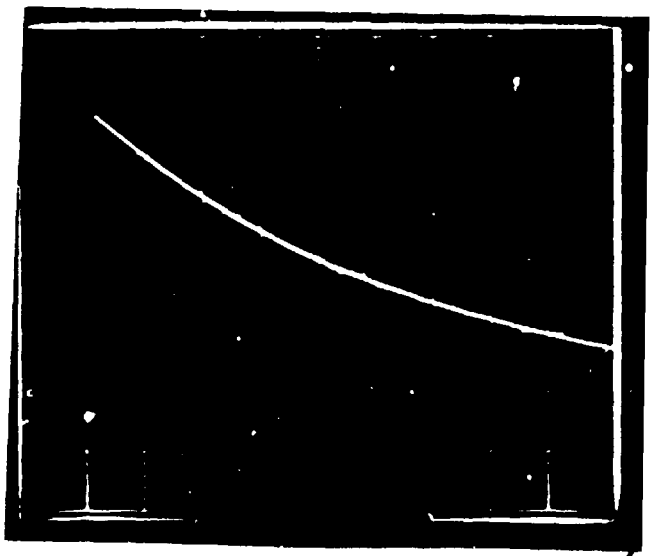
fattore di correzione k = 0,951

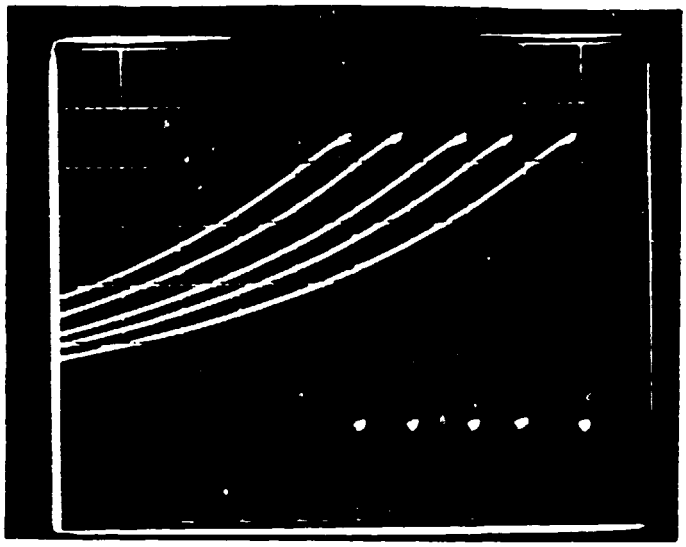
Spinterometro a sfere Ø150mm		Tensione applicata (corretta)	Oscillografo			Carica del generatore
Distan. esplos.	Tens. di scarica 50%		Attenuatore	Media ordinate di cresta	Costante di lettura	
(mm)	(kV)	(kV)	(V cm)	(mm)	(kV mm)	(kV)
22	64.5	61.5				66,25
		95				102,3

