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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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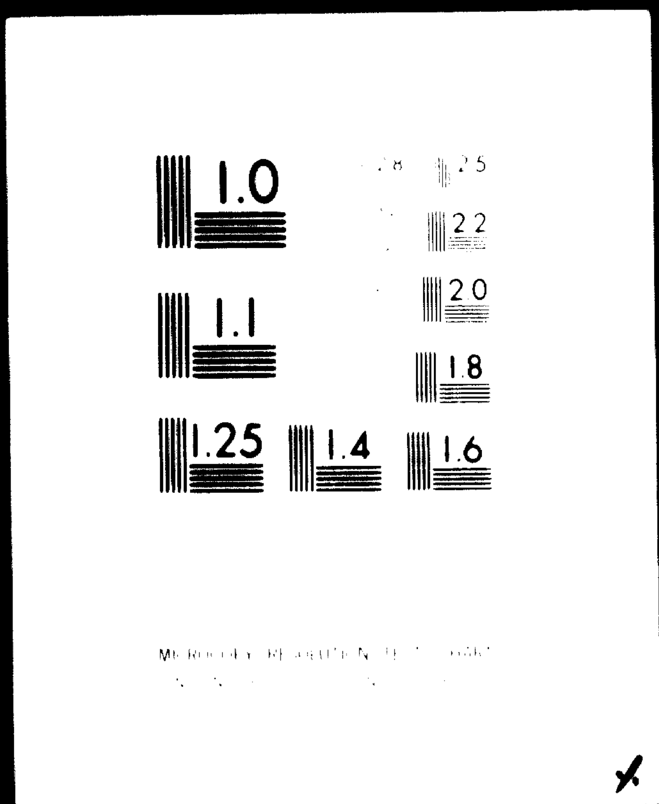

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SECOND EQUIPMENT REPORT

FOR

HIGH VOLTAGE LABORATORY

02252

(1 of 2)

UNIDO CONTRACT 72/17

To
UNITED NATIONS
INDUSTRIAL DEVELOPMENT
ORGANIZATION

For
SPAIN ELECTRICAL TESTING AND
EXPERIMENTATION CENTRE

Prepared by
Lalonde Girouard Letendre & Associates Ltd
in Association with IREQ
Montreal, Canada

September 1973

SECOND EQUIPMENT REPORT

TO

UNIDO (CONTRACT 72/17)

FOR

HIGH VOLTAGE LABORATORY

IN

MADRID

SPAIN

Lalonde Girouard Letendre & Associates Ltd
in Association with IREQ
Montreal, Canada

LALONDE, GIROUARD, LETENDRE & ASSOCIATES LTD.

CONSULTING ENGINEERS

8790 PARK AVENUE
MONTREAL 354, CANADA
TELEPHONE (514) 384-6410

Montreal, September 7, 1973

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Lerchenfelderstrasse, 1
Vienna, AUSTRIA.

Att.: Mr. D.C. Newton, Chief, Technical Equipment
Procurement and Contracting Office.

Subject: SPAIN: Electrical Industry Test Experimentation Centre
UNIDO Contract No. 72/17 - Project No. SF SPA-012

Gentlemen:

Please find herewith the Second Equipment Report which covers the specifications of all other items of equipment for the laboratories that have not been included in the First Equipment Report dealing with equipment of long delivery.

This Report is presented in two volumes: one covering the High Voltage Laboratory, the other the High Power Laboratory. A list of basic instrumentation has also been added with suggested suppliers and approximate value.

As we have mentioned in other documents, these reports have to be read carefully in conjunction with the Final Building Report by the Consultants whose services will be retained for the final design for the construction of the building.

It was indeed a pleasure to perform this most challenging study on your behalf and we may assure you of our sustained interest in this project.

Yours very truly,

Jean-Paul Lalonde, Engineer.

JPL/cl

Copies: Unido - Vienna (6)
Project Manager in Madrid (2)
Spanish Government (10)

TECHNICAL SPECIFICATIONS

HIGH VOLTAGE LABORATORY

78 MVA 100 kV test transformer	HV 14
3 MVAR 3 phase 200 Hz reactor bank	HV 15
3.5 MV Voltage dividers	HV 16
Artificial rain apparatus	HV 17
Six single phase current transformers	HV 18
Six single phase potential transformers	HV 19
Three 1.33 MVA single phase voltage regulators	HV 20
Two 350 kVA single phase voltage regulators	HV 21
Two high voltage construction kits	HV 22
1.33 MVA, 200 Hz rotating machines	HV 23
350 kVA, 50 Hz, 60 Hz, rotating machines	HV 24
350 kVA, 275 kV, single phase test transformer	HV 25
Transformer bushing test tank	HV 26
Impulse current shunts	HV 27
Oil treatment equipment	HV 28
Transport and general purposes equipment	HV 29
Instrumentation	HV 30

NOTE: HV 14, HV 15, HV 16, replace
HV 10, HV 11, HV 3 in the first equipment report.

HV 14

[illegible] MVA [illegible] KV TEST TRANSFORMER

CONTENTS

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2.- GENERAL DESCRIPTION

3.- CHARACTERISTICS AND DESIGN FEATURES

4.- SPARE PARTS AND TOOLS

5.- TECHNICAL DATA

6.- TEST SPECIFICATIONS

QUESTIONNAIRE ON TECHNICAL DATA

APPENDIX 1

APPENDIX 2

APPENDIX 3

1.- SCOPE

This specification sets out requirements for the supply of a three phase 5.0/20.0/20-100 kV - 6/72/78 MVA coupling transformer capable of operating at 50, 60 and 200 Hz.

2.- GENERAL DESCRIPTION

The coupling transformer will connect different sources to transformers on which heat runs, open-circuit, short-circuit or induced overvoltage withstand tests are performed.

Inductive or capacitive compensation will be used to limit the load on the source in use. The load may, however, have any power factor from zero leading to zero lagging. A wide range of output voltages will be required and it is proposed to achieve this by using tapped windings delta and wye connected on the H.V. winding.

The coupling transformer will be operated outdoors and installed on a concrete base.

Details of the sources to be used with the coupling transformer are given below:

.../2

(1) 3 single phase regulating transformers in three phase delta or parallel single phase connections with a total capacity of 4 MVA, 0 to 5 kV, 50 Hz.

(2) 1 three phase generator, used at times single phase in parallel with 3 MVAr reactor bank for compensation on a capacitive load.
The generator is a 1 MVA 0 to 5 kV, 3 ph., 200 Hz unit.
The various impedances will be in the order of:

xd: 60%

x'd: 15%

x"d: 10%

(3) When 60 Hz is necessary it will be derived from an alternator that has not been yet specified totally.
It is expected that the three phase capacity of this alternator will be approximately 15 MVA at 5 kV.

(4) A 40 MVAr capacitor bank will be connected to the tertiary winding at the beginning with a possible expansion to 72 MVAr in the future.
These capacitors will be used for compensation on an inductive load.

.../3

3.- CHARACTERISTICS AND DESIGN FEATURES

The transformer shall have three windings and shall be oil-immersed and forced air-cooled. The following characteristics are desired. Some departures from these may be acceptable but reasons must be given in reply to the questionnaire on technical data in the form of the Tender.

3.1 Rated Data

The following apply to three-phase operation at 50 Hz.

Rated frequency: 50 Hz

Primary winding voltage: Delta-connected 5.0 kV line-line.

Primary winding rating: 6 MVA

Secondary winding voltages: Delta connected 20-57.7 kV line - line with 19 equal steps of voltages. Star connected 34.6-100 kV line - line with 19 equal steps of voltages.

Secondary winding rating: Not less than 78 MVA at any voltage above 28 kV for delta, or 48.5 kV for star connection and not less than 70 MVA at any voltage in the specified range.

Tertiary winding voltage: 20.0 kV delta connected.

Tertiary winding rating: 72 MVA.

.../4

<u>**The following apply to three-phase operation at 200 Hz.**</u>

Frequency: 200 Hz

Primary winding voltage: As for 50 Hz

Primary winding rating: As for 50 Hz.

Secondary winding voltage: As for 50 Hz

Secondary winding rating: Not less 6 MVA

Tertiary winding voltage: As for 50 Hz

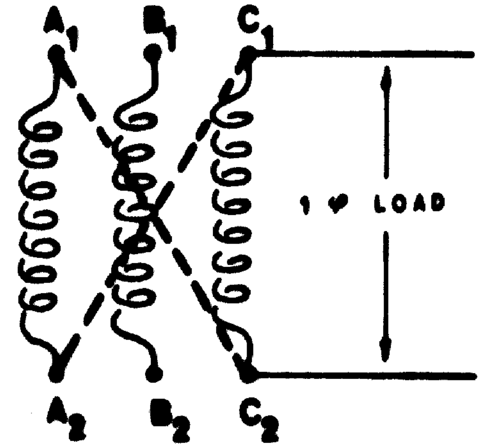
Tertiary winding rating: Not less than 6 MVA

<u>**Single phase operation**</u>

The transformer will also be used to feed single phase loads and will be connected as the following:

a) 3 phase supply on the primary winding and the single phase load connected to two of the terminals on the secondary winding or/and on the tertiary winding. At both frequencies 50 and 200 Hz the ratings of all windings should be at least equal to or better than 57% of the three phase rating.

b) The transformer bushings will have to be located in such a way as to easily reconnect it for operation as a single phase transformer using two phases in parallel. The following diagram illustrates this point.



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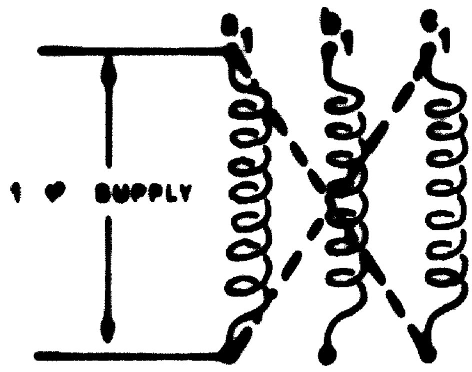

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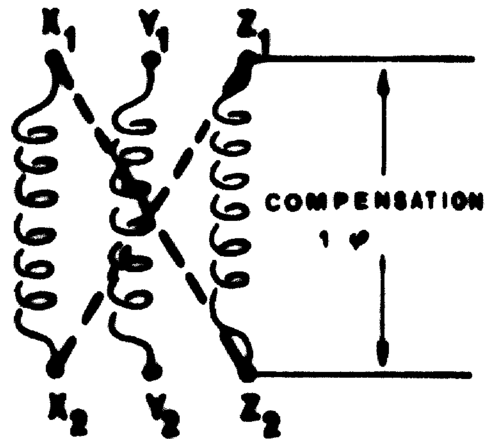


3

The transformer shall be capable of operating continuously with its primary winding energised at 1.05 times rated voltage.

3.2 <u>Short time ratings</u>

The transformer shall be capable of operating at 150% of rated load at 50 and 200 Hz for at least three minutes.

.../6

The Tenderer shall state the thirty minute rating applicable to the transformer at 50 Hz and 200 Hz single-phase and three-phase.

The Tenderer shall state the cooling interval necessary between successive periods of operation under each short-time rated condition.

3.3 <u>Winding connections and insulation</u>

The windings shall be so insulated that one terminal may be grounded at any time.

The transformer shall be able to withstand switching surges on the primary and overvoltages due to flashover or puncture of the insulation under test. The transformer's windings shall be protected by suitable surge diverters (of a resealing type) to be provided by the Tenderer. The windings shall have the following insulation levels.

WINDING	System Highest Voltage	Power Frequency Test Voltage	Impulse Test Voltage
Primary	5.0 kV	19 kV	75 kV
Secondary	100 kV	185 kV	450 kV
*Secondary	58 kV	120 kV	300 kV
Tertiary	20 kV	50 kV	150 kV

* If the transformer is so built that the same end of the secondary winding is always at the neutral connection, then this end can have a lower level of insulation as shown above.

3.4 Impedances

The short-circuit impedances between secondary and tertiary windings shall not, for any connection or any output voltage, exceed 10% on the three-phase 78 MVA rating.

It is recognized that this requirement may present manufacturing difficulties. Should the Tenderer find it necessary to exceed the specified impedance limit, a clear statement to this effect shall be made. Full details of the proposed impedances shall be given and the reasons for departure from the specification shall be stated.

3.5 Short-circuit capacity

The transformer shall be built to withstand any short-circuit which may occur in service. In particular, when energized at its primary winding at rated voltage from a source having negligible impedance, the transformer shall be capable of withstanding for three seconds a symmetrical short-circuit applied at either its secondary or tertiary terminals with the windings and tappings arranged to maximize the short-circuit current.

.../8

A typical load then could be full capacitive load on the tertiary and full inductive load on the secondary.

3.6 Harmonic content of the output voltage

The harmonic content of the secondary voltage shall be as small as practicable. The relative harmonic content D is given by:

$$D = 100 \left[\sum_{n=2}^{\infty} V_n^2 \right]^{1/2} / V_1 \ \%$$

where V_n is the rms value of the n_{th} harmonic and V_1 is the rms value of the fundamental voltage.

In no case for either single-phase or three-phase operation shall the value of D exceed 1%.

3.7 Partial discharges

The transformer will be used as a power supply during low-level partial discharge measurements and shall be virtually free from internal and external partial discharges up to 1.2 times rated voltage. The permissible magnitude of partial discharges may be subject to discussions with the Purchaser but values not exceeding a few pC are desired.

3.8 Audible Noise

The audible noise generated by the transformer and its audiliaries shall be as per NEMA Publication TR-1-1971, table 0-1.

3.9 Temperature Rise

The limits of permissible temperature rise shall be those set out in Section 6 of IEC Publication 76/1967 Power Transformers.

3.10 Cooling

ONAF cooling as defined in IEC Publication 76/1967 shall be employed. Operation of the fans shall be controlled automatically by the thermal protection of the transformer.

.../10

3.11 Terminals

The following shall be supplied:

a) Primary winding: Six bushings with appropriate links to operate three phase delta or single phase as per item 3.1 (b).

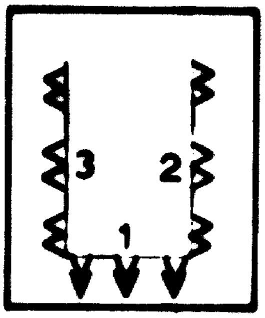
b) Secondary winding: Six bushings with appropriate off-load motor operated switch to operate star or delta and appropriate links to comply with single phase operation as per item 3.1 (b).

c) Tertiary winding: Six bushings with appropriate links to operate three phase delta or single phase as per item 3.1 (b).

Terminal boxes for the connection of auxiliary supplies wiring for control indication and protection shall be provided. These shall permit the connection of a number of flexible multipair cables to the transformer auxiliaries and shall be mounted within 1.5 meter of base level. All live metalwork bushings etc. located less than 3 meters above base level shall be enclosed. The desired relative positions of bushings are shown in Fig. 1 below.

.../11

Each secondary winding bushing must be provided with a foil tapping for use in voltage measurement.



1.- Primary winding

2.- Secondary winding

3.- Tertiary winding

3.12 <u>Voltage adjustment and selection of winding connections</u>

Where necessary for voltage adjustment, tap changing shall be effected by remotely controlled, motor-operated, off-circuit-tapping switches. The control equipment to be mounted on a modular control desk as shown in Appendix 1 attached.

.../12

The selection delta or star on the secondary winding will also be remotely controlled at the control desk but will also have a local manual operating mechanism on the transformer.

3.13 Protection

The protection of the transformer shall comprise the following. The appropriate equipment shall be offered by the Tenderer.

a) Overcurrent protection

This protection must be effective for any connection of the transformer. For this reason each winding of the transformer shall be equipped with suitable C.T.'s. Suitable overcurrent relays operating at 50 Hz/200 Hz shall be supplied. The overcurrent relays will operate the trip-circuit of the main breaker.

b) Gas relay

Protection of the transformer by a gas relay equipped for oil surge and having two floats for gas accumulation and for low oil level is also required. The gas relay shall have a check-cock for gas sampling and for testing purposes.

.../13

c) Thermal protection

An oil thermometer as well as a thermal image thermometer shall be provided. The oil thermometer could be provided with only one contact with adjustable setting used for the operation of an acoustical and/or a visual alarm.

The image thermometer must be equiped with two contacts with adjustable settings, one supplying an alarm signal and the second the trip-circuit of the main breaker.

d) Position of the tap-changer and the reconnection switches

A signal indicating the position of the tap-changer and/or the disconnect switches by which the connection of the windings of the transformer are changed, shall be provided. This signal will be used to indicate the current status of the winding-connection.

e) Interlocking of tap-changer and reconnection switches with the main breaker.

Suitable interlockings shall be provided, to prevent the operation of the tap-changer or the reconnection switches with the transformer energized. Also, it shall not be possible to operate the main breaker unless the tapping and winding connection switches have completed their operation.

.../14

All controls, interlocks or protection cables as well as power cables shall be terminated on a panel, fixed to the transformer. The panel shall have suiteble terminations where multicolored cablee could be plugged in.

f) Dryer

The transformer shell be equipped with a dryer of the silica-gel type or equivalent.

g) Lightning arresters

See section 3.3.

h) Equipment

All remote control and indication equipments have to be supplied end mounted on a control panel as shown on Appendix 1.

3.14 Climatic conditions

The transformer will be operated outdoors. The following conditions may be anticipated:

Temperature: - 5°C to + 37°C

Humidity : 10% to 100%

Wind : Average velocities 30 m/s with gusts of 35 m/s.

3.15 Aesthetics, colours

Importance is attached to the aesthetics of the design. Conventional brown glazed porcelain is preferred for bushings and the colour of other parts will be determined after the order has been placed.

3.16 Safety of personnel

The transformer shall be designed with normal regard for the safety of persons working in its vicinity.

3.17 Auxiliary supplies

The following will be available:

a) 230/380 V Y connected 50 Hz.

b) 125 V DC (battery) for circuit-breaker tripping signals, etc.

3.18 Transformer oil

The transformer shall be supplied together with its first filling of oil. The oil shall comply with specifications laid out in Appendix 3 or be miscible with it.

Suitable valves to permit filling and subsequent filtering of the oil shall be fitted to the transformer.

Cocks to permit the taking of oil samples at three levels within the transformer tank shall be fitted.

4.- SPARE PARTS AND TOOLS

4.1 The Tenderer shall furnish a list of recommended spare parts with separate prices for each item. The price of spare parts shall NOT be included in the total price quoted.

4.2 Tools

All special tools required for the operation and maintenance of the transformer and its auxiliaries shall be supplied by the Tenderer and their price stated separately and included in the total price quoted.

5.- TECHNICAL DATA

The following are required.

.../17

5.1 Dimensions and Weight

The Tenderer shall supply outline drawings indicating the overall dimensions of the transformer and its base frame together with the following weights:

a) Weight of core & core clamps.

b) Weight of windings.

c) Weight of oil.

5.2 Flux density

The maximum flux density for each operating connection set out in 3.0 shall be stated by the Tenderer.

5.3 Magnetizing current

The magnetizing current correponding to each of the following operating conditions at 100% and 110% of rated voltage shall be stated in the Tender.

a) Three-phase operation, 50 Hz.

b) Three-phase operation, 200 Hz.

c) Single-phase operation, 50 Hz.

d) Single-phase operation, 200 Hz.

.../18

5.4 No-load losses and full-load losses

The values of no-load losses at 100% and 110% of rated voltage and the values of load-losses at nominal current shall be stated and guaranteed by the Tenderer for each of the following conditions:

a) Three-phase operation at 50 Hz.

b) Three-phase operation at 200 Hz.

c) Single-phase operation at 50 Hz.

d) Single-phase operation at 200 Hz.

6.- TEST SPECIFICATIONS

6.1 Standards

Except where otherwise specified herein, the transformer and its auxiliaries shall comply with the recommendations of IEC Publication 76/1967.

Unless otherwise stated by the Purchaser, the Tenderer shall comply with the standards defined in this document.

6.2 Routine tests

All of the routine tests set out in IEC Publication 60, shall be applied to the transformer.

.../19

6.3 Type tests

The following type tests shall be applied:

Temperature rise tests at rated load under conditions of tapping and winding arrangement leading to maximum copper losses.
Temperature rise tests at rated load under conditions of tapping and winding arrangement to maximum total losses.

6.4 Special tests

Impulse voltage withstand tests including chopped wave impulses on each winding of phase at the levels set out in section 3.

Partial discharge measurements shall be carried out on the transformer at 100% and 120% rated voltage. A method which permits determination of the charges and repetition rates of individual discharges shall be used: see IEC Publication 270, 1968.

A noise level measurement shall be made with the transformer operating at rated voltage together with all of its auxiliaries. This measurement shall be made in accordance with NEMA Standard TRI, 1968.

The harmonic content of the output voltage of the transformer shall be measured with a wave analyser. All harmonics up to at least the 23rd shall be measured and the results included in the test report.

.../21

TECHNICAL DATA CONCERNING THE PROPOSED EQUIPMENT AND FORMING A PART OF OUR TENDER.

A three-phase 5.0/20.0/20 - 100 kV, 6/72/78 MVA coupling transformer capable of operating at 50 and 200 Hz.

1.- GENERAL DESCRIPTION

Description
enclosed ____________________

Drawings
enclosed ____________________

2.- RATED DATA

2.1 Three-phase operation at 50 Hz

a) Primary winding

Rated phase to phase voltage

____________________ kV

Rating

____________________ MVA

Type of connection

____

b) Secondary winding

Rated line to line voltage,

max. and min.

Star________________kV Delta________________kV

Number of steps__________________________________

I) Voltage above 28 kV delta or 48.5 kV star

II) Voltage between condition (I) and 20 kV

delta or 34.6 kV star.

I)________________MVA II)______________MVA

c) Tertiary winding

Rated phase to phase voltage

Delta______________________________________kV

Delta______________________________________MVA

2.2 Three-phase operation at 200 cycles

a) Primary winding

Rated line to line voltage

____kV

Rating

____MVA

Type of connections

____

b) Secondary winding

Rated line to line voltage,

max. and min.

Star____________________kV Delta_________________kV

Number of steps____________________________________

Voltage difference between two consecutive steps of

voltage

Star____________________kV Delta_________________kV

Rating

Star____________________MVA Delta_________________MVA

c) Tertiary winding

Rated line to line voltage,

Delta____kV

rating

Delta____MVA

2.3 Single phase operation 50 and 200 Hz

a) Primary winding

Rating when connected as per paragraph 3.1 (a) of the

specification.

50 Hz____________________MVA 200 Hz_________________MVA

as per paragraph 3.1 (b)

50 Hz____________________MVA 200 Hz_________________MVA

.../24

b) **Secondary winding**

Rating when connected as per paragraph 3.1 (a) of the specification

50 Hz________________MVA 200 Hz_______________MVA

as per paragraph 3.1 (b)

50 Hz________________MVA 200 Hz_______________MVA

c) **Tertiary winding**

Rating when connected as per paragraph 3.1 (a) of the specification

50 Hz________________MVA 200 Hz_______________MVA

as per paragraph 3.1 (b)

50 Hz________________MVA 200 Hz_______________MVA

3.- OUTPUT

3.1 Percentage of rated output under the following condition:

Primary winding energized at 1.05 times rated voltage.

Curve

enclosed____

3.2 Permissible short-time rating

Description

enclosed____

3.3 Short-circuit capacity
(Critical arrangement to be specified)

Description

enclosed____

4.- IMPEDANCE

4.1 Maximum impedance between pairs of windings based on the three-phase rating.

78 MVA____

Arrangement for maximum impedance (re. connections and tapping on the secondary).

Description

enclosed____

5.- PROTECTION

5.1 Short-circuit protection for winding of the secondary

Description

Enclosed____

5.2 Types of surge diverters and features

Description

enclosed____

5.3 Types of relays used for overcurrent protection

Description

enclosed ____

5.4 Type of gas relay

Description

enclosed ____

5.5 Type of detector and indicator used for thermal protection.

Description

enclosed ____

6.- INSULATION CLASS OF WINDINGS

Description

enclosed ____

7.- PERMISSIBLE TEMPERATURE RISE

Description

enclosed ____

.../27

8.- NUMBER OF TERMINALS PER WINDINGS AND THEIR LOCATION OF THE TRANSFORMER.