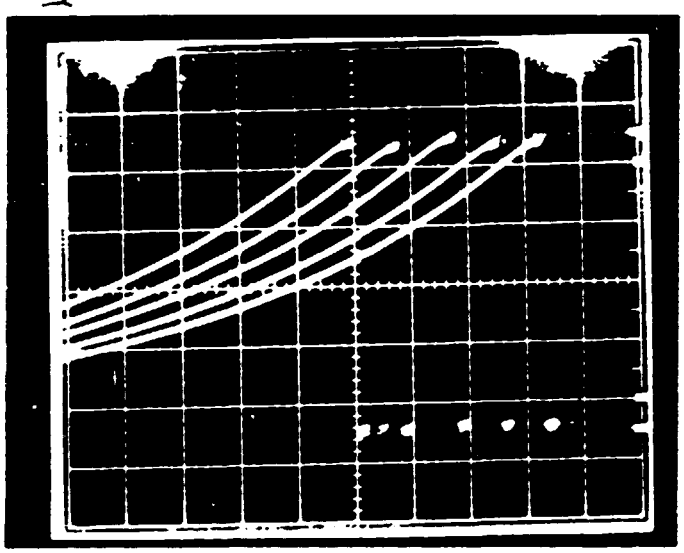
10. CARATTERISTICHE DELL'ONDA DELLA TENSIONE DI PROVA

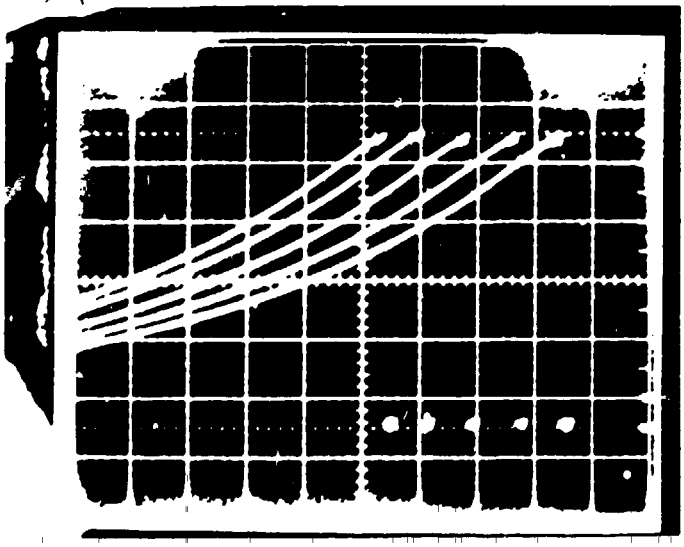


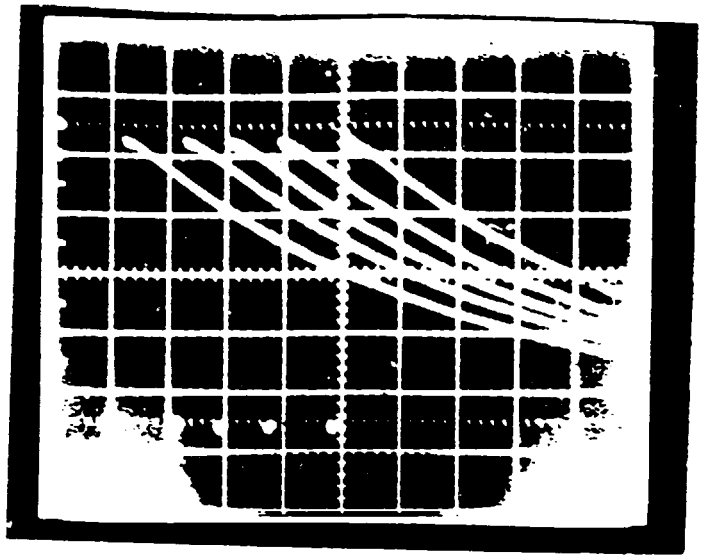
Polarità

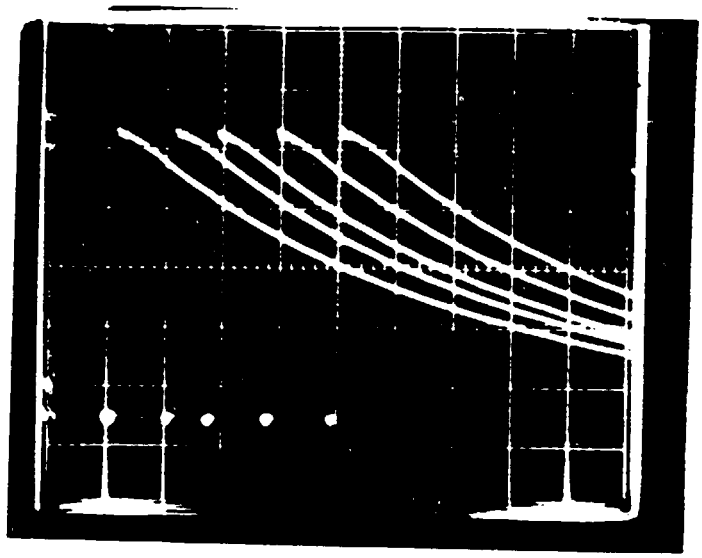


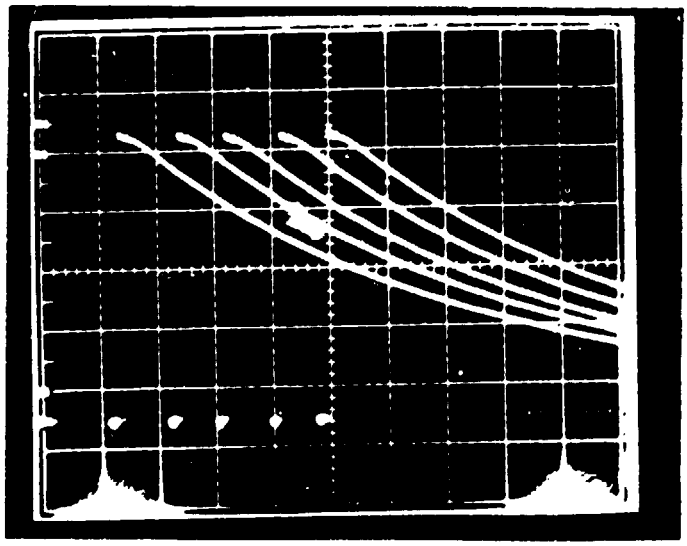












ORE		TEMPERATURE (°C)						sovratemp max custodia (°C)	Misure ai ponte Biff. Tettex 2211 C_N = 10326 pF, r_4 = — Ω, N = — Ω, schema = —, t_g = —, k = 10			
h	prog.	T_1	T_2	T_3	T_4	T_5	T_6		Tensione (V)	Letture		C_x (μF)	100 t_g δ
	28ma												
	+												
	↓												
9,45	25	49,7	49,0	51,3	47,2	46,1	45,9	3,3	10392	417,81		4,305	0,0156
10,45	26	48,6	48,0	50,2	46,4	45,2	45,3	3,0	"	417,84		4,305	0,0156
11,45	27	47,1	46,4	49,3	44,1	42,9	42,9	3,8	"	417,96		4,307	0,0156
12,45	28	49,7	49,4	52,4	47,0	46,4	46,2	3,2	"	417,93		4,306	0,0156
13,45	29	48,3	47,8	50,9	45,4	44,8	44,7	3,3	"	417,91		4,306	0,0156
14,45	30	49,1	49,0	52,0	45,1	44,3	44,3	4,5	"	413,02		4,307	0,0156
	TOTALE												
	58ma												

Cap G = 200 KVAR ; 5,66 KV
PP1 = 13,6 µm ; PP2 = 13,6 µm

REF. N° 07.90-A

ELECTRICAL AND ENVIRONMENTAL DATA

Rated output	199	K.var
Rated voltage	8.66	KV
Rated frequency	50	Hz
Rated capacitance	9.06	µF
Capacitance tolerance	-5	+10%
Minimum capacitance	7.66	µF
Maximum capacitance	8.97	µF
Rated current	21.9	A
Highest system voltage	17.5	
Insulation level	38/95	
Temperature category	-25	+40°C