Description

enclosed ______________________________

9.- REMOTE CONTROL OF TAP CHANGER

a) Type of control

Description

enclosed ______________________________

b) Equipment provided to prevent operating of tap changer when transformer is energized.

Description

enclosed ______________________________

c) Type of indication used to show position of tap-changer

Description

enclosed ______________________________

10.- CHANGE OF WINDING CONNECTIONS

a) Description of proposed arrangements

secondary winding ______________________________

tertiary winding ______________________________

Specify method used to show winding arrangement.

...28

b) Interlocking procedure to prevent operation of the selector when transformer is energized.

Description

enclosed____

11.- DRYER

Type used

Description

enclosed____

12.- AUXILIARY SUPPLIES REQUIRED

__________V_______________A______________ϕ____________Hz

__________V_______________A______________ϕ____________Hz

13.- AMPLITUDE OF PARTIAL DISCHARGE AT 1.2 TIMES RATED VOLTAGE

____%

14.- VALUE OF "D" (Re. Item 3.6 of the Specification).

____%

15.- NOISE LEVEL

____dB

16.- OUTDOOR OPERATION

a) General description

enclosed______________________________________

b) Extreme atmospheric conditions for outdoor operation

____

c) Extreme atmospheric conditions for outside storage

____

d) Permissible wind velocity

____m/s

e) Permissible gust velocity

____m/s

17.- SAFETY MEASURES FOR PROTECTION OF PERSONNEL

Description

enclosed______________________________________

18.- TECHNICAL DATA (Re. Items 5.1 at 5.4 inclusive of Specification)

Description

enclosed ________________________________

19.- TESTS

a) Temperature rise tests

i) Critical conditions of connections and secondary tapping for tests leading to maximum copper losses.

Description

enclosed ________________________________

ii) Critical conditions of connettions and secondary tapping for tests leading to maximum total losses.

Description

enclosed ________________________________

b) Types of tests proposed for measurements of harmonic content at the secondary.

____

20.- LIST AND DESCRIPTION OF ACCESSORIES

Description

enclosed_______________________________________

21.- LIST OF PROPOSED SPARE PARTS AND PERTINENT DETAILS

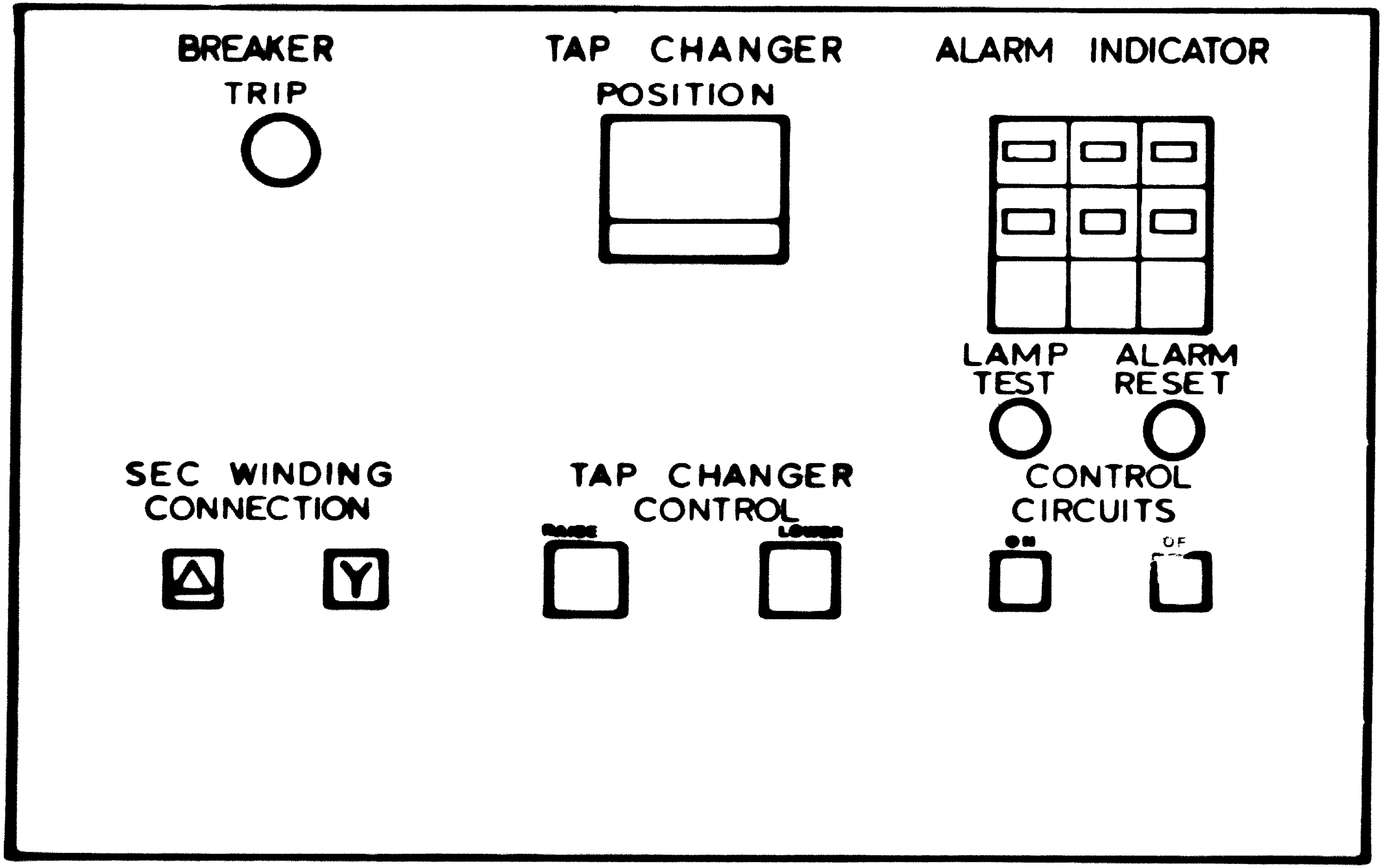
Description

enclosed_______________________________________

22.- SPECIAL MAINTENANCE TOOLS REQUIRED

Description

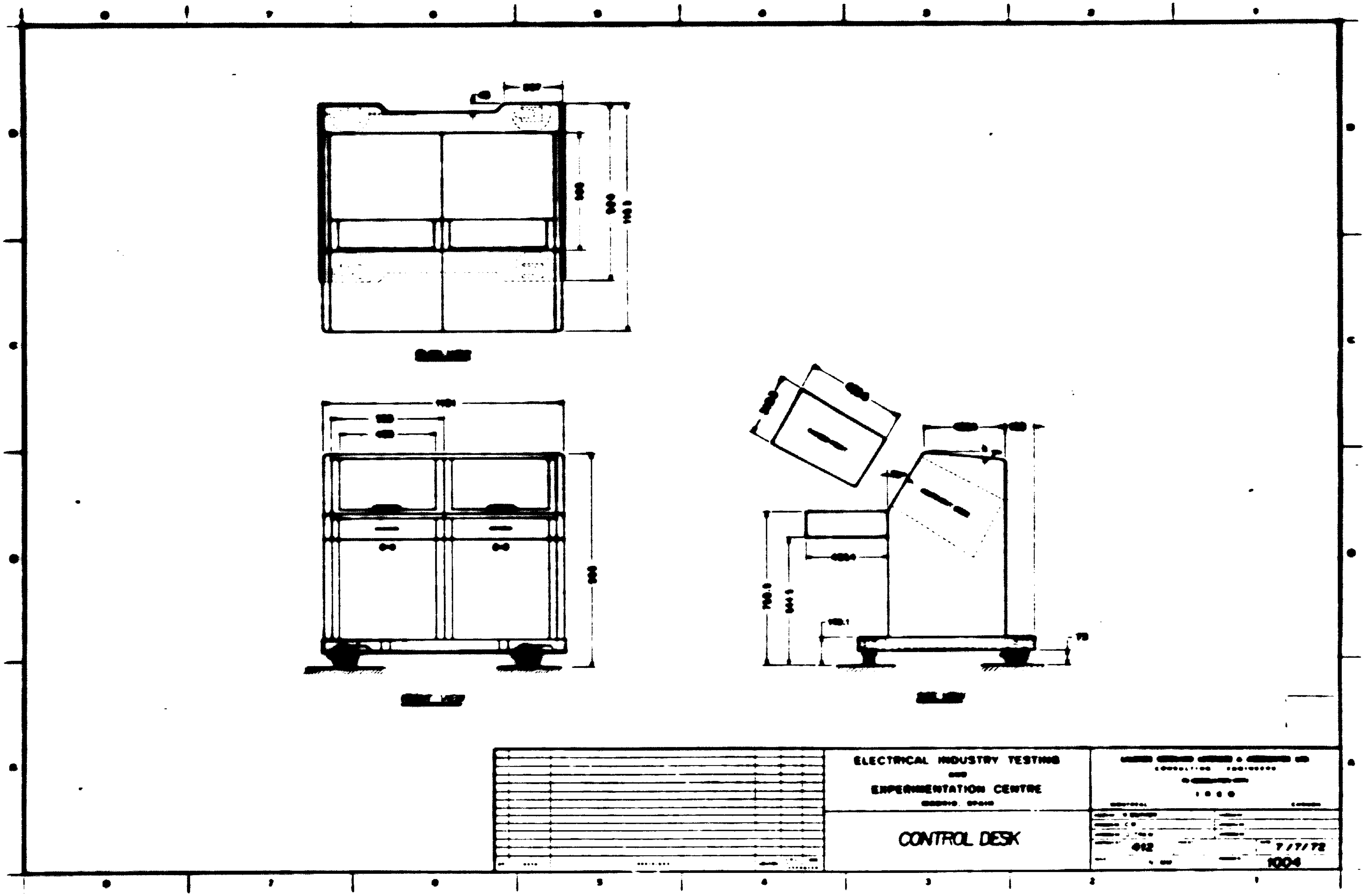
enclosed_______________________________________



APPENDIX - 1 - (CONTROL PANEL LAYOUT)

NOTES: - All pushbuttons except BREAKER TRIP are of the illuminated type
- See appendix - 2 - for panel dimensions

HV 14



APPENDIX - 2 - (CONTROL PANEL LAYOUT)

APPENDIX 3

ACEISTE REPSOL TENSION (Mémo)

(Information concerning insulating oil)

SPECIFICATIONS

TEST	METHOD	VALUES
Density at 15°C	ASTM-D-1298	0.855 - 0.865
Inflamability V/A, °C	ASTM-D-92	165 minimum
Engler Viscosity at 50°C	Engler	1.3 - 1.9
S_1S_1V Viscocity at 210°F	ASTM-D-446	36.0 - 38.0
C_1S Viscosity at 210°F	ASTM-D-445	2.92 - 3.52
Colour	ASTM-D-1500	1.5 maximum
Freezing	ASTM-D-97	-26 maximum
Neutralization degree	ASTM-D-974	0.05 maximum
Saponification degree	ASTM-D-94	to be fixed later
Ash, %	ASTM-D-482	0.005 maximum
Dielectric Rigidity, kV	ASTM-D-877	35 minimum
Corrosive Sulphur	ASTM-D-1275	1 maximum
Deposit: 72 hours	ASTM-D-1214	0.075 maximum
: 168 hours	-	0.150 maximum (1)
Interfacial strain	ASTM-D-1971	45 minimum (2)
Contents in DBPC, %	ASTM-D-1473	0.4 - 0.6
Tangent δ	-	0.0004 minimum

(1) guide value

(2) to be determinated optionally

HV 15

3 MVAR 1 PHASE 50 HZ REACTOR BANK

CONTENTS

1.- OBJECT

2.- GENERAL DESCRIPTION

3.- CHARACTERISTICS

4.- STANDARD SPECIFICATIONS AND TESTS

5.- INFORMATION REQUIRED WITH TENDERS

QUESTIONNAIRE ON TECHNICAL DATA

APPENDIX 1

1.- OBJECT

This specification covers the Spanish Government's requirements for the construction and supply of a 3 MVAr, three phase, 200 Hz reactor bank. The unit shall consist of three single phase units housed in the same tank.

2.- GENERAL DESCRIPTION

The reactors will be used to compensate for capacitive loading during high-frequency induced voltage tests on power transformers. The reactors will be used as a three-phase or as a single phase bank and will be housed outdoors. In view of their proposed use a short-time rating is acceptable. ONAN cooling (see IEC Publication 76, 1967), is desired.

3.- CHARACTERISTICS

The following characteristics are desired. Some deviations may be permitted but reasons should be stated in the reply to the questionnaire on technical data.

.../2

3.1 Rated data

Nominal rated frequency: 200 Hz

Rated voltage : 5 kV single phase

5 kV, three-phase, delta connected.

Rating of bank : 3 MVAr single or three-phase.

3.2 Windings and operating range

It is desired that each phase of the reactor bank will have two 0.5 MVAr, 5 kV windings to be connected in parallel by means of exterior links.

The reactors shall be capable of operating at rated voltage and at nominal frequency minus five per cent.

The reactors shall be capable of operating at rated frequency and at rated voltage plus five per cent.

3.3 Basis of rating and losses

The Tenderer shall submit two offers, one based on a one-hour rating and one based on a continuous rating.

.../3

A copy of the questionnaire on technical data shall be completed for each design offered.

The Tenderer shall state the cooling time necessary between successive periods of operation under short time rated conditions.

The Tenderer shall state the following:
Maximum copper losses at rated frequency.
Maximum iron losses at rated frequency.
Maximum total losses at rated frequency.

The following losses shall be guaranteed:
Maximum total losses at rated frequency.
Total losses at rated frequency under conditions of maximum copper losses.
Total losses at rated frequency under conditions of maximum iron losses.

3.4 <u>Protection and metering</u>

An overcurrent protection consisting of one built-in current transformer on one of the two windings of each phase and suitable protection relays shall be included in the tender.

The tank will be equipped with a gas relay (Buchols) having provision for operation on oil surges and gas accumulation.

A thermal image protection is also required.

3.5 Winding insulation and terminals

The windings shall be insulated in accordance with IEC Publication 76, 1967.

Since the reactors may be operated as a star connected three phase bank at 8.66 kV line to line the following insulation levels have been chosen:

Low frequency test level : 26 kV

Impulse voltage test level: 95 kV.

In addition it is required that any terminal of any winding is capable of operating at 5.0 kV with respect to earth.

Each phase of the reactor bank shall have four bushings and parallel connections shall be made by means of hand-operated link switches.

.../5

Accessibility of connections, simplicity of operation and safe enclosure or positioning of line terminals are considered essential.

All special tools, links or accessories needed to change the winding connections shall be included in the basic price.

3.6 Cooling, tanks and oil

The method of cooling shall be natural oil and air circulation (Type ONAN).

Unless the reactors have permanently sealed tanks, they shall be supplied with valves suitably placed to facilitate oil sampling and filtration.

The reactors tank shall be suitable for installation on a concrete base.

The colour of the tanks and metalwork shall be determined by the Purchaser at a later date.

If mineral oil insulation is to be supplied the oil shall comply with specifications layed down in appendix 1 or be miscible with it.

.../6

3.7 Atmospheric conditions

The range of ambient temperatures expected is - 5 to + 37°C.

The range of ambient relative humidities expected is 10 to 100%.

The maximum expected wind velocity is 30 m/sec.

4.- STANDARD SPECIFICATIONS AND TESTS

All tests will be performed at the manufacturers expense .

4.1 Standard specifications

Unless otherwise specified the reactors shall comply with the relevant provisions of IEC Publication 76, 1967.

4.2 Tests

The Tenderer shall list the tests to be applied to the reactors. The Purchaser may require that the list be modified or extended and may at his own expense repeat certain of the tests before final acceptance.

.../7

The reactor bank shall be virtually free of internal and external partial discharges up to 1.2 times rated voltage (6.0 kV) line to neutral. The permissible magnitude of partial discharges may be subject to discussion; values not exceeding a few pC are desired.

Partial discharge test shall be made by a method permitting the sizes and repetition rates of individual discharges to be determined, see IEC Publication 270; 1968.

A temperature rise test shall be applied to at least one unit of the bank.

Impulse voltage tests shall be applied to the three units in accordance with IEC Publication 76, 1967.

Measurements of MVAr and losses shall be made at rated frequency and at sufficient voltage to demonstrate compliance with the requirements of this specification and to show that the losses do not exceed their guaranteed values.

.../8

5.- **INFORMATION REQUIRED WITH TENDERS**

The Tenderer shall submit drawings showing the proposed winding arrangement, the overall dimensions of the units and the layout of bushings and winding connections.

.../9

QUESTIONNAIRE ON TECHNICAL DATA WHICH SHALL BE COMPLETED BY THE TENDERER AND WHICH SHALL FORM PART OF THE TENDER.

1.- GENERAL

General description of the reactors including means of reconnections, cooling and arrangements for metering and protection (Refer to drawings).

Description attached ______________________________

2.- RATED DATA WEIGHTS AND DIMENSIONS

Rated frequency Hz ______________________________

Rated voltage kV ____________________ line to neutral.

Nominal rating of bank

kVA ______________________________

Weight of each reactor unit

kg ______________________________

Weight of core

kg ______________________________

Weight of windings

kg_______________

Weight of tank and bushings

kg_______________

Weight of oil

kg_______________

Overall dimensions of each unit (Refer to drawings).

3.- RATING AND LOSSES

State whether or not the design of the reactors is based on continuous operation.

Maximum total losses at rated frequency

kW_______________

Voltage and winding connections (Refer to drawings)

kV_______________

Maximum copper losses at rated frequency

kW_______________

.../11

Voltage and winding connections (Refer to drawings)

kV____

Maximum iron losses at rated frequency

kW____

Voltage and winding connections (Refer to drawings)

kV____

Maximum flux density at rated frequency

T____

Voltage and winding connections (Refer to drawings)

kV____

Total losses at rated frequency under conditions causing maximum copper losses

kW____

Total losses at rated frequency under conditions causing maximum iron losses

kW____

.../12

4.- PROTECTION AND METERING

Number of current transformers

____

Ratios and ratings

____

Current transformer connections (Refer to drawings).

____

5.- COOLING

Cooling medium ____________________________________

Cooling type ______________________________________

Cooling surfaces e.g.: Plain tank, cooling tubes

____

Is a conservator fitted? ___________________________

Number and location of valves (Refer to drawings).

.../13

6.- **TESTS**

List the proposed acceptance tests and test levels applicable to the reactors

Description

attached ______________________________

Describe the temperature rise test applicable if short time rated units are offered.

Description

attached ______________________________

Proposed test method and acceptance test level for partial discharges

Description

attached ______________________________

APPENDIX 1

ACEISTE REPSOL TENSION (Mémo)

(Information concerning insulating oil)

SPECIFICATIONS

TEST	METHOD	VALUES
Density at 15°C	ASTM-D-1298	0.855 - 0.865
Inflamability V/A, °C	ASTM-D-92	165 minimum
Engler Viscosity at 50°C	Engler	1.3 - 1.9
S_1S_1V Viscocity at 210°F	ASTM-D-446	36.0 - 38.0
C_1S Viscosity at 210°F	ASTM-D-445	2.92 - 3.52
Colour	ASTM-D-1500	1.5 maximum
Freezing	ASTM-D-97	-26 maximum
Neutralization degree	ASTM-D-974	0.05 maximum
Saponification degree	ASTM-D-94	to be fixed later
Ash, %	ASTM-D-482	0.005 maximum
Dielectric Rigidity, kV	ASTM-D-877	35 minimum
Corrosive Sulphur	ASTM-D-1275	1 maximum
Deposit: 72 hours	ASTM-D-1214	0.075 maximum
: 168 hours	-	0.150 maximum (1)
Interfacial strain	ASTM-D-1971	45 minimum (2)
Contents in DBPC, %	ASTM-D-1473	0.4 - 0.6
Tangent δ	-	0.0004 minimum

(1) guide value

(2) to be determinated optionally

AS HV VOLTAGE DIVIDER

CONTENTS

1.- OBJECT

2.- GENERAL DESCRIPTION

3.- CHARACTERISTICS AND DESIGN FEATURES

4.- SPARE PARTS

5.- TEST SPECIFICATIONS

QUESTIONNAIRE ON TECHNICAL DATA

AERO-CASTERS

1.- OBJECT

This specification covers the Spanish Government's requirements for the supply of two general Voltage Dividers each consisting of one high voltage arm and three low voltage arms for 3.5 MV standard impulse voltages, 2.1 MV switching impulses, and 1.2 MV RMS alternating voltages.

2. GENERAL DESCRIPTION

Two general Voltage Dividers for 3.5 MV impulse 1.2/50 µs, 2.1 MV switching impulse, 250/2500 µs, 1.2 MV rms alternating voltage. The high voltage arms will also be used as blocking elements for the measurement of partial discharges but the Purchaser takes the responsibility for the arrangement necessary for this type of measurement. The high voltage arm of one of the dividers will be suspended from the ceiling of a laboratory building having an internal height of about 25 m. and the grounded end of the divider will be turned upwards. The high voltage end (facing downwards) of the divider will be connected to a test object located under the divider. The high voltage arm of the other divider will be mounted vertically on the floor in the conventional manner on a mobile base fitted with air cushions.

The building walls and ceiling will consist of interconnected metallic plates and a copper grid will be embedded in the floor. Thus a very low impedance will be found between the low voltage end of the dividers and the earth terminal of the test object placed on the floor.

3. CHARACTERISTICS AND DESIGN FEATURES

The following characteristics should be aimed at. Certain deviations could be accepted but the reasons should be mentioned in the response to the questionnaire on technical data, in the form of the tender.

3.1 The high voltage arm

3.1.1 Nominal data of each high voltage arm

Total series capacitance: 250 to 1000 pF.

Total resistance in series with the capacitors: 300 to 1500 ohms, (See note 1).

Rated impulse 1.2/50 μs: 3.5 MV.

Rated switching impulse voltage: 250 μs (time to crest)/2,500 μs, 2.1 MV.

Rated alternating voltage: 1.2 MV r.m.s. 50 Hz.

Note 1:

The low voltage arms are included in the offer, the Manufacturer is free to choose the resistance values in order to set the best response characteristics.

Occasionally, the dividers may be placed outdoors where they should operate throughout the full range of voltages under any weather conditions. The highest operating temperature may be + 60°C and the lowest operating temperature may be - 5°C.

3.1.2 Subdivision in units

The high voltage arm should consist of 4 to 10 units. These units should as far as possible be equal and each unit should be provided with its relevant part of the capacitance and series resistance.

3.1.3 Corona screens, conductors

The tender should, in additional prices, include the price of electrodes for the high voltage ends of the dividers permitting corona-free operation at least at the levels for switching impulse and alternating voltage given in clause 3.1.1.

The electrodes should permit a reasonably simple connection to a test object located under the divider.

It should be noted that the requirements on operation at 3.5 MV impulse voltage may necessitate larger corona electrodes than should have been necessary taking only switching impulse and alternating voltages into account in spite of the fact that no formal restrictions are given with reference to external partial discharges for this type of voltage. Other corona electrodes, for instance at the connections between the different units, should be provided on the Tenderer's discretion and be included in the basic price.

3.1.4 Internal inductance

The internal inductance of the series resistance and capacitance of the high voltage arm should be kept as low as practicable.

3.1.5 Precision, stability

The data given on total series capacitance should be kept within 1% for normal room temperature.

The variation with temperature within -5°C and + 60°C and with voltage level should if possible be kept within 3% but see clause 3.2.5. For the series resistance, the corresponding value is 10%.

NOTE:

If the conditions on temperature and voltage stability cannot be met, this should be clearly indicated in the form of the tender.

3.1.6 Height

The overall height of the dividers should be kept as low as practicable.

3.1.7 External insulation

No restrictions are placed on the external insulating material.

3.1.8 Weight

The weight of the high voltage divider including its electrodes and connections should not exceed 4000 kg.

3.1.9 Mechanical strength, wind

The mechanical strength of the divider elements should be sufficient to permit the desired operation henging from the ceiling or free-standing on the floor. The effect of wind during outdoor operation should be taken into account. Maximum wind velocities of 30 m/s may be experienced.

3.1.10 Temperature range, weather

The voltage divider should not be permanently damaged by exposure to sunlight or by temperatures from - 5°C to + 60°C.

3.1.11 Internal discharges

The requirements concerning corona in clause 3.1.3 apply also to internal partial discharges. The permissible magnitude of such discharges may be subject to discussion but values exceeding some tens of pC will not be accepted. In addition, it is required that internal partial discharges caused by the application of 3.5 MV impulse voltages should not be harmful to the divider and that external corona should not upset the measurement of such voltages.

3.1.12 Base

The tenderer should include a price for a mobile base for the free-standing divider. The base should be provided with air cushions which may be selected from the range manufactured by Aero Go. Data concerning these cushions are included with this specification. The Purchaser reserves the right to reject this part of the tender.

3.2 The low voltage arm

3.2.1 General

Each low voltage arm should consist of at least three units which should be easily disconnected from each other and the divider. These units are:

- one unit at the low voltage end of the high voltage arm.
- one or more adapting units of the cable end at the control room.

Different adaptor units may be chosen for any of the three types of voltages to be measured. Due to the difficulties of access however, it is preferred that only one unit should be used at the divider end of the cable.

One coaxial cable of 50 ohms surge impedance which shall be installed permanently between the ceiling and the control room. This cable shall be 60 m. in length and shall be in accordance with military specification No. RG 218/U. This cable shall be connected in series at each end with a 4 m. length of 50 ohms cable mil. spec. No. RG 213/U. This cable (RG 213/U) will be connected directly to the low voltage arm in the ceiling and the adaptor units in the control room. The low voltage arm and the divider units should be fitted with Amphenol sockets type No. UG-496/U. A similar arrangement will be used for the free-standing divider on the floor.

3.2.2 Condition of offering

The tenderer should give aeparate prices for the low voltage arms. The Purchaser reserves the right to reject this part of the tender and to use low voltage arms of his own design.

He slao reserves the right to order a number of equal low voltage arms to be used for instance together with spare units to form dividers for lower voltages. The matching of these low voltage arms to the high voltage units will then be the responsibility of the Purchaser.

3.2.3 Characteristics of the low voltage arms

The characteristics of the low voltage arms should preferably be such as to give a reasonably flat response in the whole range of voltages from standard impulses 1.2/50 μs to 50 Hz voltages when used together with the high voltage arms.

No requirements are given for the measurement of very rapid variables such as standard impulses chopped on the front. The unit step response should be determined according to IEC 60, 1962 and neither T_1 nor T should exceed 50 nS. If different adaptor units are used for the different types of voltages, they should each be designed such as to permit a reasonably flat response within a reasonable range of time parameters.

3.2.4 Divider ratio

The ratio between the voltage across each 3.5 MV divider and that across the output terminal of the adaptor on the low voltage arm should be variable in steps, covering the range of 10,000:1, 5000:1, 2000:1, 1000:1, 500:1; the step first mentioned will only be used for standard and switching impulse.

The impedance level of the adaptors at the cable end in the control room may be chosen by the tenderer taking into account that the adaptor may be connected to an oscillograph and a crest voltmeter in parallel, both of which may have a high impedance.

3.2.5 Precision, stability

The nominal divider ratios should be kept within 1% at room temperature.

Note:

The tenderer may choose a solution where necessary temperature correction is made by the adaptor unit located at the low voltage end of the high voltage arm.

3.2.6 Withstand voltage of the low voltage arm

The elements of each low voltage arm should be designed such that an 1.2/50 impulse of 5.0 kV, and preferably, 7.5 kV, applied to any of the adaptor terminals should not cause any flashover or damage.

4. SPARE PARTS

The tenderer should furnish a list of recommended spare parts with a separate price for each item. This list should at least include one unit of the high voltage arm (see clause 3.1.2).

3. TEST SPECIFICATIONS

3.1 Standards

Unless otherwise specified, the tests should be carried out according to IEC Publication 60, 1962, and Publication 270, 1968.

3.2 Tests on divider components

The manufacturers should provide details of proposed tests and test levels on the divider components. These proposals will be subject to discussion. The purchaser reserves the right to partly repeat such tests.

Special importance will be attached to the divider components:-

- capability to withstand, with reasonable margins, voltage and thermal stresses;
- freedom from internal partial discharge up to maximum operating voltage;
- capability to withstand stresses occurring in practice during flashovers at the test object;
- variation of impedance with reference to voltage level, duration and temperature and also its long term stability.

3.3 Tests on the complete divider

The manufacturer may decide whether the tests on the complete dividers should be carried out at his plant, or after erection at the Purchaser's site. The tests at the manufacturer's site may be carried out on a reduced number of divider units at correspondingly reduced test levels in which case the tests will be completed at full voltage after erection at the Purchaser's site. Whatever will be the case, sufficient tests should be carried out after erection to ensure satisfactory operation. A detailed program showing the sequence of the tests at the manufacturer's site should be submitted to the purchaser at least one month before the beginning of the test.

5.3.1 Voltage tests on each high voltage arm

The high voltage arm of each divider should be subjected to the following type of tests and test levels where the levels should be corrected to standard atmospheric conditions according to IEC Publication 60, 1962 European practice.

Tests with standard impulses and switching impulses should be carried out at both polarities.

- impulses 1.2/50 μs of 3.5 MV + 5% are applied and interpreted according to clause 6.3.1.1 of IEC Publication 60, 1962. The test is repeated with an external rod gap (connected between the high voltage end of the divider and the grounded grid in the floor) adjusted to chop the impulses after 2 - 5 μs.
- impulses 250/2500 μs of 2.1 MV + 5% are applied and interpreted similarly to impulses 1.2/50 μs; (250 μs refers to the time to crest).
- alternating voltage of 1.2 MV rms + 5% is applied during one minute. No flashover should occur.

5.3.2 Partial discharge test on each complete divider

The partial discharge level of each high voltage arm of the divider is checked during test with alternating voltage up to 1.2 MV rms. Any recognised method (see IEC Publication 270, 1968) can be accepted but a method showing the discharge magnitude of individual pulses is preferred. The magnitude of pulses repeated 50 times per second or more should not exceed 10 pC. No limits are given for occasional pulses.

5.3.3 Check of the response characteristics of each divider

If the tender included the low voltage arm of the divider and this part of the tender is accepted, the response characteristics of each divider should be checked according to IEC Publication 60, 1962, for the entire range of voltage types of interest.

QUESTIONNAIRE ON TECHNICAL DATA WHICH THE TENDERER SHALL COMPLETE AND WHICH SHALL FORM PART OF THE TENDER

Two high voltage arms of 3.5 MV dividers for standard impulses.

Two low voltage arms of dividers.

1. General

General description of each divider ....attached.

Drawings ....attached.

2. Characteristics

Total series capacitance .... pF.

Total resistance in series with the capacitor .... ohms.

Rated 1.2/50 µs impulse voltage.

+MV ....

-MV ....

Rated switching impulse 250/2500 µs.

+MV ....

-MV ....

Rated alternating voltage.

MV r.m.s. ....

Number of units of the high voltage arm.

n = ...

Total series capacitance of each unit.

pF ....

Total resistance in series with the capacitors of each unit.

ohm ....

Series inductance of the unit capacitance.

µH..

Series inductance of the series capacitance

µH..

Corona screens and connectors to the test object.

Description.. attached.

Precision of impedance values.

Description.. attached.

Stability of impedance values with reference to voltage levels and temperature.

Description.. attached.

Total height of divider including screens.

meters..

Permissible minimum temperature.

°C..

Permissible maximum temperature.

°C..

Detailed description of the low voltage arm, number of adaptors, cable wave impedance, permitted range of instrument impedance.

Description.. attached.

Divider ratios, precision of divider ratios.

Description.. attached.

Stability of impedance, values with reference to voltage level and temperature, method of temperature correction if any.

Description .... attached.

Response characteristics of the dividers with the proposed low voltage arms for various types of voltage. Amount of overshoot in unit step response.

Description .... attached.

Stability of the low voltage arms with reference to the same factors as above.

Description .... attached.

3. List and Details Regarding the Proposed Spare Parts

Description .... attached.

4. Tests

Proposed tests and test levels for the unit of the divider high voltage arm.

Description .... attached.

Proposed tests and test levels on each complete divider.

Description .... attached.

Proposed partial discharge test method.

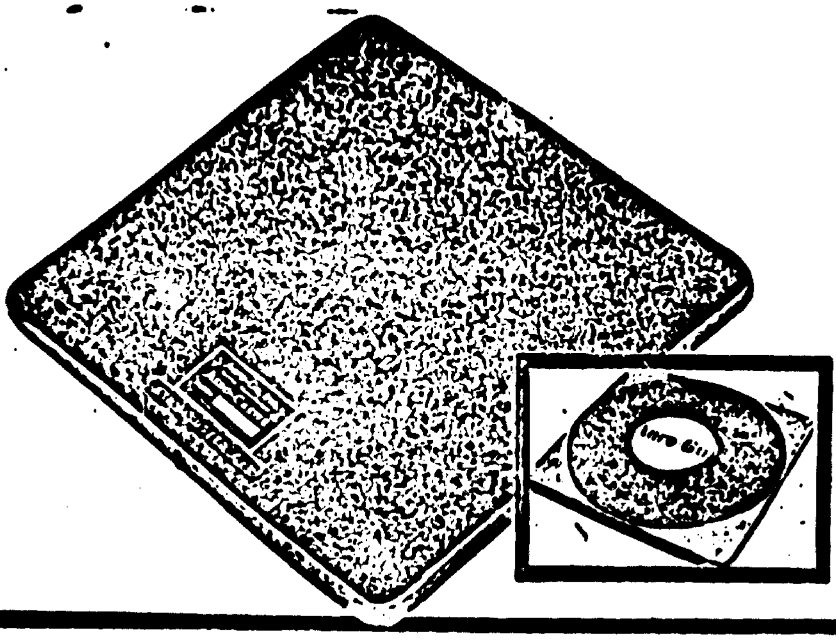
Proposed acceptance discharge magnitudes.

Description .... attached.

Impulse voltage withstand tests of the low voltage arm.

Description .... attached.

5800 Corson Avenue South
Seattle, Washington 98108
(206) RO 3-9380

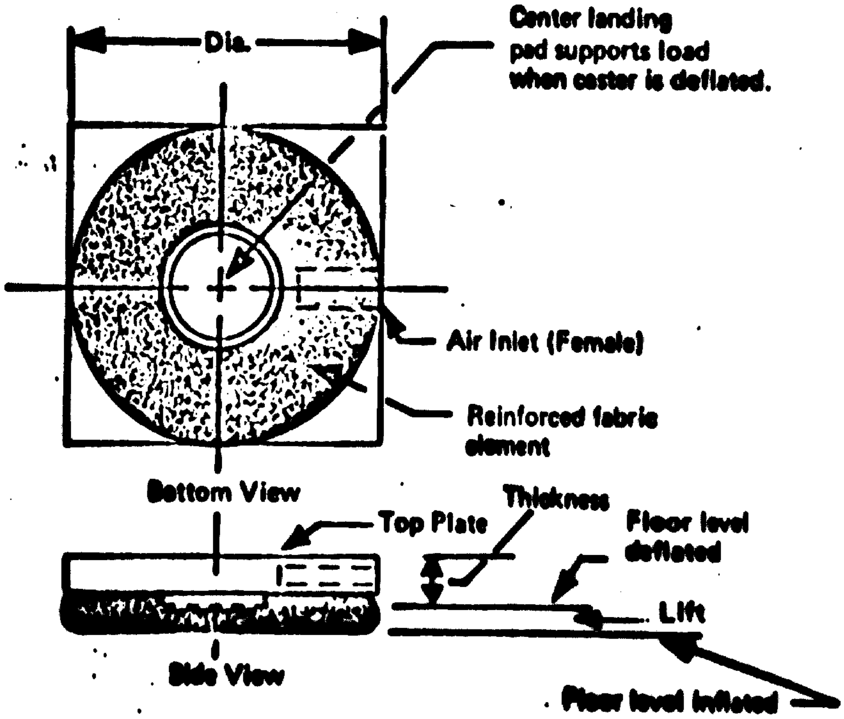


Aero-Casters are modular transfer platforms used for moving loads effortlessly.

Aero-Casters are available to match any load requirement. When used in combinations of 3 or more they provide a stable base for easy, omnidirectional movement of virtually limitless loads on a low pressure film of air. Systems from 500 pounds to hundreds of tons are now in successful operation.

AERO-CASTER LOAD MODULE PERFORMANCE AND SPECIFICATIONS

MODEL	RATED LOAD (LBS)	PRESS. AT CASTER (PSIG)	AIR FLOW (CFM)	WT. (LB.)	DIA. IN.	THICK. IN.	LIFT IN.	AIR INLET
K12	2,000	25	5-15	5	12	1	3/4	¼NPT
K15	3,500	25	5-20	8	15	1	7/8	¼NPT
K21	7,000	25	5-30	18	21	2	1	½NPT
K27	12,000	25	5-40	40	27	2	1¼	½NPT
K36	20,000	25	8-50	80	36	2½	2	½NPT
K48	40,000	25	10-60	140	48	2½	3	½NPT



MATERIALS:

Top Plates – Aluminum

Aero-Casters – Nylon Reinforced Neoprene

Use Aero-Casters to move your massive loads with great savings of time, effort, manpower, and expense. Costly crane or other lift equipment is not necessary when Aero-Casters allow one man to move many tons with slight effort.

PLACEMENT OF CASTERS . . .

For best performance the Aero-Caster assemblies should be mounted under loads in a way that divides the total weight approximately equally. For stability, three or more casters arranged in a triangle, or square pattern, is recommended. Center of gravity of load should be as close as possible to geometric center of the caster pattern. If an eccentric load is unavoidable, more air pressure may be applied through a simple regulator to the heavy side to compensate.

FLOOR SURFACE . . .

The volume of air required to float Aero-Casters is determined by the floor surface. A very smooth floor, vinyl tile, sealed concrete, metal decking, etc., requires least air. Air flow and friction force will increase in proportion to increase in surface roughness. Cracks and steps in floor surface should be bridged with common plastic tape. Plastic sheet or light gage sheet metal overlays can be used to cover rough or dirty surfaces. The substantial benefits and savings afforded by Aero-Casters will warrant the upgrading of a poor floor surface by resurfacing with fillers or terrazzo grinding. For unusual environments, please contact us.

OPERATION . . .

The load carrying capacity of the Aero-Caster is directly related to the air pressure available at the caster. In effect, the Model K21 Caster is an open ended piston with a lift area of 280 square inches. At 1 psig, 280 pounds can be lifted, at 10 psig, the same caster will lift 2,800 pounds. As the main valve is opened, compressed air is introduced into the caster through the air inlet fitting. Air is evenly distributed within the assembly and allowed to escape in a continuous flow through orifices in the flexible Aero-Caster. The Aero-Caster inflates, raising the assembly. A thin film of air flows between the periphery of the Aero-Caster and the floor surface to "float" the load. To avoid dragging the Aero-Caster and possible damage, be certain load is at full stop before cutting air supply.

MOVING FORCE . . .

Typical coefficient of friction between inflated Aero-Caster and a smooth, level surface is 0.001 or less. For example, a 2,000 pound load can be moved with a push of under 2 pounds. On inclined or undulating surfaces, free floating casters will drift to the lower level.

AIR SUPPLY . . .

Aero-Casters are designed to operate from clean compressed air. Air should be supplied to casters through piping or hoses of nearly equal length and diameter to assure uniform operation. 3/4" ID hose or larger (available from Aero-Go) is normally required. Smaller hose may be used under certain conditions.

ACCESSORIES . . .

Air supply source, control, and distributing devices are available separately from Aero-Go. Sources of air supply can be plant air, portable piston type compressor accumulator, low pressure centrigugal blower or air bottle, depending on load and floor surface conditions. Aero-Casters are self pressure regulating systems that may be operated without separate line regulators. A slow opening flow control valve is recommended to avoid sudden pressure surge and to meter volume of air for most economical performance. In some applications, a quick opening relief valve may be desired to provide rapid lowering of load. Screw jacks, clamps or other devices to attach load are available mounted upon Aero-Caster module. Aero-Go, Inc., will recommend and provide complete accessories for specific applications upon request.

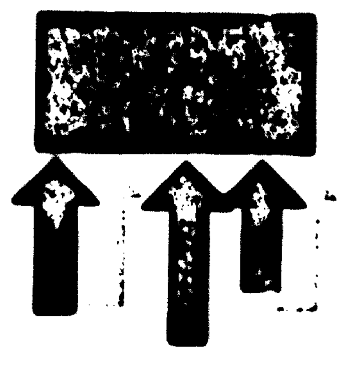
NOTE:

Aero-Go produces complete systems to resolve critical material handling problems or can supply you with custom designs to incorporate into your product for lifelong mobility.

As progress in air film technology is dynamic, products and specifications may be changed without notice.

HOW TO ORDER

Other Aero-Caster sizes, standard transport pallets to fit under your entire load, and units with self-contained air source are available. Call your Aero-Go representative.



SOLD BY:

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2.- GENERAL DESCRIPTION

3.- CHARACTERISTICS AND DESIGN FEATURES

QUESTIONNAIRE ON TECHNICAL DATA

AERO-CASTERS

1.- OBJECT

This specification covers the Spanish Government's requirements for one apparatus for the production of artificial rain to be used during high voltage tests.

2.- GENERAL DESCRIPTION

The wet test apparatus will be used for tests on high voltage equipment for system voltages up to and including 750 kV RMS.

The following list is indicative of the different types of objects which will be tested:-

Insulators

Bushings

Instrument Transformers

Circuit Breakers

Disconnecting Switches

The wet test apparatus will normally be located along the side of a high voltage test hall and the water will be projected inwards towards the centre. The precipitation and droplet size shall be uniform in the centre of the test hall.

.../2

The hall dimensions are 28 m. x 44 m. x 25 m. H. The precipitation rates, droplet sizes and angle incidence must all be reproduceable.

3.- CHARACTERISTICS AND DESIGN FEATURES

The following characteristics should be aimed at. Certain deviations are acceptable but ths reasons should be given in the response to the questionnaire on technical data in the form of the Tender.

3.1- Maximum projected area of test object

The wet test apparatus should be capable of spraying a maximum projected area of 11 m. long x 12 m. high.

3.2- Precipitation rates

The wet test apparatus should be designed to give the following precipitation rates (for both the vertical and the horizontal components on the test object:-

5 mm/min.

3 mm/min.

1.25 mm/min.

The manufacturer may achieve the different precipitation rates by switching in different numbers of nozzles or by any other method. However, whichever method is used should permit changing in the shortest possible time.

The precipitation rate should fall within the required value at an angle of 45° over the full height of 12 m.

3.3- Distance to test object

The distance from the nozzles to the test object will be 7 m.

3.4- Mobility

The wet test apparatus will be displaced indoors and outdoors on a conventional concrete floor employing an air cushion system.

The air cushions to be used on the base must be selected from the standard range supplied by AERO-GO Inc. Data relative to these air cushions are supplied at the end of this specification. In order to prevent oscillations during transport, air tanks equal to a least three times the volume of the air cushions must be connected in parallel with each air cushion.

The base should be designed so that the air cushions can be easily attached or removed without lifting the apparatus.

The speed of transportation will not exceed 0.2 m/s. All reasonable precautions will be taken to prevent occasional stops or bumps during transport, but the wet test apparatus should not be damaged if such a stop or bump should occur.

3.5- Nozzle array

The apparatus should be designed so that the nozzles are arranged in arrays each approximately 2m. x 2 m. The number of nozzles for each array is the responsability of the manufacturer. Each array should be independently controlled, preferably by means of valves installed on the base. This is to permit the testing of objects having widely differing projected areas.

The nozzles should be made to give a confined spray similar to those described for European practice in IEC Recommendation 60, 1962.

.../5

3.6- <u>Maximum depth of wet test apparatus</u>

The maximum depth of the apparatus should not exceed 2m. when in operation. Extendable legs are permitted for increased stability during transportation. The apparatus may be guyed to the wall when in operation but the main weight will be carried by the floor.

3.7- <u>Access</u>

Ladders and catwalks should be provided inside the main structure to allow maintenance or nozzle adjustment.

3.8- <u>Pump</u>

The manufacturer should provide a pump driven by an electric motor. The available supply is 380 V. 3 φ 50 Hz.

3.9- <u>Pipes and fittings</u>

The manufacturer should provide all pipes, valves, fittings, pressure gauges and controls necessary for the satisfactory operation of the equipment.

.../6

3.10- Demineralising equipment

The supply of the necessary demineralising equipment including mixing unit and storage tanks is the responsability of the purchaser.

3.11- Measuring equipment

The manufacturer must provide means for measuring the precipitation rates at different heights from 0 to 12 m. These measurements will be carried out before the application of the test voltage. The measuring apparatus will be removed during the actual high voltage test. The measuring apparatus should be capable of measuring the horizontal and vertical components of the artificial rain.

.../7

TECHNICAL DATA RELATIVE TO THE WET TEST APPARATUS

1.- General description of the wet test apparatus

Attached ______________________________

Drawings ______________________________

2.- Number of nozzles arrays ______________________________

3.- Number of nozzles for:

1.25 mm/min ______________________________

3 mm/min ______________________________

5 mm/min ______________________________

4.- Type of nozzle and material of nozzle

Drawing ______________________________

5.- Maximum dimensions of apparatus

Length ______________________________ m

Breadth ______________________________ m

Height ______________________________ m

6.- Weight ______________________________ kg

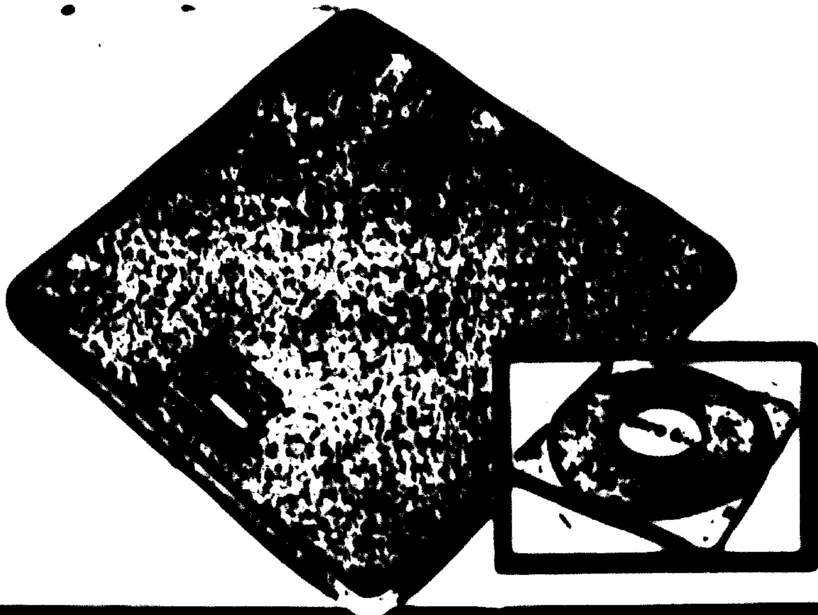
7.- Pump Capacity ______________________________ l/min

8.- Driving motor power ______________________________ kW

9.- Supply voltage for motor ______________________________ V.