Service	outdoor	
Altitude	1000	m

INTERNAL CONSTRUCTION

Internal connections

Series sectio	5	
Parallel elements	3	
Element capacitance	15.13	µF
Voltage per series section	1443	V

Dielectric thickness

PP1 weight thickness	13.6	µm
PP1 measured thickness	15	µm
PP2 weight thickness	13.6	µm
PP2 measured thickness	15	µm
Conv. V/µm ref. to W.Th.	53.06	V/µm

Winding data

Space factor ref. to M.Th.	19.5	%
Height of the dielectric	550	mm
Height of margin	12.5	mm
Useful Height	525	mm
Type of winding	EXTENDED FOIL	
Height of aluminium	540	mm
Thickness of aluminium	6	µm
Length of winding	26.0	m
Diameter of mandrel	70	mm
Number of turns	105	

Element dimension

Element Thickness	17.6	mm
Element Width	127.6	mm
Element Height	555	mm

Pack data

Wrapping number of 63 µm paper	50	
Wrapping Thickness	4.7	mm
Pack Length	327.2	mm
Pack Width	128.2	mm
Pack Height	555.0	mm
Pack Length after wrapping	337	mm
Pack Width after wrapping	138	mm
Pack Height after wrapping	580	mm

Case data

Case Material	Alluminium	
Case Thickness	2	mm
Minimum Length of the case	344	mm
Minimum Width of the case	145	mm
Minimum Height of the case	650	mm
Length of the case	343	mm
Width of the case	145	mm
Height of the case	650	mm

Discharge device

Time of discharge	600	s
Residual voltage	75	V
Maximum discharge resistance	12.6	Mohm
N° 0.75 Mohm-850 V resistors	11	
Series connections	11	
Parallel connections	1	