[illegible]

[illegible]

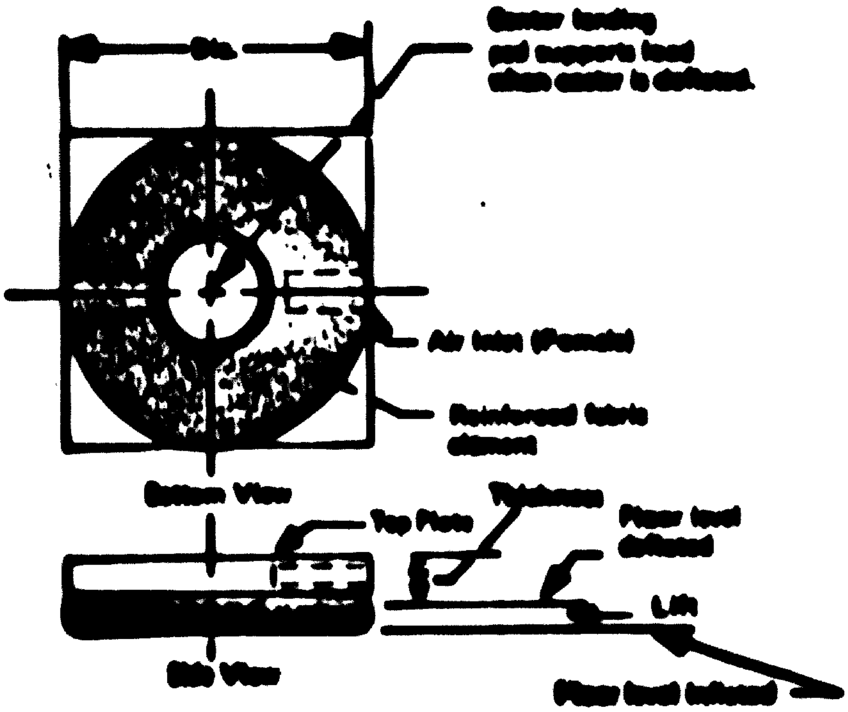


Aero-Casters are modular transfer platforms used for moving loads effortlessly.

Aero-Casters are available to match any load requirement. When used in combinations of 3 or more they provide a stable base for easy, omnidirectional movement of virtually limitless loads on a low pressure film of air. Systems from 500 pounds to hundreds of tons are now in successful operation.

AERO-CASTER LOAD MODULE PERFORMANCE AND SPECIFICATIONS

MODEL	RATED LOAD [illegible]	[illegible] AT CASTER [illegible]	AIR FLOW [illegible]	WT. [illegible]	DIA. [illegible]	THICK. [illegible]	LIFT [illegible]	AIR INLET
K12	2,000	[illegible]	5-15	6	12	1	[illegible]	[illegible] NPT
K16	3,000	[illegible]	[illegible]	8	16	1	[illegible]	[illegible] NPT
K21	7,000	[illegible]	[illegible]	18	21	2	1	[illegible] NPT
K27	12,000	[illegible]	[illegible]	40	27	2	[illegible]	[illegible] NPT
[illegible]	20,000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	[illegible] NPT
[illegible]	40,000	[illegible]	[illegible]	140	[illegible]	[illegible]	2	[illegible] NPT



MATERIALS:

Top Plates – Aluminum

Aero-Casters – Nylon Reinforced Neoprene

Use Aero-Casters to move your massive loads with great savings of time, effort, manpower, and expense. Costly crane or other lift equipment is not necessary when Aero-Casters allow one man to move many tons with slight effort.

PLACEMENT OF CASTERS . . .

For best performance the Aero Caster assemblies should be mounted under loads in a way that divides the total weight approximately equally. For stability, three or more casters arranged in a triangle, or square pattern, is recommended. Center of gravity of load should be as close as possible to geometric center of the caster pattern. If an eccentric load is unavoidable, more air pressure may be applied through a simple regulator to the heavy side to compensate.

FLOOR SURFACE . . .

The volume of air required to float Aero Casters is determined by the floor surface. A very smooth floor, vinyl tile, sealed concrete, metal decking, etc., requires least air. Air flow and friction force will increase in proportion to increase in surface roughness. Cracks and steps in floor surface should be bridged with common plastic tape. Plastic sheet or light gage sheet metal overlays can be used to cover rough or dirty surfaces. The substantial benefits and savings afforded by Aero Casters will warrant the upgrading of a poor floor surface by resurfacing with fillers or terrazzo grinding. For unusual environments, please contact us.

OPERATION . . .

The load carrying capacity of the Aero Caster is directly related to the air pressure available at the caster. In effect, the Model K21 Caster is an open ended piston with a lift area of 280 square inches. At 1 psig, 280 pounds can be lifted, at 10 psig, the same caster will lift 2,800 pounds. As the main valve is opened, compressed air is introduced into the caster through the air inlet fitting. Air is evenly distributed within the assembly and allowed to escape in a continuous flow through orifices in the flexible Aero Caster. The Aero Caster inflates, raising the assembly. A thin film of air flows between the periphery of the Aero Caster and the floor surface to "float" the load. To avoid dragging the Aero Caster and possible damage, be certain load is at full stop before cutting air supply.

MOVING FORCE . . .

Typical coefficient of friction between inflated Aero Caster and a smooth, level surface is 0.001 or less. For example, a 2,000 pound load can be moved with a push of under 2 pounds. On inclined or undulating surfaces, free floating casters will drift to the lower level.

AIR SUPPLY . . .

Aero-Casters are designed to operate from clean compressed air. Air should be supplied to casters through piping or hoses of nearly equal length and diameter to assure uniform operation. 3/4" ID hose or larger (available from Aero-Go) is normally required. Smaller hose may be used under certain conditions.

ACCESSORIES . . .

Air supply source, control, and distributing devices are available separately from Aero Go. Sources of air supply can be plant air, portable piston type compressor accumulator, low pressure centrifugal blower or air bottle, depending on load and floor surface conditions. Aero Casters are self pressure regulating systems that may be operated without separate line regulators. A slow opening flow control valve is recommended to avoid sudden pressure surge and to meter volume of air for most economical performance. In some applications, a quick opening relief valve may be desired to provide rapid lowering of load. Screw jacks, clamps or other devices to attach load are available mounted upon Aero Caster module. Aero Go, Inc., will recommend and provide complete accessories for specific applications upon request.

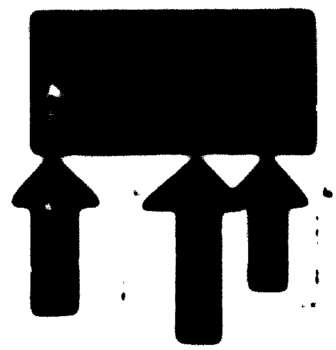
NOTE:

Aero Go produces complete systems to resolve critical material handling problems or can supply you with custom designs to incorporate into your product for lifelong mobility.

As progress in air film technology is dynamic, products and specifications may be changed without notice.

HOW TO ORDER

Other Aero Caster sizes, standard transport pallets to fit under your entire load, and units with self contained air source are available. Call your Aero-Go representative.



SOLD BY:

HV 18

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CONTENTS

1.- SCOPE

2.- GENERAL DESCRIPTION

3.- CHARACTERISTICS AND DESIGN FEATURES

4.- TESTS

QUESTIONNAIRE ON TECHNICAL DATA

1.- SCOPE

This specification covers the Spanish Government's requirements for the supply of two sets of three single phase precision current transformers for measurements at 50 and 60 Hz.

2.- GENERAL DESCRIPTION

These transformers will be used for measurements of currents during routine and type tests on transformers and other electrical equipments. They will be connected to ammeters and wattmeters.

They need to be as compact as insulation levels and current carrying capacities permit.

3.- CHARACTERISTICS AND DESIGN FEATURES

NOTE: To cover the required range of currents, it is required to have two separate sets of three single phase units. Should the Tenderer find that the ranges should be different than those described below, it should be stated clearly in the questionnaire.

3.1 Group 1

Quantity: 3

Use : These transformers will be connected on the lines of a three phase system. It is required that the primary bushings be fully insulated. They will be used indoors.

Insulation class : a) Primary winding

i) Nominal voltage $100/\sqrt{3}$ kV

ii) BIL 380 kV

iii) Low frequency test voltage 120 kV

b) Secondary winding

i) 2.5 kV, 50 Hz for 1 minute.

Primary currents: 2000, 1000, 500, 250, 125 A.

Secondary current : 5 A

Frequencies : 50 and 60 Hz

Temperature rise: 55°C

Precision : For the range of 10 to 100% of rated current and a burden of 5 VA with p.f. 0.8 to 1.0.

a) 50 and 60 Hz

Maximum ratio error ± 0.1%

Maximum phase displacement ± 1 min.

.../3

Protection : Suitable spark gaps shall be installed on the secondary terminals.

3.2 Group 2

These transformers shall have the same characteristics as those of group 1 except for the following
Primary currents: 50, 25, 10, 5 and 2.5 A.

4.- TESTS

All routine and type tests as outlined in IEC Publication 185,1966 shall be performed except the "Short time current tests".

.../4

QUESTIONNAIRE

Technical and general data on two sets of three single phase precision current transformers.

1.- GENERAL DESCRIPTION

Description

Enclosed ______________________________

2.- RATED DATA

Insulation Class	Group 1	Group 2
a) Primary winding		
i) Nominal voltage	______kV	______kV
ii) BIL	______kV	______kV
iii) Low frequency test voltage	______kV	______kV
b) Secondary winding		
i) Insulation level	______kV	______kV
Primary currents	________	________
Secondary current	______A	______A
Frequencies	______Hz	______Hz
Temperature rise	______°C	______°C

.../5

Precision (Group 1)

Description

Enclosed____

Precision (Group 2)

Description

Enclosed____

Production (Group 1)

Description

Enclosed____

Production (Group 2)

Description

Enclosed____

[redacted]

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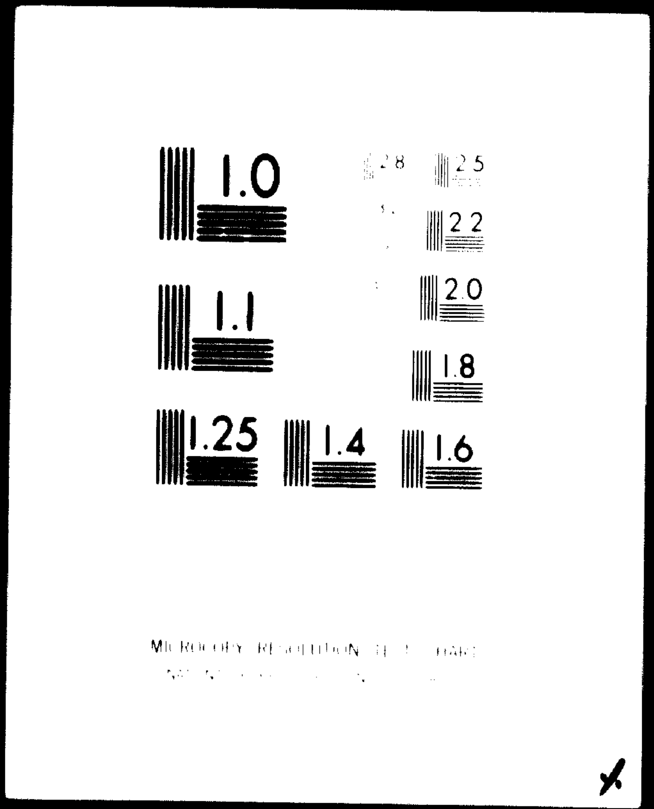
2 OF 7



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CONTENTS

1.- SCOPE

2.- GENERAL DESCRIPTION

3.- CHARACTERISTICS AND DESIGN FEATURES

4.- TESTS

QUESTIONNAIRE ON TECHNICAL DATA

1.- SCOPE

This specification covers the Spanish Government's requirements for the supply of two sets of three single phase precision potential transformer for measurements at 50, 60 and 200 Hz.

2.- GENERAL DESCRIPTION

These transformers will be used for measurements of voltage levels during routine and type tests performed on transformers and other electrical equipments. They will be connected to voltmeters and wattmeters.

They need to be as compact as permit the insulation levels required.

3.- CHARACTERISTICS AND DESIGN FEATURES

NOTE: To cover the required range of voltage, it is required to have two separate sets of three units. Should the Tenderer find that the ranges should be different than those described below, it should be stated clearly in the questionnaire.

.../2

3.1 GROUP 1

Quantity: 3

Use : These transformers will be connected between two phases or between phase and neutral on a three phase supply. They will be used indoors.

Insulation class:

a) HV winding in its highest voltage connection

i)	Nominal voltage:	$165/\sqrt{3}$ kV
ii)	BIL	450 kV
iii)	Low frequency test voltage	185 kV

b) Secondary winding insulation level

i) 2.5 kV, 50 Hz for 1 minute

Primary voltages: $165/\sqrt{3}$, $88/\sqrt{3}$, $44/\sqrt{3}$ kV.

NOTE: The transformers shall be able to operate continuously at 1.2 times rated voltage.

Secondary voltage : $110/\sqrt{3}$

Frequencies: 50, 60 and 200 Hz.

Temperature rise: 55°C

Precision: For the range of 40 to 120% of nominal voltage and for a Burden of 5 VA with p.f. 0.8 to 1.0.

a) 50 and 60 Hz

Maximum ratio error: ± 0.1%

Maximum phase displacement: ± 1 min.

.../3

b) 200 Hz

Maximum ratio error: ± 1.0 %

Maximum phase displacement - not specified

Protection: Suitable spark gaps shall be installed on the secondary terminals.

3.2 Group 2

These three transformers shall base the same characteristics as those of Group 1 except for the following:

Insulation class:

a) HV winding in its highest voltage connection.

i) Nominal voltage: $22/\sqrt{3}$ kV

ii) BIL : 95 kV

iii) Low frequency test voltage: 38 kV

b) Secondary winding insulation level.

i) 2.5 kV, 50 Hz for 1 minute.

Primary voltages: $22/\sqrt{3}$, $11/\sqrt{3}$, $5.5/\sqrt{3}$ kV

NOTE: The transformers shall be able to operate continuously at 1.2 times rated voltage.

Protection: Same as group 1.

.../4

3.3 Partial discharges

The transformer will be used during low level partial discharge measurements. Consequently they must be free from internal and external discharges at 1.2 times nominal voltage.

4.- TESTS

All routine and type tests as outlined in IEC Publication 186-1969 shall be performed.

.../5

QUESTIONNAIRE

Technical and general data on two sets of three single phase precision potential transformers.

1.- GENERAL DESCRIPTION

Description
Enclosed ______________________________

2.- RATED DATA

Insulation class

	Group 1	Group 2
a) HV Winding		
i) Nominal voltage	______ kV	______ kV
ii) BIL	______ kV	______ kV
iii) Low frequency test voltage	______ kV	______ kV
b) Secondary winding		
i) Insulation level	______ kV	______ kV

Primary voltages ______________ ______________

Secondary voltages ______________ ______________

.../6

Highest continuous operating voltage ______________ %Un ______________ %Un

Frequencies ______________ Hz ______________ Hz

Temperature rise ______________ °C ______________ °C

Precision (Group 1)

Description

Enclosed ______________________________

Precision (Group 2)

Description

Enclosed ______________________________

Protection (Group 1)

Description

Enclosed ______________________________

Protection (Group 2)

Description

Enclosed ______________________________

3. PARTIAL DISCHARGES

Amplitude of partial discharges at 1.2 Un

______________________________ μV

THREE 1.33 MVA SINGLE PHASE VOLTAGE REGULATORS

CONTENTS

1.- OBJECT

2.- GENERAL DESCRIPTION

3.- CHARACTERISTICS AND DESIGN FEATURES

4.- SPARE PARTS

5.- ERECTION

6.- TESTS

QUESTIONNAIRE ON TECHNICAL DATA

CONTROL DESK

ACEISTE REPSOL TENSION

1. OBJECT

This specification covers the Spanish Governments' requirements for the supply of three (3) single phase voltage regulators each rated at

1.33 MVA 50 Hz

22 kV / 0-5 kV RMS

and the necessary control equipment for regulation.

2. GENERAL DESCRIPTION

The three voltage regulators shall be identical single-phase units, each of which is designed for continuous operation at 1.33 MVA, 50 Hz, 22 kV primary voltage, secondary voltage continuously variable over the range 0-5 kV.

The regulati[illegible] should be virtually without steps.
The regulators will mainly be used for heat run tests of large single phase and three phase transformers, with an intermediate multi-tap coupling transformer.

The regulators will be supplied from a 3-phase 22 kV line-to-line delta connected transformer.

The regulators shall be designed so that the outputs may be connected in either star or delta when used for 3-phase operation. In addition, the regulators shall be designed for single operation and for parallel operation with 2 and 3 units in parallel.

For any three-phase and parallel connection of two and three units, the output voltage of the regulators shall be matched within ½% or better over the entire voltage range.

When 2 or 3 regulators are connected in parallel, they shall be capable of delivering 2.66 or 4 MVA respectively, at full voltage, without exceeding the specified temperature rise. If load sharing reactors are required in order to limit circulating currents, the price shall be quoted separately and not included in the basic price of the regulators.

3. CHARACTERISTICS AND DESIGN FEATURES

The following characteristics should be aimed at. Certain deviations could be acceptable but the reasons shall be stated in the response to the questionnaire on technical data in the form of the tender.

3.1 CHARACTERISTICS OF EACH REGULATOR

Rated primary voltage:	22 kV
Rated frequency:	50 Hz
Rated secondary voltage:	0-5 kV
Rated continuous power at maximum rated secondary voltage and frequency:	1.33 MVA

Short-circuit impadance corrasponding to maximum rated secondary voltaga and frequency (saa note): 7% approx.

Note: ZscX = U/Uo 100%

whare U: change in secondary voltage from its rated value at rated current without change in the regulator setting.

U_o: rated maximum secondary voltage.

3.2 Overload characteristics

No specifications are given for the overload characteristics of the regulators but thosa inherent for 10 minutes operation and for 1 hour operation shall be clearly stated in the form of the tender.

3.3 Relative harmonic content

The reletive harmonic content shall be no greater than 0.02 when determined et no load over the uppar 85% of the voltage range assuming that the regulatore are supplied et rated voltage and frequency from a zero impedence source.

The manufacturer shall estimate the magnitudee of the third, fifth and seventh harmonic raletive to the fundamental at 0.25, 0.5, 0.75 and 1.0 times rated voltage.

The relative harmonic content is defined as

$$\frac{\sqrt{\Sigma U_n^2}}{U}$$

where U_n is the r.m.s. value of the n^{th} order harmonic and U is the r.m.s. value of the total voltage.

3.4 Location

The regulators will be situated outdoors and the ambient temperature range will be -5°C to + 37°C.

3.5 Temperature-rise limits

The temperature rise limits should be chosen in accordance with IEC recommendations (Publication 76/1967), when the units are loaded with rated current and voltage, for continuous duty, with ONAN cooling.

3.6 Partial discharges

The voltage regulators shall be virtually free from internal and external partial discharges up to a voltage 20% higher than the rated voltage. The permissible magnitude of partial discharges may be subject to discussion but values exceeding some tens of pC will not be accepted.

3.7 Withstand capability to short-circuits and overvoltages

Due to the special operation, the regulators may be subjected to short-circuits, via a low impedance.

Thus, the regulators shall be designed to withstand short-circuits at the secondary terminals when being supplied via a very strong network. The withstand short-circuit duration has to be specified.

The special operating conditions may also cause overvoltages to occur at the secondary terminals. The magnitudes of these overvoltages are difficult to foresee. Thus, the regulators shall be protected on the secondary side by lightning arresters or by other auto-extinguished devices capable of operating during switching overvoltages without damage.

The insulation level of the secondary windings shall conform to the requirements of the IEC Publication 76/1967.

The overvoltage protecting device will conform to the insulation level of the windings.

The primary winding will be connected to a network subject to normal frequency of occurrence of overvoltages of various kinds. The insulation of these windings thus shall be designed for an exposed location according to IEC Publication 76/1967. Protection equivalent to a station type lightning arrester of 10 kA or better shall also be provided.

3.8 Regulation

The regulation shall be virtually without steps and from zero up to nominal voltage.

The regulator shall be motor driven with provision for remote control. An auxiliary supply 230 V, 50 Hz, single phase or 400 V, line 50 Hz 3 phase will be available for this purpose. The time taken to raise the voltage from its lower limit to rated value shall not exceed 30 seconds for operation at maximum speed. A slower speed, half of the above or less is also required. The foregoing shall not be taken to exclude the offer of a d.c. driving motor capable of a wide range of operating speeds. Note, however, that in such a case, a suitable d.c. supply must be provided by the manufacturer.

In addition to the basic offer, the tender shall also include an automatic regulating system whereby the output voltage can be set, independently for each regulator at a desired level and held within ½% or less of the set value, independent of load variation or fluctuations of primary voltage. The price of the system, including its controls designed for a control panel (see clause 3.9) should be included in the additional prices list but not in the basic price.

3.9 Controls

The control equipment in the basic offer should be such as to permit the regulators to be controlled individually or together (See clause 3.7). One additional control desk should be provided.

The control equipment shall be installed in control panels, drawer type. Instruments must be installed in the control panels for the measurement of output voltage, output current, and output power factor. The control desks should conform to the dimensions shown on drawing No. 1004 included in this specification. Dimensions are in millimeters.

3.10 Internal insulation

If normal transformer oil is used as internal insulation, it shall conform to the specifications shown in Table 1.

3.11 Mechanical details

Particular attention shall be paid to the avoidance of jamming of the moving parts at either end of the voltage range and adequate means shall be provided for manual adjustment of the "zero" position of each regulator prior to mechanically coupling (if required)the units for three phase or parallel operation. Any slipping clutch or fragile coupling shall be installed so as to be readily accessible for adjustment or maintenance. Details of such components shall be included in drawings accompanying the tender. Where fixed or movable brushes are used in a regulator, full details of their composition and mounting shall be supplied.

In such cases, dasigns whera the brushes are supported betwaan symmetrically disposed driving points will be praferred.

3.12 Oil tightness of the tank

Spacial importance is attached to the oil tightness of the tank, the bushings and other connections.

3.13 Painting

The tank, frame, radiators and all metallic accessories should be painted. The surfaces should, after having baan thoroughly cleanad, be properly coated with a suitable primer. The actual colours will be specified aftar the order is placad.

3.14 Earthed screen

It should be considared as an advantage if each regulator were providad with an earthed screen betwaen H.V. and L.V. winding.

3.15 H.V. and L.V. Terminals

The H.V. as well as the L.V. terminals should be provided for cabla connections.

3.16 Instrument transformers

Each regulator shall be provided with instrument transformers for the measurement of voltage, current, and tha operation of protection relays.

4. <u>SPARE PARTS</u>

The tenderer shall provide a complete list of recommended spare parts with a separate price for each item.

5. <u>ERECTION</u>

The regulators will be erected either by the manufacturer or by the purchaser at the latter's choice. The tenderer shall state whether he considers it necessary to supervise the erection of the regulators by the purchaser. The price of the required supervision shall be stated. Furthermore, a separate price shall be given for the complete erection of the regulators by the manufacturer.

6. <u>TESTS</u>

6.1 <u>Standards</u>

Unless otherwise specified and when applicable, the tests should be made according to IEC (Publications 76/1967, 137/1962 and 270/1968).

6.2 <u>Power frequency</u>

The tests specified at power frequency must be made at 50 Hz.

6.3 Type of tests

The regulators, including the controls, shall be tested at the manufacturer's expense before shipping. The purchaser reserves the right to repeat the tests after delivery at his expense to a sufficient extent to assure satisfactory performance. The type of tests and test-levels should be proposed by the manufacturer and will be subject to discussion. They should at least include the following:

- measurement of no load and load losses, short-circuit voltage ,
- temperature rise tests (at least on one regulator),
- over magnetisation test,
- tests with impulse voltage, at levels in accordance with IEC Publication 76/1967, Table VIII, Series II,
- check of the partial discharge level (any recognized method, see IEC Publication 270/1968, is acceptable but a method showing the magnitude of individual pulses is preferred.)
- check of the harmonic content,
- check of the control and regulating circuitry when the regulators are used singly or in parallel.

I - QUESTIONNAIRE ON TECHNICAL DATA WHICH THE TENDERER SHALL COMPLETE AND WHICH FORM A PART OF THE TENDER

Three single-phase regulators each for 1.33 MVA, 22 kV/0 - 5 kV, 50 Hz, continuous regulation.

1. GENERAL

General description of the regulators including their control, regulating and protection equipment

Description attached ....