Active and isulation material quantity

Polypropylene 13.6 µm	6.98	kg
Polypropylene 13.6 µm	6.98	kg
Aluminium 6 µm	9.02	kg
Insulation paper 63 µm x 760	1.89	kg
PXE oil	12.51	kg

DATE 05/07/90

DESIGNED BY : Mr DAN

CHECKED BY :

Cap. Q = 300 kvar ; 5,5 KV
PP1 = 15,2 µm ; PP2 = 15,2 µm

REF. N° 07.90-A

CAPACITOR DESIGN

ELECTRICAL AND ENVIRONMENTAL DATA

Rated output	300	kvar
Rated voltage	5.50	kV
Rated frequency	50	Hz
Rated capacitance	15.24	µF
Capacitance tolerance	-5	+10%
Minimum capacitance	14.48	µF
Maximum capacitance	16.76	µF
Rated current	31.2	A
Highest system voltage	7.2	
Insulation level	20/60	
Temperature category	-25	+40°C
Service	Outdoor	
Altitude	1000	m

INTERNAL CONSTRUCTION

Internal connections

Series sections	8	
Parallel elements	1	
Element capacitance	15.24	µF
Voltage per series section	687.5	V

Dielectric thickness

PP1 weight thickness	15.2	µm
PP1 measured thickness	16.8	µm
PP2 weight thickness	15.2	µm
PP2 measured thickness	16.8	µm
Conv. V/µm ref. to W.Th.	51.81	V/µm

Winding data

Space factor ref. to M.Th.	20	%
Height of the dielectric	550	mm
Height of margin	12.5	mm
Useful Height	525	mm
Type of winding	EXTENDED FOIL	
Height of aluminium	540	mm
Thickness of aluminium	6	µm
Length of winding	27.6	m
Diameter of mandrel	70	mm
Number of turns	110	

Element dimension

Element Thickness	20.3	mm
Element Width	130.3	mm
Element Height	555	mm

Pack data

Wrapping number of 63 µm paper	32	
Wrapping Thickness	3.0	mm
Pack Length	334.4	mm
Pack Width	130.9	mm
Pack Height	555.0	mm
Pack Length after wrapping	340	mm
Pack Width after wrapping	137	mm
Pack Height after wrapping	580	mm

Case data

Case Material	Alluminium	
Case Thickness	2	mm
Minimum Length of the case	347	mm
Minimum Width of the case	144	mm
Minimum Height of the case	650	mm
Length of the case	343	mm
Width of the case	145	mm
Height of the case	650	mm

Discharge device

Time of discharge	300	s
Residual voltage	50	V
Maximum discharge resistance	3.3	Mo
N° 0.75 Mohm-850 V resistors	8	
Series connections	8	
Parallel connections	1	

Active and isulation material quantity

Polypropylene 15.2 µm	7.36	kg
Polypropylene 15.2 µm	7.36	kg
Aluminium 6 µm	8.51	kg
Insulation paper 63 µm x 760	1.22	kg
PXE oil	12.30	kg

DATE 05/07/90

DESIGNED BY : Mr DAN

CHECKED BY :

Cap G = 100 KVAR ; 6,3 KV
PP1 = 15,2 µm ; PP2 = 15,2 µm

POWER COMPANY N°3
TESTING CENTRE

REF. N° 07.90-8

LP-1 CAPACITOR DESIGN

ELECTRICAL AND ENVIRONMENTAL DATA		
Rated output	100	kvar
Rated voltage	6.30	kV
Rated frequency	50	Hz
Rated capacitance	8.02	µF
Capacitance tolerance	-5 +10%	
Minimum capacitance	7.62	µF
Maximum capacitance	8.82	µF
Rated current	15.9	A
Highest system voltage	7.2	
Insulation level	20/60	
Temperature category	-25 +40°C	
Service	outdoor	
Altitude	1000	m

INTERNAL CONSTRUCTION		
Internal connections		
Series sections	4	
Parallel elements	1	
Element capacitance	8.02	µF
Voltage per series section	1575	V
Dielectric thickness		
PP1 weight thickness	15.2	µm
PP1 measured thickness	16.8	µm
PP2 weight thickness	15.2	µm
PP2 measured thickness	16.8	µm
Conv. V/µm ref. to W.Th.	51.81	V/µm
Winding data		
Space factor ref. to M.Th.	20	%
Height of the dielectric	350	mm
Height of margin	12.5	mm
Usefull Height	325	mm
Type of winding	EXTENDED FOIL	
Height of aluminium	340	mm
Thickness of aluminium	5	µm
Length of winding	23.5	m
Diameter of mandrel	62.5	mm
Number of turns	104	