2. CHARACTERISTICS

2.1 Rated primary voltage ....kV

2.2 Rated frequency ....Hz

2.3 Rated secondary voltage ....kV

2.4 Rated power at rated secondary voltage and frequency, ...MVA

2.5 Short-circuit impedance at maximum rated secondary voltage and frequency ....%

2.6 Variations of the short-circuit impedance at rated frequency, throughout the range of output voltages.

Description attached ....

2.7 Secondary inherent overload power, for 10 minutes operation, repeated once per hour for four hours

....MVA

2.8 Secondary inherent overload power for one hour operation preceded and followed by a four hour period of rest ....MVA

2.9 Overload characteristics for other conditions of load.

Description attached ....

2.10 Relative harmonic content ....

2.11 Insulation class and withstand voltages, for each winding.

Description attached ....

2.12 Temperature rise at continuous nominal load,

copper, hot spot, ...°C

top oil ....°C

2.13 Flux densities, at nominal voltage and frequency

Description attached ....

2.14 No load losses at nominal voltage and frequency

....kW

2.15 Copper losses at nominal current,

....kW

2.16 Stray load losses at nominal voltage and current

....kW

2.17 Withstand capacity to short-circuit and overvoltages; proposed protection against such stresses.

Description attached ....

2.18 Lowest regulating limit, % of nominal voltage,

....

2.19 Shortest time for automatic regulation from lowest regulating limit to full voltage,

....s

2.20 Longest time for automatic regulation from lowest regulating limit to full voltage,

....s

2.21 Type and accuracy of regulation; possibility of regulating parallel, star and delta connected units, possibility and accuracy of automatically maintained voltage levels.

Description attached ....

2.22 Control equipment.

Description attached ....

2.23 Possibilities of remote control from several control rooms.

Description attached ....

2.24 Type and amount of internal insulating fluid

Description attachad ....

2.25 Weight end dimension of each regulator,

....lbs

2.26 Internal or external installation and insulating liquid provided.

....Type

2.27 Earthed screen between primary and secondary winding,

yes ....   no ....

2.28 Overvoltage protection,

Primary ....

Secondary ....

2.29 Load shering reactors.

Description attached ....

3. TESTS

3.1 Proposed tests and test levels for the regulators

Description attachad ....

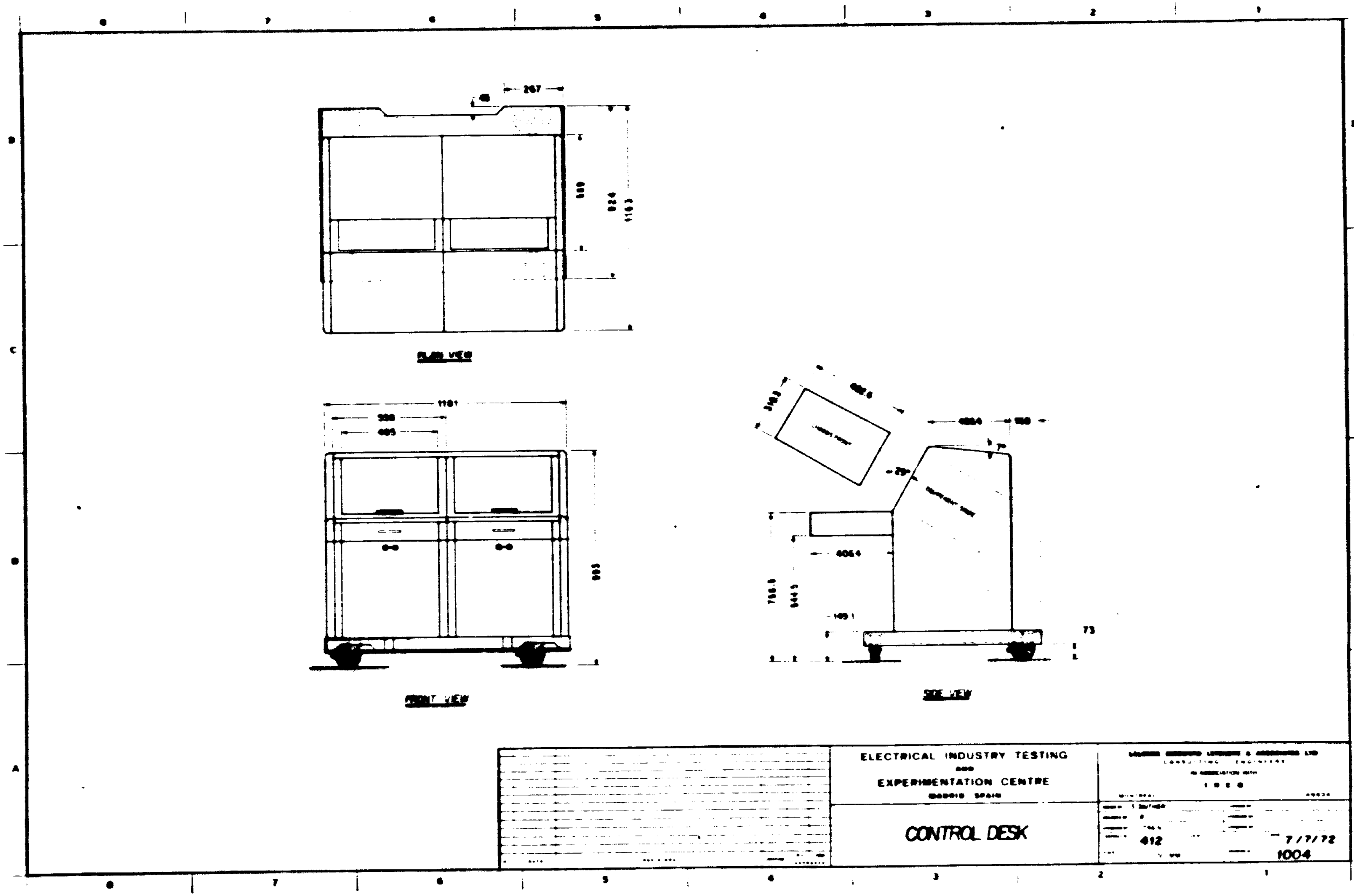
3.2 Proposed tests regarding the characteristics and performance of the control and regulating systems.

Description attached ....

4. SPARE PARTS

List of recommended spare parts

Description attached ....


PLAN VIEW
FRONT VIEW
SIDE VIEW
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988
405
73
ELECTRICAL INDUSTRY TESTING
EXPERIMENTATION CENTRE
MADRID SPAIN
CONTROL DESK
412
7/7/72
1004

ACEISTE REPSOL TENSION (Mémo)

(Information concerning insulating oil)

SPECIFICATIONS

TEST	METHOD	VALUES
Density at 15°C	ASTM-D-1298	0.855 - 0.865
Inflamability V/A, °C	ASTM-D-92	165 minimum
Engler Viscosity at 50°C	Engler	1.3 - 1.9
S_1S_1V Viscocity at 210°F	ASTM-D-446	36.0 - 38.0
C_1S Viscosity at 210°F	ASTM-D-445	2.92 - 3.52
Colour	ASTM-D-1500	1.5 maximum
Freezing	ASTM-D-97	-26 maximum
Neutralization degree	ASTM-D-974	0.05 maximum
Saponification degree	ASTM-D-94	to be fixed later
Ash, %	ASTM-D-482	0.005 maximum
Dielectric Rigidity, kV	ASTM-D-877	35 minimum
Corrosive Sulphur	ASTM-D-1275	1 maximum
Deposit: 72 hours	ASTM-D-1214	0.075 maximum
: 168 hours	-	0.150 maximum (1)
Interfacial strain	ASTM-D-1971	45 minimum (2)
Contents in DBPC, %	ASTM-D-1473	0.4 - 0.6
Tangent δ	-	0.0004 minimum

(1) guide value

(2) to be determinated optionally

CONTENTS

1.- OBJECT

2.- GENERAL DESCRIPTION

3.- CHARACTERISTICS AND DESIGN FEATURES

4.- SPARE PARTS

5.- ERECTION

6.- TESTS

QUESTIONNAIRE ON TECHNICAL DATA

TABLE I

CONTROL DESK

1.- OBJECT

This specification covers the Spanish Government's requirements for the supply of two (2) single phase voltage regulators each rated at

350 kVA 50 Hz

22 kV/0 - 5 kV RMS

2.- GENERAL DESCRIPTION

The two voltage regulators shall be identical single-phase units, each of which is designed for continuous operation at 350 kVA, 50 Hz, 22 kV primary voltage, secondary voltage continuously variable over the range 0 - 5 kV.

The regulation should be virtually without steps. The regulators will mainly be required to energise high voltage test transformers which are used for general dielectric testing in a High Voltage Laboratory.

The regulators will be supplied from a 3 - phase, 22 kV line-to-line delta connected transformer.

3.- CHARACTERISTICS AND DESIGN FEATURES

The following characteristics should be aimed at. Certain deviations could be acceptable but the reasons shall be stated in

.../2

response to the questionnaire on technical data in the form of the tender.

3.1 Characteristics of each regulator

Rated primary voltage	: 22 kV
Rated frequency	: 50 Hz
Rated secondary voltage	: 0-5 kV
Rated continuous power at maximum rated secondary voltage and frequency	: 350 kVA

Short-circuit impedance corresponding to maximum rated secondary voltage and frequency (see note): 7% approx.

Note: Zsc% = U/Uo 100%

where U: change in secondary voltage from its rated value at rated current without change in the regulator setting.

U_o: rated maximum secondary voltage.

3.2 Overload characteristics

No specifications are given for the overload characteristics of the regulators but those inherent for 10 minutes operation and for 1 hour operation shall be clearly stated in the form of the tender.

3.3 Relative harmonic content

The relative harmonic content shall be no greater than 0.02 when determined at no load over the upper 85% of the voltage range assuming that the regulators are supplied at rated voltage and frequency from a zero impedance.

The manufacturer shall estimate the magnitudes of the third, fifth and seventh harmonic relative to the fundamental at 0.25, 0.5, 0.75 and 1.0 times rated voltage.

The relative harmonic content is defined as $\sqrt{\frac{\Sigma U_n^2}{U}}$

where U_n is the rms value of the n^{th} order harmonic and U is the rms value of the total voltage.

3.4 Location

The regulators will be situated outdoors and the ambient temperature range will be - 5°C to + 37°C.

3.5 Temperature-rise limits

The temperature rise limits should be chosen in accordance with IEC recommendations (Publication 76/1967), when the units are loaded with rated current and voltage, for continuous duty, with ONAN cooling.

.../4

3.6 Partial discharges

The voltage regulators shall be virtually free from internal and external partial discharges up to a voltage 20% higher than the rated voltage. The permissible magnitude of partial discharges may be subject to discussion but values exceeding some tens of pC will not be accepted.

3.7 Withstand capability to short-circuits and overvoltages

Due to the special operation, the regulators may be subjected to short-circuits, via a low impedance.

Thus, the regulators shall be designed to withstand short-circuits at the secondary terminals when being supplied via a very strong network. The withstand short-circuit duration has to be specified.

The special operating conditions may also cause overvoltages to occur at the secondary terminals. The magnitudes of these overvoltages are difficult to foresee. Thus, the regulators shall be protected on the secondary side by lightning arresters or by other auto-extinguishing devices capable of operating during switching overvoltages without damage.

.../5

The overvoltage protecting device will conform to the insulation level of the windings.

The primary winding will be connected to a network subject to normal frequency of occurrence of overvoltages of various kinds. The insulation of these windings thus shall be designed for an exposed location according to IEC Publication 76/1967. Protection equivalent to a station type lightning arrester of 10 kA or better shall also be provided.

3.8 Regulation

The regulation shall be virtually without steps and from zero up to nominal voltage.

The regulator shall be motor driven with provision for remote control. An auxiliary supply 230 V, 50 Hz, single phase or 400 V, line 50 Hz 3 phase will be available for this purpose. The time taken to raise the voltage from its lower limit to rated value shall not exceed 30 seconds for operation at maximum speed. A slower speed, half of the above or less is also required. The foregoing shall not be taken to exclude the offer of a d.c. driving motor capable of a wide range of operating speeds. Note, however, that in such case, a suitable d.c. supply must be provided by the manufacturer.

.../6

3.9 Controls

Four identical control desks shall be provided. The control equipment shall be installed in control panels, drawer type. Instruments must be installed in the control panels for the measurement of output voltage, output current, and output power factor. The control desks should conform to the dimensions shown on drawing No. 1004 included in this specification. Dimensions are in millimeters.

3.10 Internal insulation

If normal transformer oil is used as internal insulation, it shall conform to the specifications shown in Table I.

3.11 Mechanical details

Particular attention shall be paid to the avoidance of jamming of the moving parts at either end of the voltage range and adequate means shall be provided for manual adjustment of the "zero" position of each regulator. Any slipping clutch or fragile coupling shall be installed so as to be readily accessible for adjustment or maintenance. Details of such components shall be included in drawings accompanying the tender. Where fixed or movable brushes are used in a regulator, full details of their composition and mounting shall be supplied.

.../7

In such cases, designs where the brushes are supported between symmetrically disposed driving points will be preferred.

3.12 Oil tightness of the tank

Special importance is attached to the oil tightness of the tank, the bushings and other connections.

3.13 Painting

The tank, frame, radiators and all metallic accessories should be painted. The surface should, after having been theroughly cleaned, be properly coated with a suitable primer. The actual colours will be specified after the order is placed.

3.14 Earthed screen

It should be considered as an advantage if each regulator were provided with an earthed screen between H.V. and L.V. windings.

3.15 H.V. and L.V. Terminals

The H.V. as well as the L.V. terminals should be provided for cable connections.

3.16 Instrument transformers

Each regulator shall be provided with instrument transformers for the measurement of voltage, current, and for the operation of protective relays.

.../8

4.- SPARE PARTS

The tenderer shall provide a complete list of recommended spare parts with a separate price for each item.

5.- ERECTION

The regulators will be erected either by the manufacturer or by the purchaser at the latter's choice. The tenderer shall state whether he considers it necessary to supervise the erection of the regulators by the purchaser. The price of the required supervision shall be stated. Furthermore, a separate price shall be given for the complete erection of the regulators by the manufacturer.

6.- TESTS

6.1 Standards

Unless otherwise specified and when applicable the tests should be made according to IEC (Publications 76/1967, 137/1962 and 270/1968).

.../9

6.2 Power frequency

The tests specified at power frequency must be made at 50 Hz.

6.3 Type of tests

The regulators, including the controls, shall be tested at the manufacturer's expense before shipping. The purchaser reserves the right to repeat the tests after delivery at his expense to a sufficient extent to assure satisfactory performance. The type of tests and test-levels should be proposed by the manufacturer and will be subject to discussion. They should at least include the following:

- measurement of no load and load losses, short-circuit voltage;
- temperature rise tests (at least on one regulator);
- tests with impulse voltage, at levels in accordance with IEC Publication 76/1967, Table VIII, Series II;
- check of the partial discharge level (any recognized method, see IEC Publication 270/1968, is acceptable but a method showing the magnitude of individual pulses is preferred);
- check of the harmonic content;
- check of the control and regulating circuitry.

.../10

QUESTIONNAIRE ON TECHNICAL DATA WHICH THE TENDERER SHALL COMPLETE AND WHICH FORM A PART OF THE TENDER.

Two single-phase regulators each for 350 kVA, 22 kV/0 - 5 kV, 50 Hz, continuous regulation.

1.- GENERAL

General description of the regulators including their control, regulating and protection equipment

Description attached..

2.- CHARACTERISTICS

2.1 Rated primary voltage.................................kV

2.2 Rated frequency.......................................Hz

2.3 Rated secondary voltage...............................kV

2.4 Rated power at rated secondary voltage and frequency..MVA

2.5 Short-circuit impedance at maximum rated secondary voltage and frequency......................................%

2.6 Variations of the short-circuit impedance at rated frequency, throughout the range of output voltages ..

Description attached.................................

2.7 Secondary inherent overload power, for 10 minutes operation, repeated once per hour for four hours

....MVA

2.8 Secondary inherent overload power for one hour operation preceded and followed by a four hour period of rest

....MVA

2.9 Overload characteristics for other conditions of load

Description attached.................................

2.10 Relative harmonic content............................

2.11 Insulation class and withstand voltages, for each winding

Description attached.................................

2.12 Temperature rise at continuous nominal load,

copper, hot spot....................................^{o}C

top oil...^{o}C

2.13 Flux densities, at nominal voltage and frequency

Description attached.................................

2.14 No load losses at nominal voltage and frequency

....kW

2.15 Copper losses at nominal current

....kW

2.16 Stray load losses at nominal voltage and current

....kW

.../12

2.17 Withstand capacity to short-circuit and overvoltages; proposed protection against such stresses

Description attached.....................................

2.18 Lowest regulating limit, % of nominal voltage

....

2.19 Shortest time for regulators from lowest regulating limit to full voltage

....s

2.20 Longest time for regulation from lowest regulating limit to full voltage

....s

2.21 Type and accuracy of regulation

Description attached.....................................

2.22 Control equipment

Description attached.....................................

2.23 Possibilities of remote control from several control rooms.

Description attached.....................................

2.24 Type and amount of internal insulating fluid

Description attached.....................................

2.25 Weight and dimension of each regulator

....lbs

2.26 Internal or external installation and insulating liquid

provided..Type

2.27 Earthed screen between primary and secondary winding

yes....................   no.....................

2.28 Overvoltage protection

Primary...

Secondary...

3.- TESTS

3.1 Proposed tests and test levels for the regulators

Description attached.................................

3.2 Proposed tests regarding the characteristics and performance of the control and regulating systems

Description attached.................................

4.- SPARE PARTS

List of recommended spare parts

Description attached.......-..................................

TABLE I

ACEISTE REPSOL TENSION (Mémo)

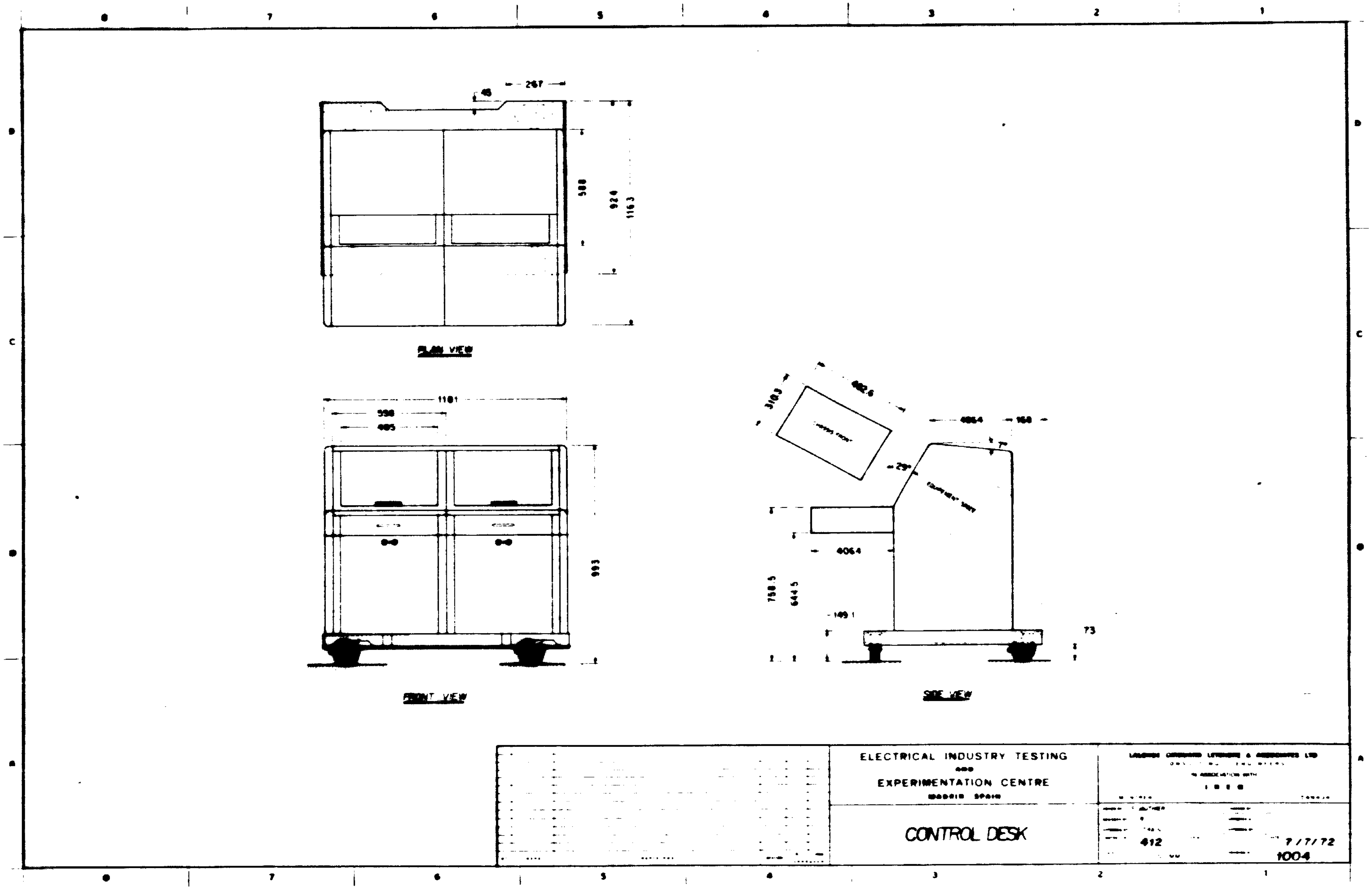
(Information concerning insulating oil)

SPECIFICATIONS

TEST	METHOD	VALUES
Density at 15°C	ASTM-D-1298	0.855 - 0.865
Inflamability V/A, °C	ASTM-D-92	165 minimum
Engler Viscosity at 50°C	Engler	1.3 - 1.9
S_1S_1V Viscocity at 210°F	ASTM-D-446	36.0 - 38.0
C_1S Viscosity at 210°F	ASTM-D-445	2.92 - 3.52
Colour	ASTM-D-1500	1.5 maximum
Freezing	ASTM-D-97	-26 maximum
Neutralization degree	ASTM-D-974	0.05 maximum
Saponification degree	ASTM-D-94	to be fixed later
Ash, %	ASTM-D-482	0.005 maximum
Dielectric Rigidity, kV	ASTM-D-877	35 minimum
Corrosive Sulphur	ASTM-D-1275	1 maximum
Deposit: 72 hours	ASTM-D-1214	0.075 maximum
: 168 hours	-	0.150 maximum (1)
Interfacial strain	ASTM-D-1971	45 minimum (2)
Contents in DBPC, %	ASTM-D-1473	0.4 - 0.6
Tangent δ	-	0.0004 minimum

(1) guide value

(2) to be determinated optionally


PLAN VIEW
FRONT VIEW
SIDE VIEW
267
45
588
924
1163
1181
598
485
993
310.3
482.6
406.4
168
7°
29°
406.4
758.5
644.5
149.1
73
ELECTRICAL INDUSTRY TESTING
AND
EXPERIMENTATION CENTRE
MADRID SPAIN
CONTROL DESK
412
7/7/72
1004

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TWO HIGH VOLTAGE CONSTRUCTION KITS

TWO (2) HIGH VOLTAGE CONSTRUCTION KITS

REQUIREMENT: 2 units of 100 kV

PROPOSED EQUIPMENT: High Voltage Construction Kit

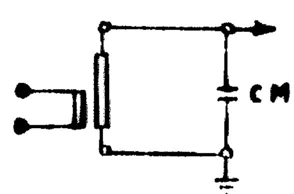
Circuit for single-phase.

- AC Voltage Testing Equipment

  Maximum power: 5 kVA

  Maximum voltage: 100 kV rms

  Diagram

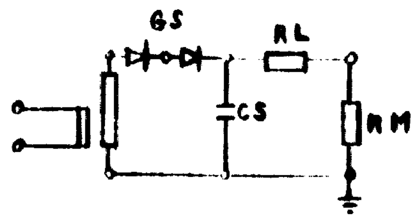


- DC Voltage Testing Equipment.

Maximum current: 5 mA

Maximum voltage: 100 kV

Diagram

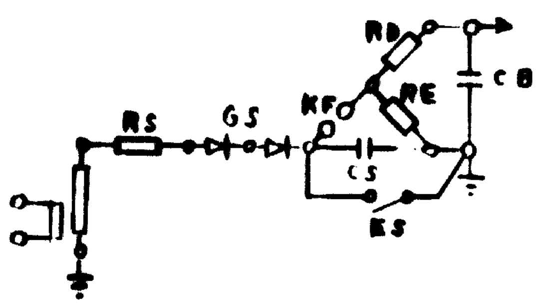


- Impulse Voltage Testing Equipment

Maximum power: 50 Ws

Maximum voltage: 130 kV

Diagram



Description Kit Elements

- **SRP 0.5/5: Remote Control Gear Desk**

  Power Supply: 220 V, 50 Hz

  Throughput : 5 kVA

  Regulating transformer hand-operated:

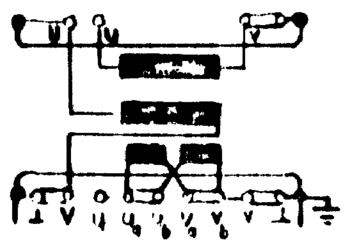
  220/0... 230 V

  5 kVA, 50 and 60 Hz.

  Desk to control AC, DC and impulse voltages during tests.

Number required: 2

TOE 100/10 Testing Transformer



Primary		Connection	Secondary		Output (kVA)	Short-Circuit Voltage %
Input Terminals	Voltage (V)		Output Terminal	Voltage (kV) rms		
u - v	220	$u_a - u_b$ $v_a - v_b$	U - V	100	5	5
u - v	220	$u_b - v_a$	U - V	50	2.5	10

The given output refers to continuous duty for double output, 60 minutes short-time duty refers.

Number required: 2

.../4

- GS H.V. Selenium Rectifier

  Inverse peak voltage: 140 kV

  Rated Current : 5 mA

  Protective Resistor : 500 kΩ

  Rectification in impulse and DC voltage generation.

Number required: 4

- CS Impulse Capacitor

  DC and impulse voltages: 140 kV

  Capacitance : 6000 pF

  Impulse capacitor in impulse voltage generation, and filter capacitor in DC voltage generation.

Number required: 2

- CB Load Capacitor

  DC and impulse voltage: 140 kV

  Capacitance : 1200 pF

  Load capacitor and H.V. capacitor in impulse voltage measurement.

Number required: 2

- RS Protective Resistor

  DC and impulse voltage: 140 kV

  Resistance : 10 MΩ

  Dissipation : 60 Watts

  Current limiting resistor, or for reducing the sequence of impulse.

Number required: 2

.../5

- RL Charging Resistor

  DC and impulse voltages: 140 kV

  Resistance : 50 kΩ

  Current limiting resistor for DC voltage generation.

Number required: 2

- RD Damping Resistor

  Impulse voltage : 140 kV

  Resistance at impulse waves:

775Ω	1.2/5
455Ω	1.2/10
375Ω	1.2/50
360Ω	1.2/200

  Resistor for determining the rise time of the impulse voltage.

Number required: 2 sets of 4 resistors.

- RE Discharging Resistor

  Impulse voltage : 140 kV

  Resistance at impulse waves:

290Ω	1.2/5
1025Ω	1.2/10
6100Ω	1.2/50
25500Ω	1.2/200

  Resistor for determining the time to half-value or the wave tail of an impulse voltage.

Number required: 2 sets of 4 resistors.

.../6

- CM Measuring Capacitor

    AC voltage : 100 kV rms

    Capacitance : 100 pF

    H.V. capscitor of the peak voltage measuring equipment.

Number required: 2

- RM Measuring Resistor

    DC voltage : 140 kV

    Resistance : 140 MΩ

    Rated current : 1 mA

    H.V. resistor for DC voltage measurement.

Number required: 2

- ES Grounding Switch

    AC voltage : 100 kV rms

    DC voltage : 140 kV

    Grounds when power supply is switched off.

    Switch for discharging the capscitors at DC and impulse voltage. (Will be connected through latches in parallel with the capacitor).

Number required: 2

- KF Ignition Spark Gap

    DC Voltage : 140 kV

    Sphere diameter : 100 mm

    Max. gap setting : 80mm

.../7

With gap setting indicator.

Device to set tha peak impulse voltage.

Numbar required: 2

- JS Support Insulator

AC voltaga : 100 kV rms

DC voltaga : 140 kV

Insulation construction alament.

Numbar required: 6

- AKF Drive for Sphera Gap

With insulating shaft.

With capacitor motor : 220 V A.C.

50 and 60 Hz

Device to set tha spacing of tha ignition spark gap kF (operation via insulating shafts; drive is attached to spacer bar D).

Number required: 2

- V Connecting Rod

Aluminium tube.

Conducting construction element.

Number required: 2

.../8

- K Connecting Cup

  Aluminium cast

  Conducting node point to sit on a vertical construction element and suited to clip in four construction elements horizontally, and one vertically.

Number required: 12

- F (a) Floor Pedestal

  Aluminium cast.

  Node point to clip in spacer bars horizontally, and for mounting one construction element vertically.

Number required: 12.

- D Spacer Bar

  Aluminium tube.

  Rod to provide electrical and mechanical connection between pedestals.

Number required: 14

- SM 615 Peak Voltmeter

  Measuring ranges: 100 - 50 - 20 $\hat{U}/\sqrt{2}$ (kV)

  or: 200 - 100 - 50 $\hat{U}/\sqrt{2}$ (kV)

  Instrument to measure the AC voltage peak (connected to capacitor CM or CP 120)

Number required: 2

.../9

- STM 615 Impulse Voltmeter

  Measuring ranges: 150 - 75 - 37.5 $\hat{U}$ (kV)

  or: 300 - 150 - 75 $\hat{U}$ (kV)

  Instrument to measure the impulse voltage peak

Number required: 2

- CT 0.5 L.V. Dividers

  Measuring ranges: 300 kV

  150 kV

  75 kV

  37.5 kV

  L.V. Capacitor for the capacitor voltage divider (plug in module in the HF output terminal of main load capacitor).

Number required: 6

- ZAN 150 Cable Adapter

  Characteristic impedance: 150 MΩ

  Impedance termination for coaxial cable.

Number required: 2

.../10

- GM 700 D.C. Voltmeter

The built-in measuring range switching allows the measurement of 37.5 - 75 - 150 kV with one measuring resistor or 75 - 150 - 300 kV with two measuring resistors. In addition to this, it is possible to directly measure DC voltages of up to 150 V in switch position "D". The voltmeter possesses a polarity reversal switch and built-in overvoltage protection. The measuring error amounts to < ± 1.5%.

Instrument to measure the DC voltage.

(Connected to Resistor RM).

Number required: 2

- VK 150 Coaxial Cable

Surge impedance: 150 Ω

Coaxial cable to connect H.V. divider to measuring instrument.

Number required: 2

- MF Measuring Spark Gap

AC voltage : 130 kV Peak

DC voltage : 130 kV

Impulse voltage : 130 kV

To be hand and motor operated (220 V 50 and 60 Hz).

With various electrodes:

Sphere type, dia. : 100 mm

Sphere type, dia. : 50 mm

Rod type, dia. : 20 mm

Needle electrodes : 90°

Spark gap for measuring the insulation breakdown voltage with various electrode arrangements.

Number required: 2

SUMMARY OF COMPONENTS

TYPE	DESCRIPTION	NO. REQUIRED FOR TWO UNITS OF 100 kV.
SRP 0,5/5	Control Desk, standard	2
TEO 100/10	Testing Transformer, oilinsulated, 100 kV	2
GS	Selenium Rectifier	4
CS	Impulse Capacitor	2
CB	Load Capacitor	2
RS	Protective Resistor	2
RL	Charging Resistor	2
RD	Damping Resistor	8
RE	Discharging Resistor	8
CM	Measuring Capacitor	2
RM	Measuring Resistor	2
ES	Grounding Switch	2
KF	Sphere Gap	2
JS	Support Insulator	6
AKF	Drive for Sphere Gap	2
V	Connecting Rod	2
K	Connecting Cup	12
F (s)	Floor Pedestal	12
D	Spacer Bar	14
SM 615	Peak Voltmeter	2
StM 615	Impulse Voltmeter	2
CT 0,5	L.V. Divider	6
ZAK 150	Cable Adapter	2
GM 700	DC Voltmeter	2
VK 150	Coaxial Cable	2
MF	Measuring Gap	2

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3.- SCOPE OF THE WORK

4.- REFERENCE STANDARDS

5.- CHARACTERISTICS AND DESIGN FEATURES

6.- EFFICIENCY

7.- INSTALLATION

8.- SPARE PARTS

9.- MAINTENANCE TOOLS

10.- PAINTING

11.- TESTS

CONTROL DESK

1.- OBJECT

This specification covers the Spanish Government's requirements for the supply, installation and testing of two rotating machines including all necessary regulating and control equipment. These machines will be used to test large power transformers.

2.- GENERAL DESCRIPTION

The machines shall serve to supply single and three-phase loads at various voltages, but shall have the following nominal ratings:

Machine No. 1: - Synchronous motor, 500 kW, 3 ϕ, 5 kV, 50 Hz.

Machine No. 2: - Synchronous alternator 5 kV, 3 ϕ, 1.33 MVA continuous at nominal frequency of 200 Hz.

Machines Nos. 1 and 2 shall be placed on a common baseplate and directly coupled together.

3.- SCOPE OF THE WORK

The machines shall be complete in every respect and shall be tested, inspected and set up in perfect operating conditions.

.../2

It shall include the following:

- The starting and excitation systems for the synchronous motors.
- The excitation and automatic voltage regulation systems for the alternator.
- The 1 ϕ/3 ϕ, winding connections system for machine No. 2
- The measurement and control systems.
- The electrical thermal and mechanical protective systems.
- The cooling and lubrication systems.
- All anchors, supports, bearings and the bed plates couplings.

The Purchaser will supply the following:

- Building and foundations.
- Auxiliary power supply at 5 kV, 3 ϕ.
- Load breakers for the generators.

4.- REFERENCE STANDARDS

The design, manufacture , installation, identification, inspection and testing of equipment covered by this specification shall comply with the relevant standards issued by the International Electrotechnical Commission or with equivalent standards.

.../3

5.- CHARACTERISTICS AND DESIGN FEATURES

5.1 Machine No. 1

Three-phase Synchronous motor.

Nominal frequency	: 50 Hz
Continuous rated power at nominal frequency and at power factor of 0.9 lagging	: 500 kW
Rated voltage	: 5 kV
Nominal speed	: Such as to give 200 Hz output for machine No. 2.
Excitation	: The tenderer shall submit different prices for the following alternatives : - Direct-coupled rotating exciter with complete control system. - Complete static excitation system with control.
Starting	: All necessary facilities shall be included. A design aim shall be to limit the starting current to 4 times the full load current.

.../4

The Tenderer shall submit as a separate item details and costs of additional equipment necessary to use machine No. 1 to bring machine No. 2 to synchronous speed.

5.2 Machine No. 2

Three-phase Synchronous alternator.

Nominal frequency	:	200 Hz
Continuous rated powerat nominal frequency and for all lagging power factors	:	1.33 MVA
Voltages	:	0 - 5 kV, Y, 4 terminals.

NOTE: The windings shall be so insulated that any terminal may be grounded.

Unsaturated subtransient reactance	:	20%

3 ϕ, Y open circuit voltage distribution factor D = 3.5%

In single phase D = 4.0 %

(D is defined as

$$D = 100 \sqrt{\sum_{n=2}^{\infty} U_n^2} \; / \; U_1$$

where U_n is the RMS value of the n^{th} harmonic phase to ground voltage and U_1 is the RMS value of the fundamental phase to ground voltage).

.../5

The generator shall be equipped with connected damper windings such as to make the ratio.

$$x''_q / x''_d \approx 1.$$

Values for x_q'', x_d'', (saturated), x_0 and R_2 shall be stated in the Tender Form.

The alternator armature terminals will periodically be short-circuited during normal operation. The machine shall be capable of withstanding repeated short-circuits as a normal operating condition and the tenderer shall include an adequate protection system.

5.3 Power Connections

Terminals on the leads shall be provided for connection to standard power cables. Facilities for the inter-connections which shall be simple to make, as well as the cubicle located at the generator, shall be supplied by the contractor.

5.4 Partial Discharge Level

The partial discharge level of the set should be as low as possible. Special attention should be given to the insulation structures and slip-rings of the alternators in order to limit the conducted interference of these machines to a minimum.

The tenderer should, in the tender form give his estimate of the radio interference voltage on the terminals due to partial discharge and measured according to NEMA Standards No. 107, 1964.

5.5 Control and Regulating Systems

The excitation and regulating systems of the alternator shall permit continuous variation of the voltage from practically zero up to nominal voltage plus 5%.

The voltage should be kept automatically within ± 0.5% of the preset value. The regulating time for any condition of load shall be stated in the tender form.

The possibilities of flashovers at the test objects require that the voltage can be automatically decreased rapidly to zero after such a flashover, and also that the alternator can withstand the overvoltages which may be caused by such flashovers.

5.6 Protection

The machines shall as far as practicable, be self-protected against any damage caused by the operation during laboratory conditions. The risk of transient overvoltages during failure of the test object and the risk of overspeed and overvoltage during load rejection should be especially noted.

.../7

The reactance between each machine and its test object will normally be 5% to 15% on the base of the machines nominal MVA and frequency.

The tenderer shall state in the form of the tender what special precautions must be taken by the Purchaser to prevent damage to the set of machines due to failure of the test objects.

5.7 Switchgear and Control Panels

All necessary switchgear, as well as control, measuring, indicating and protective equipment shall be supplied by the manufacturer. The equipment shall be housed in switchgear and control cubicles. It shall be possible to conveniently start-up, load, vary the voltage, unload and shut down the machine set automatically from the cubicles.

All relevant electrical operating parameters for the equipment shall be displayed on instruments to be approved by the purchaser.

Control of the voltage will also be effected from six (6) different additional control rooms located in the laboratory. The tender shall include as a separate item, the necessary equipment to permit this control and six desks. The control desks shall comply with the dimensions shown on drawing No. 1004 included in this specification.

.../8

Provision shall ba mada in the control cubicles. furnishad by the manufacturer for connection to the ramote control desks.

All secondary and control circuits shall be provided with approved pressure type terminal lugs and shall be terminated on approved type terminal blocks with removable marking strips. Sufficient terminal blocks shall be provided for all circuits plus 25% spares.

Flat pad, clamp type suitable for connection to either coppar or aluminium conductors shall be furnished for primary connections and for all primary equipment.

Tha voltage for the control, metering and relaying equipment will be 380 V (3 ϕ) and 220 V (1 ϕ).

6.- EFFICIENCY

The efficiency of the equipment is not specified. The equipment offared shall have losses which, to the satisfaction of the purchaser, are not excessive and do not inhibit satisfactory performance in any respect.

.../9

7.- INSTALLATION

The tenderer shall include in his tender one or several drawings showing the external dimensions and the weight of each unit.

The machine bedplates shall be designed for a normal flat concrete floor. No damage to the concrete floor shall result from the operation of the sets. Necessary attachments to be embedded in the floor such as studs or bearing rails shall be provided by the Contractor.

The stresses to be transmitted to the floor and details of the required attachments shall be indicated in the tender form. The attachments shall be designed such as to take account of the forces caused by short-circuits on these machines. Such short-circuits may occur more frequently than for normal machines and will be caused primarily by failure of the test object constituting the load.

8.- SPARE PARTS

The tenderer shall provide a complete list of recommended spare parts with a separate price for each item.

9.- MAINTENANCE TOOLS

The tenderer shall provide separate lists of special tools required for installation and for maintenance with a price for each item.

.../10

10.- **PAINTING**

All surfaces, except machined, current carrying and finished surfaces, shall be thoroughly cleaned and properly coated with a suitable primer.

The final colours will be advised at a later date by the purchaser.

11.- **TESTS**

The individual components and the complete set shall be tested in accordance with the applicable standards.

All tests shall be witnessed by the purchaser unless this right is especially waived by the purchaser in writing.

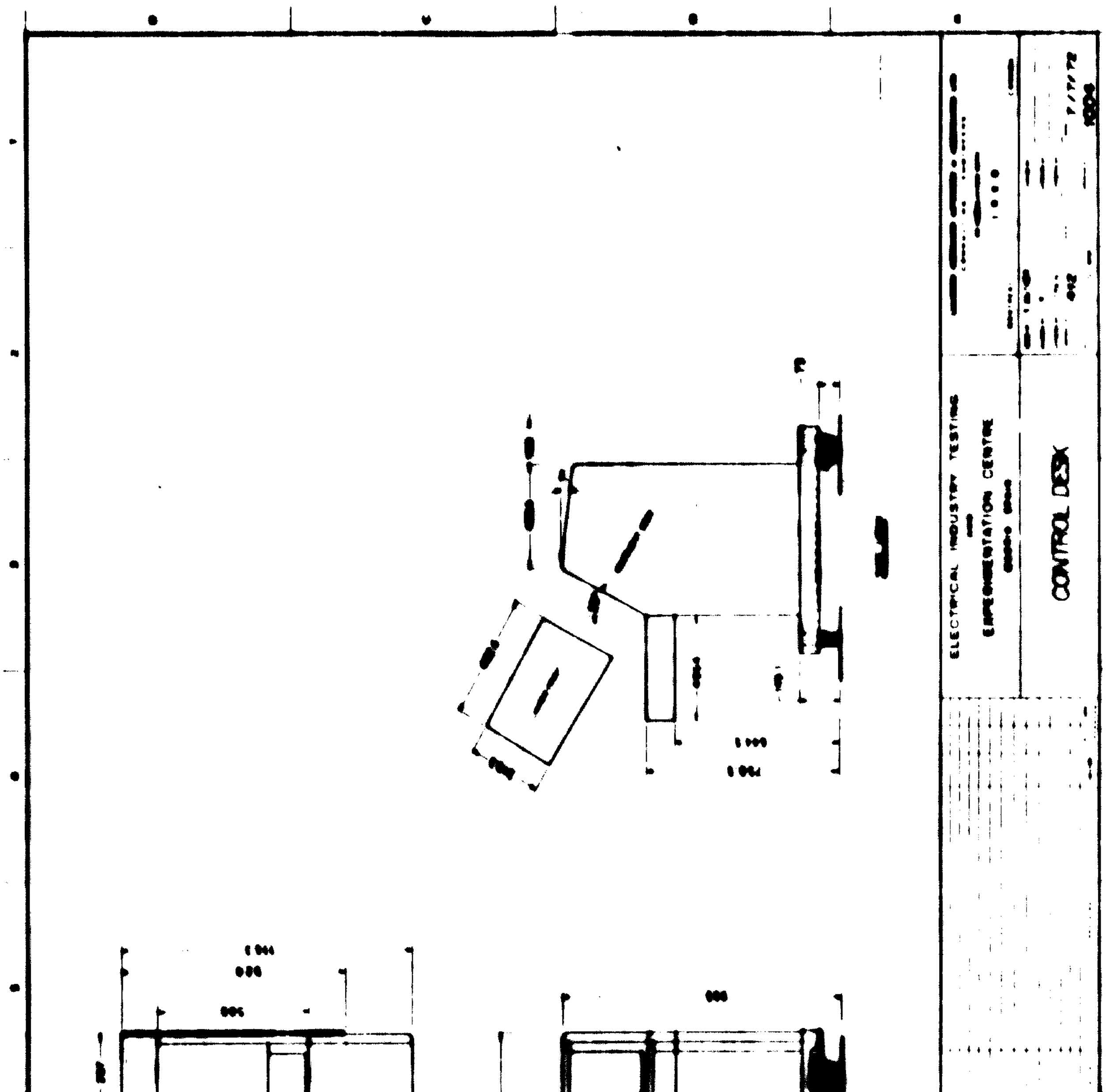
Routine tests on each item and on the sets shall be carried out at the supplier's works.

Tests at the Supplier's works and at the purchaser's site shall be carried out to demonstrate to the satisfaction of the purchaser that the equipment meets the specific and functional requirements of this specification.

The tenderer shall propose separate test programs for the equipment at the supplier's site, and after installation. These programs shall be subject to discussion and to the approval of the purchaser.

A detailed program showing this sequence and the nature of the test at the supplier's works should be submitted to the purchaser at least one month before the beginning of tests.

The supplier shall provide all equipment and personnel required to perform the tests at the purchaser's site. The purchaser reserves the right to monitor the tests with his own personnel and equipment.



ELECTRICAL INDUSTRY TESTING
EXPERIMENTATION CENTRE
CONTROL DESK

HV 24

[redacted]

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CONTROL DESK

1.- OBJECT

This specification covers the Spanish Government's requirements for the supply, installation and testing of two rotating machines including all necessary regulating and control equipment. These machines will be used to supply a cascade transformer set.

2.- GENERAL DESCRIPTION

The machines shall serve to supply single phase loads at various voltages, and frequencies but shall have the following nominal ratings:

Machine No. 1: - Synchronous motor, 400 kW, 3 ϕ, 5 kV, 50 Hz.

Machine No. 2: - Synchronous alternator 5 kV, 1 ϕ, 350 kVA continuous at nominal frequencies of 50 and 60 Hz.

Machines Nos. 1 and 2 shall be coupled through a speed converter permitting 50 and 60 Hz operation on machine No. 2.

3.- SCOPE OF THE WORK

The machines shall be complete in every respect and shall be tested, inspected and set up in perfect operating conditions.

The contract shall include the following:

- The starting and excitation systems for the synchronous motors.
- The excitation and automatic voltage regulation systems for the alternator.

- The measurement and control systems.
- The electrical thermal and mechanical protective systems.
- The cooling and lubrication systems.
- All anchors, supports, bearings, bed plates couplings and the speed converter for 50 or 60 Hz operation on machine No. 2.

The Purchaser will supply the following:

- Building and foundations.
- Auxiliary power supply at 5 kV, 3 ϕ.
- Load breakers for the generators.

4.- REFERENCE STANDARDS

The design, manufacture, installation, identification, inspection and testing of equipment covered by this specification shall comply with the relevant standards issued by the International Electrotechnical Commission or with equivalent standards.

5.- CHARACTERISTICS AND DESIGN FEATURES

5.1 Machine No. 1

Three-phase Synchronous motor.

Nominal frequency	: 50 Hz
Continuous rated power at nominal frequency and at power factor of 0.9 lagging	: 400 kW
Rated voltage	: 5 kV
Nominal speed	: Such as to give 50 and 60 Hz output for machine No. 2.
Excitation	: The tenderer shall submit different prices for the following alternatives: - Direct-coupled rotating exciter with complete control system. - Complete static excitation system with control.
Starting	: All necessary facilities shall be included. A design aim shall be to limit the starting current to 4 times the full load current.

The tenderer shall submit as a separate item details and costs of additional equipment necessary to use machine No. 1 to bring machine No. 2 to any of its synchronous speeds.

5.2 <u>Machine No. 2</u>

Single phase Synchronous alternator.

Nominal frequency	: 50 and 60 Hz.
Continuous rated power at nominal frequency and for all lagging power factors	: 350 KVA
Voltages	: 0 - 5 kV
Unsaturated subtransient reactance	: 20%

open circuit voltage distribution factor D = 4.0%

(D is defined as

$$D = 100 \sqrt{\sum_{n=2} U_n^2} \Big/ U_1$$

where U_n is the RMS value of the n^{th} harmonic voltage and U_1 is the RMS value of the fundamental voltage).

.../5

The generator shall be equipped with connected damper windings such as to make the ratio.

$$x''_q / x''_d \approx 1.$$

Values for x''_q, x''_d, shall be stated in the Tender form.

The alternator will often be required to suply leading power factor loads. The maximum continuous 0.0. p.f. leading load which the alternator can supply shall be stated in the Tender Form. Also, the tenderer shall state the price addition required, if necessary, for the alternator to supply its continuous rated power at 0.0 f.p. leading.

The alternator armature terminals will periodically be short-circuited during normal operation. The machine shall be capable of withstanding repeated short-circuits as a normal operating condition and the tenderer shall include an adequate protection system.