Element dimension		
Element Thickness	18.8	mm
Element Width	117.0	mm
Element Height	355	mm
Pack data		
Wrapping number of 63 µm paper	32	
Wrapping Thickness	3.0	mm
Pack Length	310.7	mm
Pack Width	117.6	mm
Pack Height	355.0	mm
Pack Length after wrapping	317	mm
Pack Width after wrapping	124	mm
Pack Height after wrapping	380	mm
Case data		
Case Material	Alluminium	
Case Thickness	2	mm
Minimum Length of the case	324	mm
Minimum Width of the case	131	mm
Minimum Height of the case	450	mm
Length of the case	325	mm
Width of the case	145	mm
Height of the case	650	mm
Discharge device		
Time of discharge	300	s
Residual voltage	50	V
Maximum discharge resistance	6.2	Mohm
N° 0.75 Mohm-850 V resistors	8	
Series connections	8	
Parallel connections	1	

Active and isulation material quantity		
Polypropylene 15.2 µm	3.98	kg
Polypropylene 15.2 µm	3.98	kg
Aluminium 5 µm	3.80	kg
Insulation paper 63 µm x 560	0.83	kg
PXE oil	19.12	kg

DATE 05/07/90

DESIGNED BY : Mr DAN

CHECKED BY :

Cap. C = 200 KVAR ; 8,66 KV
PP1 = 14,5 µm ; PP2 = 13,6 µm

REF. N° 7.90

CAPACITOR DESIGN

ELECTRICAL AND ENVIRONMENTAL DATA			Element dimension		
Rated output	194	kvar	Element Thickness	17.6	mm
Rated voltage	8.66	kV	Element Width	127.5	mm
Rated frequency	50	Hz	Element Height	606	mm
Rated capacitance	8.23	µF			
Capacitance tolerance	-5	+10%	Pack data		
Minimum capacitance	7.82	µF			
Maximum capacitance	9.05	µF	Wrapping number of 63 µm paper	50	
Rated current	22.4	A	Wrapping Thickness	4.1	mm
Highest system voltage	17.5		Pack Length	327	mm
Insulation level	38/95		Pack Width	128	mm
Temperature category	-25	+40°C	Pack Height	606	mm
Service	outdoor		Pack Length after wrapping	335	mm
Altitude	< 1000	m	Pack Width after wrapping	136	mm
			Pack Height after wrapping	630	mm
INTERNAL CONSTRUCTION					
			Case data		
Internal connections					
			Case Material	Alluminium	
Series sections	6		Case Thickness	2	mm
Parallel elements	3		Minimum Length of the case	342	mm
Element capacitance	15.47	µF	Minimum Width of the case	143	mm
Voltage per series section	1443	V	Minimum Height of the case	700	mm
			Length of the case	343	mm
Dielettric thickness			Width of the case	145	mm
			Height of the case	700	mm
PP1 weight thickness	14.5	µm			
PP1 measured thickness	15	µm	Discharge device		
PP2 weight thickness	13.6	µm			
PP2 measured thickness	15	µm	Time of discharge	600	s
Conv. V/µm ref. to W.Th.	51.36	V/µm	Residual voltage	75	V
			Maximum discharge resistance	12.4	Moh
Winding data			N° 0.75 Mohm-850 V resistors	11	
			Series connections	11	
Space factor ref. to M.Th.	20	%	Parallel connections	1	
Height of the dielectric	600	mm			
Height of margin	12.5	mm	Active and isulation material quantity		
Usefull Height	575	mm			
Type of winding	EXTENDED FOIL		Polypropylene 14.5 µm	7.85	kg
Height of aluminium	590	mm	Polypropylene 13.6 µm	7.36	kg
Thickness of aluminium	6	µm	Aluminium 6 µm	9.52	kg
Length of winding	25.2	m	Insulation paper 63 µm x 810	2.00	kg
Diameter of mandrel	70	mm	PXE oil	13.39	kg
Number of turns	102				

DATE 05/07/90

DESIGNED BY : Mr DAN

CHECKED BY :