5.3 Speed Converter

As machine No. 2 is to be operated either at 50 or 60 Hz, a two fixed ratio coupling shall be provided between machines No. 1 and No. 2.

The 50 Hz operation is dominant over the 60 Hz operation. The conversion from one speed to the other shall be possible within reasonable time (4-8 hours) without realignment or major adjustment work.

5.4 Power Connections

Terminals on the leads shall be provided for connection to standard power cables. Facilities for the interconnections which shall be simple to make, as well as the cubicle located at the generator, shall be supplied by the contractor.

5.5 Partial Discharge Level

The partial discharge level of the set should be as low as possible. Special attention should be given to the insulation structures and slip-rings of the alternators in order to limit the conducted interference of these machines to a minimum.

The tenderer should, in the tender form give his estimate of the radio interference voltage on the terminals due to partial discharge and measured according to NEMA Standards No. 107, 1964.

5.6 Control and Regulating System

The excitation and regulating systems of the alternator shall permit continuous variation of the voltage from practically zero up to nominal voltage plus 5%.

The voltage should be kept automatically within ± 0.5% of the preset value. The regulating time for any condition of load shall be stated in the tender form.

The possibilities of flashovers at the test objects require that the voltage can be automatically decreased rapidly to zero after such a flashover, that the alternator can withstand the overvoltages which may be caused by such flashovers.

5.7 Protection

The machines shall as far as practicable, be self-protected against any damage caused by the operation during laboratory conditions. The risk of transient overvoltages during failure of the test object and the risk of overspeed and overvoltage during load rejection should be especially noted.

The reactance between each machine and its test object will normally be 5% to 15% on the base of the machines nominal MVA and frequency.

The tenderer shall state in the form of the tender what special precautions must be taken by the Purchaser to prevent damage to the set of machines due to failure of the test objects.

5.8 Switchgear and Control Panels

All necessary switchgear, as well as control, measuring, indicating and protective equipment shall be supplied by the manufacturer. The equipment shall be housed in switchgear and control cubicles. It shall be possible to conveniently start-up, load, vary the voltage, unload and shut down the machine set automatically from these cubicles.

All relevant electrical operating parameters for the equipment shall be displayed on instruments to be approved by the purchaser.

Control of the voltage will also be affected from six (6) different additional control rooms located in the laboratory. The tender shall include as a separate item, the necessary equipment to permit this control (plus six) control desks. The control desk shall comply with the dimensions shown in drawing No. 1004 included in this specification.

Provision shall be made in the control panels furnished by the manufacturer for connection to the remote control desks.

All secondary and control circuits shall be provided with approved pressure type terminals lugs and shall be terminated on approval type terminal blocks with removable marking strips. Sufficient terminal blocks shall be provided for all circuits plus 25% spares.

.../9

Flat pad, clamp type suitable for connection to either copper or aluminium conductors shall be furnished for primary connections and for all primary equipment.

The voltage for the control, metering and relaying equipment will be 380 V (3 ϕ) and 220 V (1 ϕ).

6.- EFFICIENCY

The efficiency of the equipment is not specified. The equipment offered shall have losses which, to the satisfaction of the purchaser, are not excessive and do not inhibit satisfactory performance in any respect.

7. INSTALLATION

The tenderer shall include in his tender one or several drawings showing the external dimensions and the weight of each unit.

The machine bedplates shall be designed for a normal flat concrete floor. No damage to the concrete floor shall result from the operation of the sets. Necessary attachments to be embedded in the floor such as studs or bearing rails shall be provided by the Contractor.

The stresses to be transmitted to the floor and details of the required attachments shall be indicated in the tender form. The attachments shall be designed such as to take account of the forces caused by short-circuits on these machines. Such short-circuits may occur more frequently than for normal machines and will be caused primarily by failure of the test object constituting the load.

8.- <u>SPARE PARTS</u>

The tenderer shall provide a complete list of recommended spare parts with a separate price for each item.

9.- <u>MAINTENANCE TOOLS</u>

The tenderer shall provide separate lists of special tools required for installation and for maintenance with a price for each item.

10.- <u>PAINTING</u>

All surfaces, except machined, current carrying and finished surfaces, shall be thoroughly cleaned and properly coated with a suitable primer.

The final colours will be advised at a later date by the purchaser.

11.- [illegible]

The individual components and the complete set shall be tested in accordance with the applicable standards.

All tests shall be witnessed by the purchaser unless this right is especially waived by the purchaser in writing.

Routine tests on each item and on the sets shall be carried out at the supplier's works.

Tests at the Supplier's works and at the purchaser's site shall be carried out to demonstrate to the satisfaction of the purchaser that the equipment meets the specific and functional requirements of this specification.

The tenderer shall propose separate test programs for the equipment at the supplier's site, and after installation. These programs shall be subject to discussion and to the approval of the purchaser.

A detailed program showing this sequence and the nature of the tests at the supplier's works would be submitted to the purchaser at least one month before the beginning of tests.

The supplier shall provide all equipment and personnel required to perform the tests at the purchaser's site. The purchaser reserves the right to monitor the tests with his own personnel and equipment.

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HV 25

[illegible]

[illegible]

1.- OBJECT

2.- GENERAL DESCRIPTION

3.- CHARACTERISTICS AND DESIGN FEATURES

4.- SPARE PARTS

5.- TESTS

6.- CURRENT TRANSFORMERS

QUESTIONNAIRE ON TECHNICAL DATA

1. **OBJECT**

This specification covers the Spanish Government's requirements for the supply of one 275 kV/5 kV/5 kV, 150 kVA 50 Hz, single phase transformer to be used for pollution testing.

2. **GENERAL DESCRIPTION**

The transformer will be used for pollution testing using both clean fog and salt fog techniques.

The transformer will normally be supplied by a 150 kVA voltage regulator at voltages from 0-5 kV RMS.

The transformer will be located inside the pollution chamber and will then be exposed to severe atmospheric conditions. The porcelain bushings will be covered with grease to eliminate flashovers and all metallic parts must be coated with a paint which will give protection against the corrosive salt atmosphere.

3. **CHARACTERISTICS AND MAIN FEATURES**

The following characteristics are desired but certain deviations could be accepted. The reasons for the deviations should be stated in the response to the questionnaire on technical data in the form of the tender.

3.1 Rated Data

Rated Frequency	50 Hz
No. of primary windings	2
No. of secondary windings	1
Primary voltage	5 kV
Secondary voltage	275 kV
Rated kVA of each primary winding	175 kVA
Rated kVA of secondary winding	350 kVA
Power frequency test voltage of each primary winding	22 kV
Power frequency test voltage of secondary winding	350 kV
Impulse test voltage of each primary winding	60 kV
Impulse test voltage including chopped waves of secondary winding	1050 kV

Note: Although the transformer will normally operate at 50 Hz, it may occasionally be energised at 60 Hz. In this case, the data given above should, as far as possible, apply at 60 Hz also.

3.2 Impedance

It is intended to operate the transformer with the primary windings connected either in series or in parallel.

For each arrangement the transformer will be energised by a 350 kVA voltage regulator having an impedance of 8 - 10% based on 350 kVA. The transformer impedance should be designed such that the short circuit current for each arrangement is not less than 12.5 A. on the high voltage side. No restrictions are placed on the upper limit of the short circuit current.

3.3 Overload characteristics

No specifications are given for the overload characteristics of the transformer but those applicable for 1 minutes operation and for 30 minutes operation should be clearly stated in the form of the tender.

3.4 Temperature-rise limits

The temperature-rise limits shall be in accordance with IEC recommendations Publication 76, 1967 when the transformer is loaded at rated current and voltage, for continuous operation.

3.5 Partial discharges

The transformer shall be virtually free from internal and external partial discharges up to a voltage 1.2 times rated voltage (130 kV RMS). The permissible magnitude of partial discharges may be subject to discussion but values exceeding some tens of pC will not be accepted.

3.6 Short-circuit capacity

Owing to the nature of pollution testing the transformer shall be built to withstand short circuits (3 to 10 cycles duration) on the secondary winding when being supplied by a very strong network. The withstand short-circuit duration shall be stated in the tender.

3.7 Cooling

The transformer shall be an oil-immersed natural cooled (ONAN) transformer, as defined in IEC Publication 76, 1967.

3.8 Transformer Oil

The transformer shall be supplied together with its first filling of oil. The oil shall comply with specifications laid out in Appendix 1 or be miscible with it.

Suitable valves to permit filling and subsequent filtering of the oil shall be fitted to the transformer.

3.9 Oil tightness of tank

Special importance is attached to the oil tightness of the tank, the bushings and other connections.

3.10 Painting

The tank and all metallic accessories should be painted. The surfaces should after having being thoroughly cleaned, be properly coated with a suitable primer.

The colour used for the final coats will be specified at a later stage by the Purchaser.

3.11 Earthed screen

An earthed screen shall be provided between the H.V. and other windings.

3.12 H.V. and L.V. Terminals

The low voltage end of the H.V. winding shall be brought out of the tank through a suitable low voltage bushing. The insulation of this end of the winding shall be designed in accordance with Table VIII Series II of IEC publication 76, 1967, for highest system voltage of 5.5 kV RMS. The connection to ground shall be made by means of a copper link adjacent to the bushing.

The high voltage bushing will normally be covered with grease to prevent flashover when operating in the salt fog atmosphere. It is recommended that a 300 kV system bushing with extended or anti-fog type sheds be installed. The bushing should be provided with both test and measuring tappings.

Both ends of the L.V. windings 1 and 2 shall be brought out of the tank through suitable low voltage bushings. The transformer shall be designed so that either end of each L.V. winding may be connected to ground.

Conventional brown glazed porcelain is preferred for the bushings.

4. SPARE PARTS

4.1 Spare Parts

The Tenderer shall furnish a list of recommended spare parts with separate prices for each item. The price of spare parts shall NOT be included in the total price quoted.

4.2 Tools

All tools required for the operation and maintenance of the transformer and its auxiliaries shall be supplied by the Tenderer and their price stated separately and included in the total price quoted.

5. TESTS

5.1 Standards

When applicable and unless otherwise specified, the tests shall be made according to IEC Publication 76, 1967.

5.2 Tests

All routine and type tests mentioned in IEC Publication 76, shall be performed.

5.3 Special tests

Chopped impulse waves shall be applied to the transformer at voltages at least equal to the BIL's shown in section 1.1.

Three flashover tests at 200 kV RMS shall be performed. The flashover shall be accomplished by means of either a rod gap or a sphere gap connected in parallel with the transformer. The tests may be made at a frequency greater than 50 Hz. Partial discharge measurements shall be made before and after the flashover tests. The partial discharge measurements made after the flashover tests should be performed with the shortest possible delay. There should be no significant difference between the partial discharge measurements made before and after the flashover tests.

The partial discharge level shall be measured by any recognised method. See IEC Publication 270, 1968. However, a method showing the magnitude of the individual pulses is preferred.

6. CURRENT TRANSFORMERS

The Tenderer shall quote the additional price for primary current transformers suitable for metering and protection purposes.

TECHNICAL DATA CONCERNING THE PROPOSED EQUIPMENT

AND FORMING PART OF THE TENDER.

One single phase transformer, 3 kV/ 275 kV, 350 kVA, 50 Hz.

1. GENERAL

General description of the transformer.

Description attached ....

Drawings attached ....

2. RATED DATA

2.1 Rated frequency, Hz ....

2.2 Rated primary voltage, kV RMS. ....

2.3 Rated primary current, A RMS. ....

2.4 Rated secondary voltage, kV RMS. ....

2.5 Rated secondary current, A, RMS. ....

2.6 Impedance primary to secondary based on 350 kVA, % ......

2.7 Rated power at rated secondary voltage and frequency, kVA.....

2.8 Secondary overload power for 3 minutes operation repeated once per hour for four hours, kVA........................

2.9 Secondary overload power for 30 minutes followed by four hours rest, kVA. ....

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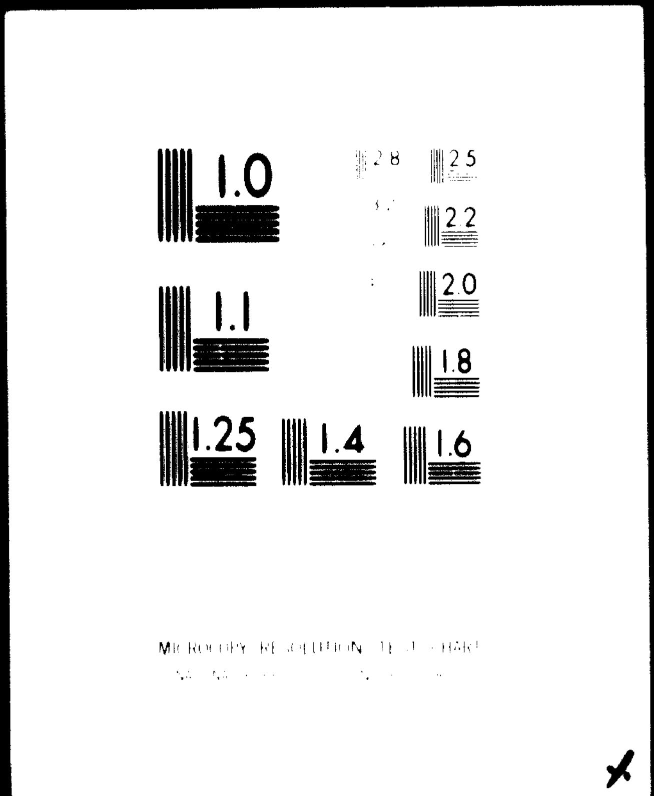

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2.10 Insulation class and withstand voltages for each winding and for bushing. Description attached. ....

2.11 Permissible temperature rise at continuous nominal load, copper, hot spot, top oil, °C. ....

2.12 No load losses at nominal voltage and frequency, kW. ....

2.13 Load loss at nominal voltage and current, kW. ....

2.14 Magnetizing current at 5 kV, A. ....

2.15 Type of amount of internal insulating fluid. Description attached. ....

2.16 Guaranteed partial discharge level, pC. ....

2.17 Weight of transformer, Tons. ....

3. TESTS

Description of all tests and tests level attached ....

CONTENTS

1.- OBJECT

2.- GENERAL DESCRIPTION

3.- CHARACTERISTICS AND DESIGN FEATURES

AERO-CASTERS

TABLE I

FIG. 1 - TEST TANK

1. OBJECT

This specification covers the Spanish Government's requirements for the supply of one test tank for testing transformer bushings for system voltages up to 750 kV RMS.

2. GENERAL DESCRIPTION

The tank shall be cylindrical in shape with its axis vertical. The internal dimensions must be 4.25 m Diameter, 4.5 m Height giving a volume of 64 m^3.

The top cover must be provided with a hole in the centre to accommodate transformer bushings for dielectric test purposes.

The tank will normally be filled with transformer oil and it is required to be mobile on air cushions.

3. CHARACTERISTICS AND DESIGN FEATURES

The following characteristics should be aimed at. Certain deviations could be acceptable but the reasons should be stated in the tender.

3.1 Tank dimensions

The internal dimensions of the tank shall be:

4.25 m D. ± 20 cm.

4.5 m H. ± 20 cm.

No restrictions are placed on the external dimensions.

The tank should conform as far as possible to the outline drawing shown in Fig. 1.

3.2 Tank materials

The tank shall be made from steel. Any gaskets, paints or other materials must be compatible with the transformer oil specified in Table 1.

3.3 Internal ressure

No limitations are required concerning the ability of the tank to withstand vacuum or overpressure.

3.4 Weather Conditions

The tank must be designed for operation outdoors or indoors. The ambient temperature range will be -5°C to + 37°C.

3.5 Observation Windows

Four circular observation windows of 40 cm Diameter are required around the circumference of the tank at the positions shown in Fig. 1. They should be made from toughened glass or Plexiglass.

3.6 Internal Projections

The internal surface of the tank will be highly stressed electrically during dielectric tests on bushings. Consequently, internal projections such as stiffening ribs etc. which may give rise to partial discharges will not be permitted.

3.7 Weight

The weight of oil in the full tank will be: 55,000 kg

The maximum weight of a transformer bushing located in the centre of the cover will be: 4500 kg.

3.8 Bushing Hole

The top cover shall be provided with a 1.2 m diameter hole to accommodate the bushing under test. When not in use this hole shall be sealed by a circular plate attached by means of a ring of bolts or studs. This sealing plate must also be provided by the tank manufacturer.

When bushings with flanges smaller than 1.2 m diameter are tested an adapting ring will be used to attach the bushing flange to the top cover. The supply of the adapting ring is the responsibility of the purchaser.

3.9 Valves

Valves for filling and emptying the tank should be fitted at the positions indicated on Fig. 1.

3.10 Oil-Tightness

Considerable importance is attached to the oil tightness of the tank and the manufacturer should propose suitable tests to demonstrate the performance of the tank in this respect.

3.11 Mobility

The tank is required to be mobile on a smooth horizontal concrete floor. The means of transport shall be by air cushions fitted in the base of the tank. The air cushions shall be chosen from the range shown at the end of this specification. These air cushions are supplied by the Aero-Go Company.

3.12 Lifting and Towing

Brackets must be attached as shown in Fig. 1 for lifting by means of an overhead crane. The brackets should be strong enough to carry the weight of the tank filled with oil plus the weight of a bushing.

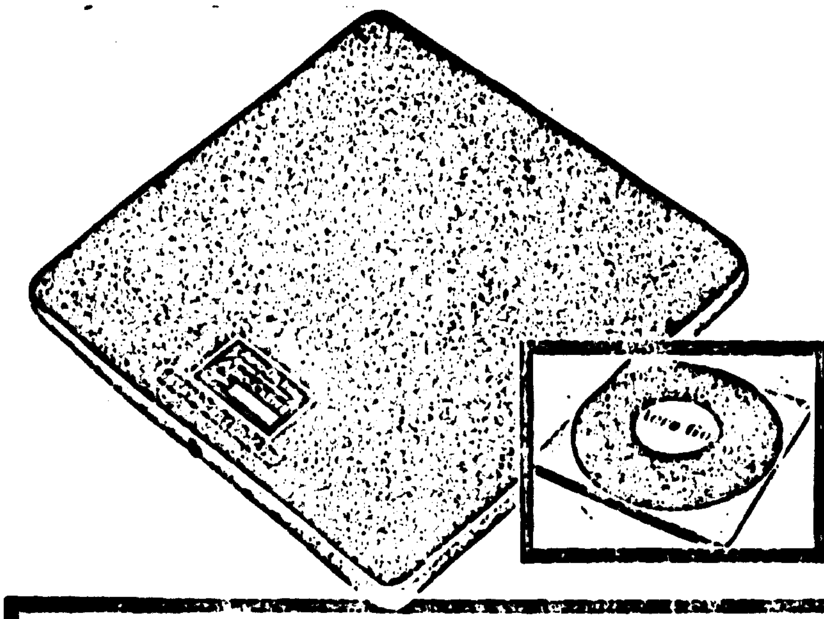
Additional brackets should be attached for towing by means of a tractor when supported on air cushions. The coefficient of friction should be assumed to be 0.002.

3.13 Paint

The internal surface of the tank shall be painted white with a paint which is compatible with the transformer oil specified in Table 1. The external surfaces shall be painted with a good quality primer and the final colour shall be specified at a later date.

Aero-Go, Inc.

5800 Corson Avenue South
Seattle, Washington 98108
(206) RO 3-9380

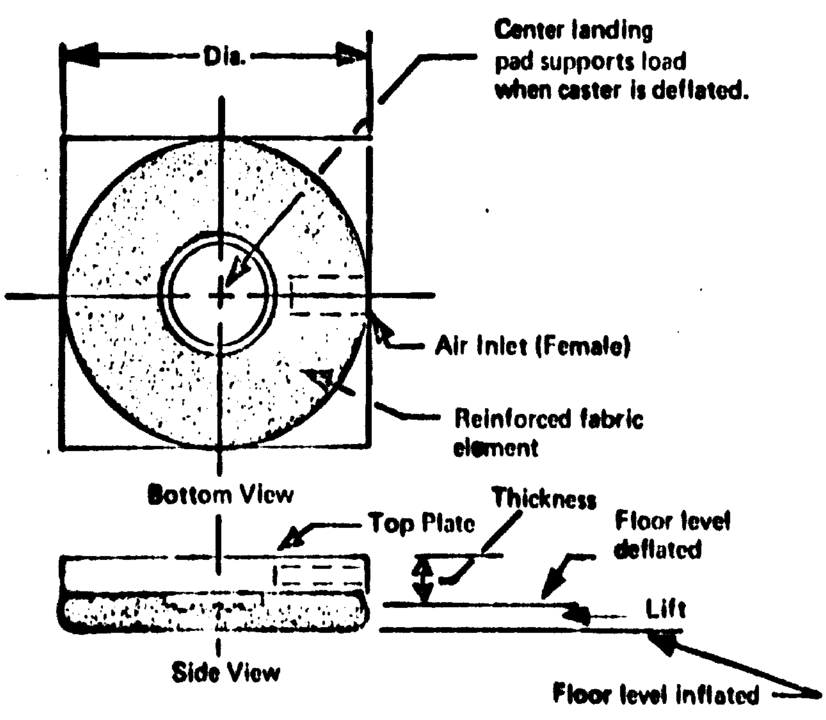


Aero-Casters are modular transfer platforms used for moving loads effortlessly.

Aero-Casters are available to match any load requirement. When used in combinations of 3 or more they provide a stable base for easy, omnidirectional movement of virtually limitless loads on a low pressure film of air. Systems from 500 pounds to hundreds of tons are now in successful operation.

AERO-CASTER LOAD MODULE PERFORMANCE AND SPECIFICATIONS

MODEL	RATED LOAD (LBS)	PRESS. AT CASTER (PSIG)	AIR FLOW (CFM)	WT. (LB.)	DIA. IN.	THICK. IN.	LIFT IN.	AIR INLET
K12	2,000	25	5-15	5	12	1	3/4	¼NPT
K15	3,500	25	5-20	8	15	1	7/8	¼NPT
K21	7,000	25	5-30	18	21	2	1	½NPT
K27	12,000	25	5-40	40	27	2	1¼	½NPT
K36	20,000	25	8-50	80	36	2¼	2	½NPT
K48	40,000	25	10-60	140	48	2¼	3	½NPT



MATERIALS:

Top Plates – Aluminum

Aero-Casters – Nylon Reinforced Neoprene

Use Aero-Casters to move your massive loads with great savings of time, effort, manpower, and expense. Costly crane or other lift equipment is not necessary when Aero-Casters allow one man to move many tons with slight effort.

PLACEMENT OF CASTERS . . .

For best performance the Aero-Caster assemblies should be mounted under loads in a way that divides the total weight approximately equally. For stability, three or more casters arranged in a triangle, or square pattern, is recommended. Center of gravity of load should be as close as possible to geometric center of the caster pattern. If an eccentric load is unavoidable, more air pressure may be applied through a simple regulator to the heavy side to compensate.

FLOOR SURFACE . . .

The volume of air required to float Aero-Casters is determined by the floor surface. A very smooth floor, vinyl tile, sealed concrete, metal decking, etc., requires least air. Air flow and friction force will increase in proportion to increase in surface roughness. Cracks and steps in floor surface should be bridged with common plastic tape. Plastic sheet or light gage sheet metal overlays can be used to cover rough or dirty surfaces. The substantial benefits and savings afforded by Aero-Casters will warrant the upgrading of a poor floor surface by resurfacing with fillers or terrazzo grinding. For unusual environments, please contact us.

OPERATION . . .

The load carrying capacity of the Aero-Caster is directly related to the air pressure available at the caster. In effect, the Model K21 Caster is an open ended piston with a lift area of 280 square inches. At 1 psig, 280 pounds can be lifted, at 10 psig, the same caster will lift 2,800 pounds. As the main valve is opened, compressed air is introduced into the caster through the air inlet fitting. Air is evenly distributed within the assembly and allowed to escape in a continuous flow through orifices in the flexible Aero-Caster. The Aero-Caster inflates, raising the assembly. A thin film of air flows between the periphery of the Aero-Caster and the floor surface to "float" the load. To avoid dragging the Aero-Caster and possible damage, be certain load is at full stop before cutting air supply.

MOVING FORCE . . .

Typical coefficient of friction between inflated Aero-Caster and a smooth, level surface is 0.001 or less. For example, a 2,000 pound load can be moved with a push of under 2 pounds. On inclined or undulating surfaces, free floating casters will drift to the lower level.

AIR SUPPLY . . .

Aero-Casters are designed to operate from clean compressed air. Air should be supplied to casters through piping or hoses of nearly equal length and diameter to assure uniform operation. 3/4" ID hose or larger (available from Aero-Go) is normally required. Smaller hose may be used under certain conditions.

ACCESSORIES . . .

Air supply source, control, and distributing devices are available separately from Aero-Go. Sources of air supply can be plant air, portable piston type compressor accumulator, low pressure centrifugal blower or air bottle, depending on load and floor surface conditions. Aero Casters are self pressure regulating systems that may be operated without separate line regulators. A slow opening flow control valve is recommended to avoid sudden pressure surge and to meter volume of air for most economical performance. In some applications, a quick opening relief valve may be desired to provide rapid lowering of load. Screw jacks, clamps or other devices to attach load are available mounted upon Aero-Caster module. Aero-Go, Inc., will recommend and provide complete accessories for specific applications upon request.

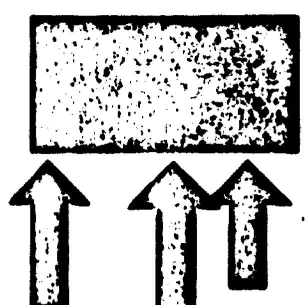
NOTE:

Aero-Go produces complete systems to resolve critical material handling problems or can supply you with custom designs to incorporate into your product for lifelong mobility.

As progress in air film technology is dynamic, products and specifications may be changed without notice.

HOW TO ORDER

Other Aero-Caster sizes, standard transport pallets to fit under your entire load, and units with self-contained air source are available. Call your Aero-Go representative.



SOLD BY:

TABLE I

ACEISTE REPSOL TENSION (Mémo)

(Information concerning insulating oil)

SPECIFICATIONS

TEST	METHOD	VALUES
Density at 15°C	ASTM-D-1298	0.855 - 0.865
Inflamability V/A, °C	ASTM-D-92	165 minimum
Engler Viscosity at 50°C	Engler	1.3 - 1.9
S_1S_1V Viscocity at 210°F	ASTM-D-446	36.0 - 38.0
C_1S Viscosity at 210°F	ASTM-D-445	2.92 - 3.52
Colour	ASTM-D-1500	1.5 maximum
Freezing	ASTM-D-97	-26 maximum
Neutralization degree	ASTM-D-974	0.05 maximum
Saponification degree	ASTM-D-94	to be fixed later
Ash, %	ASTM-D-482	0.005 maximum
Dielectric Rigidity, kV	ASTM-D-877	35 minimum
Corrosive Sulphur	ASTM-D-1275	1 maximum
Deposit: 72 hours	ASTM-D-1214	0.075 maximum
: 168 hours	-	0.150 maximum (1)
Interfacial strain	ASTM-D-1971	45 minimum (2)
Contents in DBPC, %	ASTM-D-1473	0.4 - 0.6
Tangent δ	-	0.0004 minimum

(1) guide value

(2) to be determinated optionally

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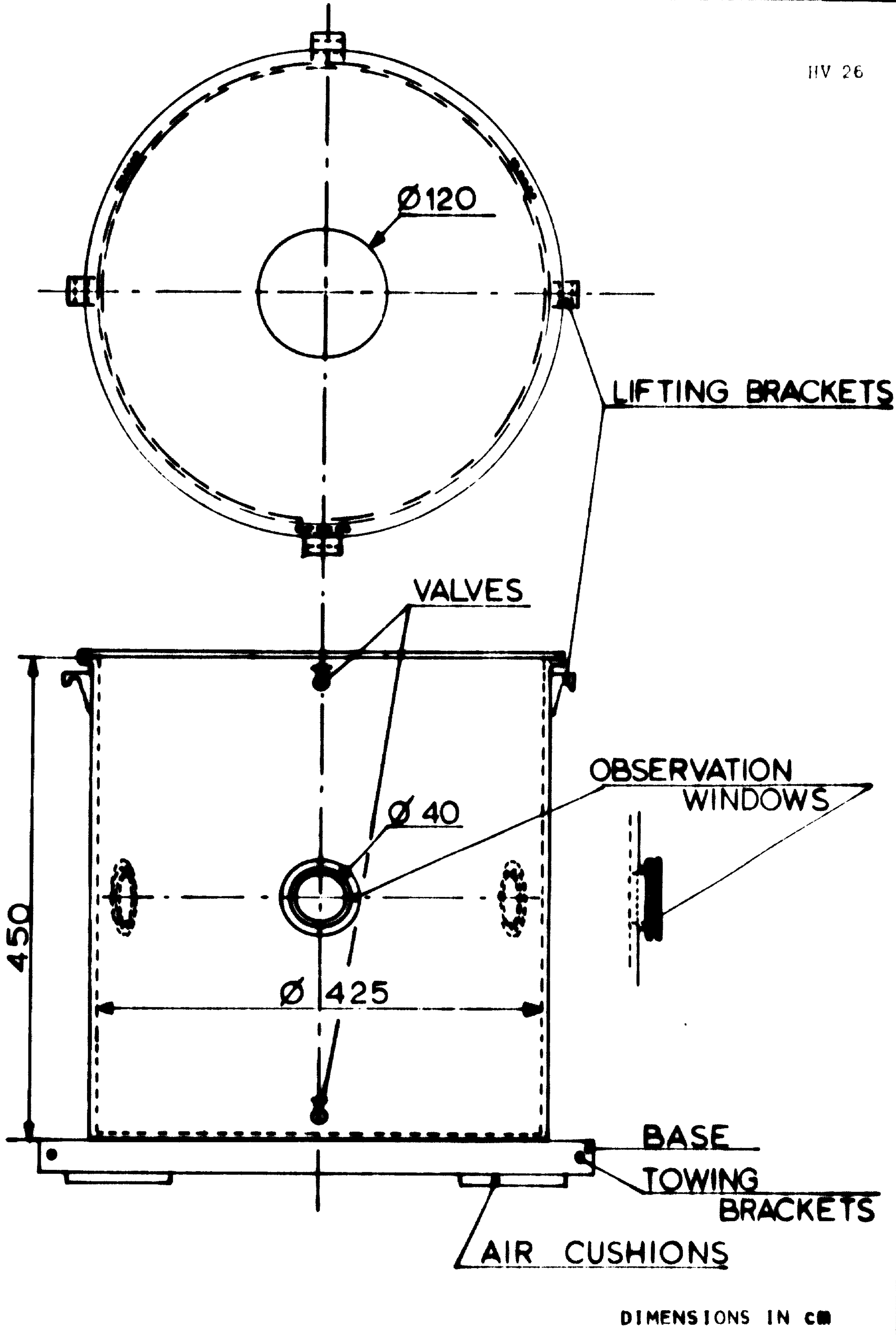

Fig. 1 _ TEST TANK

CONTENTS

1.- OBJECT

2.- CHARACTERISTICS

QUESTIONNAIRE ON TECHNICAL DATA

1.- OBJECT

This specification covers the Spanish Government's requirements for the supply of one set of resistive shunts for impulse current measurements.

1.1- Reserve

It is clearly understood that the buyer reserves the right to choose one, or more than one form of apparatus. stipulated in the present technical specification.

2.- CHARACTERISTICS

The following characteristics should be aimed at. Certain deviations are acceptable but the reasons should be mentioned in the form of the Tender.

2.1- Resistor shunts

The set should consist of the following units where the values of resistance R, signal level U, mass M of resistor material and response time T are only indicative.

Shunt No.	R Ω	U V	M g	T ns
1	10^{-3}	200	200	100
2	10^{-2}	200	150	50
3	10^{-1}	200	80	50
4	1	200	50	20
5	10	200	30	20

The first three shunts should be of tubular design, and the 1 and 10 ohms shunts can be wirewound, equipped with an inductance compensation network. The resistive material applied must be nonferromagnetic and its thermal resistance coeficient should not exceed 0.0001 $\frac{\Omega}{\Omega \cdot {}^{\circ}C}$ within a temperature range $+10^{\circ}C$ - $+120^{\circ}C$.

The shunts should comply with IEC Publication 60,1962 with the additional requirement of the aperiodic front of their step unit response.

The manufacturer should include in his offer oscillograms of the unit step response for each shunt. These oscillograms may be obtained from measurements made on identical or similar shunts.

.../3

The shunts will be used together with 15-50 m, coaxial cable of 50 Ω, wave impedance leading to a control room.

The cables will be of military type RG-217-U and will be provided by the purchaser. The shunts should be provided with necessary female contacts of military type UG-496-U.

The Tenderer should propose a suitable test program for the shunts.

.../4

QUESTIONNAIRE ON TECHNICAL DATA WHICH THE TENDERER SHALL COMPLETE AND WHICH FORMS PART OF THE TENDER.

RESISTOR SHUNTS

Shunt No.	R Ω	U V	M g	T ns
1				
2				
3				
4				
5				

General description of the shunts, including information on the characteristics of the resistor material.

Description

Enclosed____

Methods used to verify the response characteristics.

Description

Enclosed____

Duty cycle

Description

Enclosed____

TECHNICAL SPECIFICATIONS

HIGH VOLTAGE LABORATORY

78 MVA 100 kV test transformer	HV 14
3 MVAR 3 phase 200 Hz reactor bank	HV 15
3.5 MV Voltage dividers	HV 16
Artificial rain apparatus	HV 17
Six single phase current transformers	HV 18
Six single phase potential transformers	HV 19
Three 1.33 MVA single phase voltage regulators	HV 20
Two 350 kVA single phase voltage regulatore	HV 21
Two high voltage conetruction kits	HV 22
1.33 MVA, 200 Hz rotating machines	HV 23
350 kVA, 50 Hz, 60 Hz, rotating machines	HV 24
350 kVA, 275 kV, single phase test transformer	HV 25
Transformer bushing test tank	HV 26
Impulse current shunts	HV 27
Oil treatment equipment	HV 28
Transport and general purposes equipment	HV 29
Instrumentation	HV 30

NOTE: HV 14, HV 15, HV 16, replace HV 10, HV 11, HV 3 in the first equipment report.

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OBJECT

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GENERAL

DETAILED DESCRIPTION OF COMPONENTS

QUESTIONNAIRE ON TECHNICAL DATA

Specification of a unit which shall be used for insulating oil conditioning, drying and filling under vacuum of transformers.

This specification fully describes the unit and its accessories.

OBJECT

This specification covers the Spanish Governments requirements for the supply of a unit which shall be used for:-

1. Insulation oil conditioning.
2. Drying transformer windings under vacuum using the oil from which gas has been removed; the oil will be heated to raise the winding temperature to about 90°C.
3. Filling transformer tanks under vacuum with oil.

PRINCIPAL CHARACTERISTICS

1. Oil treatment

   - The unit shall be capable of operating under an ambient temperature that may vary from -5°C to + 37°C.

   - Output of unit shall be 10,000 litres per hour for an oil input temperature of 20°C.

   - If a liquid is used for heating, the liquid shall be contained within a closed circuit.

2. Filter

A filter (1 μm) which shall permit 10,000 litres per hour at the output shall be installed between the inlet heating elements and the gas removal unit. Two isolating valves and a differential pressure gauge shall be included with the filter.

3. Gas removal unit

- The gas removal unit shall conform to the requirements of D I N Boiler and Pressure Vessel Standards for fireproof tanks.

- There are no objections to vacuum being created in either one or several stages, provided the oil meets the aforementioned standards after it has passed through once.

- Precautions shall be taken so as to prevent any air or gas returning to the vacuum chamber. Control handles and taps for the gas removal unit shall be located so that they are easily accessible. Precautions shall also be taken so as to avoid excessive accumulation of oil and foam in the vacuum chamber.

4. Pumps

- Oil inlet and discharge pumps shall be the positive-displacement type, with sufficient capacity to maintain the required output 10,000 litres per hour at 20°C when the two sets of hoses (20 m.) are connected in series with the unit.

- The vacuum pump will be used for the following three purposes: removing gas from oil, evacuating transformer tank and maintaining vacuum during filling. The vacuum pump shall have sufficient capacity to make all those operations simultaneously.

- The liquid used in the cooling system shall be easily obtained on the market. It must be circulated within a closed circuit.

- The vacuum pump shall be equipped with an oil seal conditioner (water and sediments), complete with hand-automatic-selector switch and pilot light located on the control panel.

- A valve shall be installed at the inlet of the vacuum pump for the purpose of insulating the vacuum pump from the remainder of the unit.

- There shall be a device in the vacuum line for preventing foreign bodies from damaging the vacuum pump. This device shall not reduce appreciably the flow output of the vacuum pump.

GENERAL

- The Manufacturer shall provide a set of flexible hoses 10 cm in diameter and 20 meters long divisible into 5 metre lengths, to be used when creating vacuum in transformer tanks. Couplings between hoses and from hose to tank shall be a quick adaptor type.

- The Manufacturer shall supply two sets of flexible hose, one for oil input (40 meters) and one for oil output (20 meters). The hoses shall have 5 cm as a minimum diameter, divisible into lengths of 5 meters and provided with connectors. These two sets of hose shall withstand vacuum of 1 mm Hg.

- The unit shall be provided with a McLeod gauge capable of measuring residual pressures, in the transformer tank, of approximately 100 mm. of Hg at 100 microns. The gauge shall be part of the unit but shall nonetheless be portable.

- The unit shall be equipped with a device for continuous measurement of water content at the exit complete with a high water content warning which shall be ajustable between 1 and 10 ppm by weight at 25°C.

- A timer shall be installed for totalizing the hours of operation of the vacuum pump.

- An oil-sampling valve shall be installed at the input and output of the unit, as well as two totalizing flow meters with a capacity of 500 kilolitres and 50 kilolitres. Those totalizing flow meters shall be located so as to register only kilolitres of oil delivered at the outlet.

- In a single pass, the unit shall be capable of reducing the water content of incoming oil from a maximum of 50 ppm by weight at 25°C and of 15 ppm by weight at 0°C and saturated with air to approximately 10% by volume to a maximum at 1 ppm by weight at 25°C with a maximum air content of 0.1% by volume.

2. Drying and filling under vacuum

- The degassifier vacuum pump shall be powerful enough to evacuate a 50 cu. metres transformer tank to 100 microns in two hours.

- Oil flow shall be adjustable from 1000 litres to 5000 litres per hour during drying under vacuum.

DETAILED DESCRIPTION OF COMPONENTS

1. Heating elements at inlet and outlet of gas removal unit

- The heating elements shall be designed so that at no time shall the oil be damaged if oil flow stops for any period of time whatever. Oil temperature inside the system shall be thermostatically controlled. Power rating of the heating elements shall not exceed 250 W/Cm^2.

- Operation of the inlet and outlet heating elements in series only shall be possible through a by-pass around the rest of the unit.

- A three channels paper chart recorder with cells and all the accessories shall be included for the continuous recording of the temperature and resistivity of oil at the outlet of the unit and the vacuum pressure obtained on transformer tanks when filling.

- The unit shall be provided with a by-pass circuit and adequate valves.

- There shall be a control panel containing a diagram of the mechanical and electrical circuits, and located so that the operator can start, stop and control all motors in the installation. This panel shall also contain all controls necessary for proper operation of the unit.

- Red lights on control panel shall come as well as audio alarms when the unit is not delivering processed oil to the apparatus in which the oil is being treated.

- Temperature gauges shall be installed at the following points:-

  a) at the oil inlet

  b) at the oil outlet

  c) at the inlet of the vacuum chamber

  d) at the outlet of the vacuum chamber

- Flexible connections used in the unit shall be strong enough to withstand road vibration and shocks during transport.

- All piping shall be adequately secured and supported so as to prevent damage during transport.

- The complete wiring unit shall be weatherproof.

- Oil inlet and outlet as well as auxiliary vacuum connection for transformer drying shall be located at the front of the unit. The control panel shall be mounted at the opposite extremity at the rear of the trailer.

- There shall be a strainer at the input to the oil circuit so as to prevent foreign bodies from entering.

- A complete list of suitable lubricants for all the components shall be given in the tender. This list shall indicate at least 3 products for each application and these products shall be readily available locally. The use of these lubricants shall be compatible with the recommendations of the manufacture of equipment and shall validate the guarantee.

- Grounding: There shall be an appropriate grounding device for the whole unit, it shall be connected at a central point on the outside of the trailer chassis.

- Power supply: All motors, elements, etc., shall be built to operate from a 400 volts, 3-phase, 50 Hertz power source. The manufacturer shall supply a power cable 30 meters long to feed the unit. Lugs at the free end of the cable shall be mounted to permit the bolting to bus bars at differents locations in the laboratory and outside.

- <u>Mounting</u>: All components of the unit shall be mounted on a four-wheeled trailer. On the chassis there shall be a metallic structure covered with a solidly fixed canvas used as a protection against weather.

The unit shall be used inside a building and occasionally outside and the speed at travelling shall be low. For all those reasons it is not required to equip the unit with brakes, but a locking device should be fitted for use when the trailer is stationary. In addition springs are not required, pneumatic tires will provide sufficient suspension.

The base of the degassifier unit shall be moved as close as possible to the front of the trailer to allow as much standing room as possible at the rear,in front of the control panel.

<u>GENERAL</u>

In the trailer there shall be a space provided for storing all flexible hoses.

- <u>Checking and Testing</u>: The complete installation shall be checked at the Manufacturer's plant before delivery and after reception if necessary.

- <u>Operation and maintenance</u>: The Manufacturer shall supply six copies of the operation and maintenance manual. They shall be sent upon delivery of the equipment.

- Spanish shall be used on all name plates and other printed instructions and indications.

- Temperature shall be indicated in centigrade degrees, pressure in mm Hg.

- The tender shall include a list of recommended spare parts.

QUESTIONNAIRE ON TECHNICAL DATA WHICH THE TENDERER SHALL COMPLETE AND WHICH FORM A PART OF THE TENDER

Unit to be used for insulating oil conditioning, drying and filling under vacuum of transformers.

1. General

General description of the unit and of its accessories.
Description attached ....

2. Characteristics

2.1 Maximum power consumption with heating elements for drying
kVA ....
without heating elements for drying
kVA ....

2.2 Maximum flow of oil at the outlet for a continuous process.
Litres per hour ....

2.3 Oil temperature at the outlet for an inlet temperature of 20°C and a flow of 500 litres per hour in a drying process
temp. °C ....

2.4 Reducing factors for water and air content with maximum flow.

From 50 ppm of water by weight at 25°C
to .... ppm by weight at 25°C.

From 10% of air by volume to ....%
by volume.

2.5 Characteristics and capacity of the vacuum pump.
Description attached ....

2.6 Trailer type
Description attached ....

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FORK LIFT TRUCK

TOWING TRACTOR

TELESCOPIC PLATFORM

TELESCOPIC PLATFORM TRAILER

STAIRWAY SCAFFOLD

HANDLING EQUIPMENT

TOOLS AND EQUIPMENT LIST

FORK LIFT TRUCK

This specification represents the general fork lift truck characteristics suitable for interior and exterior use. The specification should be followed as closely as possible. However, some deviations are permitted, particularly if they lead to a reduction in price of the equipment. The reasons for any deviations should be mentioned in the tender.

SPECIFIC REQUIREMENTS

- Rated capacity: 2 metric tons rated at 60 cm load center.
- Lift height: 9 meters
- Capacity at 9 m. : 400 kg.
- Drawbar pull empty: 2.5 metric tons
- Forks length: 150 cm.

ENGINE REQUIREMENTS

The engine must be an industrial fuel type. The engine exhaust must be purified by an oxy-catalyst. A pyrometric meter must be installed on the dash board.

Electrical System:

It must be equipped with a 12 volts electrical system, 60 amp. hour battery, 41 amp. alternator, controlled by voltage regulator, electric starter, splash proof distributor, key starting switch, electric horn.

Steering

A power steering with dual cylinders must be provided.

Springs

The lift truck must be mounted with springs to maintain four wheels contact in all terrain.

Instruments

The controls must include all necessary instruments to ensure satisfactory operation. They should not be damaged by occasional exposure to rain when used outdoors.

Towing Capability

The lift truck must be provided with towing equipment for a drawbar pull load of 3 metric tons. The rugged tow bar must be built with king pin inclination coupled with articulation mounted heavy leaf springs.

Forks

The forks must be designed to pick-up load within 3 cm from the floor. Each fork must have 1.75 cm diameter holes drilled as follows:

- one at 20 cm from each fork end
- one on each fork middle.

Manuals

Parts manual, maintenance manual and operator's manual must be supplied in three copies.

TOWING TRACTOR

Specification of a towing tractor which must be equipped with hydraulic or mechanical winch.

- Service Weight .... 7,200 kilograms
- Drawbar pull capacity .... 5,400 kilograms
- Maximum towing capacity .... 300 tons/metric
- Turning radius .... 3 metres

Travel Speed

The low gear must have a maximum speed ...... 3 KM/Hr.

N.B. To anticipate jerking, minimum speed should be .. 2 KM/Hr. or slower.

Industrial Engine

The towing tractor must be equipped with an industrial fuel type engine. The engine exhaust must be purified by an oxy-catalyst filter. A pyrometric meter must be installed on the dash board.

Electrical System

It must be equipped with a heavy-duty 70 amp hour rated battery and 30 amp low cut-in generator. Dust-proof distributor, key ignition switch, starter button, electric horn, headlights, recessed driving lights and tail light complete this reliable electrical system.

Instruments

Instrument cluster consists of engine hour meter, ammeter, engine oil pressure gauge, fuel gauge, ignition switch and starter button. These should all be mounted on dash panel within easy view.

Axle and final drive

The axle and final Drive must be designed to reduce causes of axle shaft failure.

Friction Clutch Transmission

The transmission must be a heavy duty spur gear unit.

Brakes

The towing tractor must be provided with two hydraulic systems operated by a power booster to reduce braking effort. An independent parking brake must be convenient for operation.

Steering

The towing tractor must be equipped with a power steering.

Seating

The seat must be adjustable and mounted to afford best visibility and comfort for maximum driving efficiency.

Paint

The towing tractor colour should be according to the purchaser's choice and will be specified later.

Anchorage ring:

The towing front anchorage ring must have a 10 metric tons capacity. This anchorage ring must be attached to the frame.

Shock-absorbing Fluid Coupling

The towing tractor must be provided at the back with a shock-absorbing fluid coupling to get loads moving without jerking.

Safety grating panel

The towing tractor must be equipped with a safety grating panel to protect the driver in case of winch cable failure. A steel grille having a mesh size of 10 cm^2 is acceptable for good driving visibility.

Winch

The winch driven by the engine must have the following characteristics:

a) The drive controls must be positioned near the driving seat.

b) The winch capacity: 10 metric tons.

c) The cable must be at least 60 metres long.

d) Recommended ratios of: 44:1 and 22:1

Manuals:

Parts manual, maintenance manual and operator's manual must be supplied in three copies.

Specification deviation

The specification should be followed as closely as possible. However, some deviations are permitted, particularly if they lead to a reduction in price of the equipment. The reasons for any deviations should be mentioned in the tender.

TELESCOPIC PLATFORM

This specification covers the Spanish Government's requirements for the supply of a telescopic working platform.

Technical characteristics

Radius of action in extended position .... 20.5 m

Transport clearance .... 3.5 m

Total capacity of the platform .... 300 kg

Capacity of the extensible platform .... 150 kg

Lifting time .... 170 sec.

Lowering time .... 190 sec.

Speed translation motion .... 20 km/hr

Maximum height .... 12.2 m

These platforms must be free to turn over 360° around the vertical telescopic column.

Minimum load requirement

The load requirements must be according to DIN 4112 specification issue March 1960.

a) Vertical load on main platform .... 300 kg

b) Vertical load on extending platform .... 150 kg

c) Minimum horizontal load at the maximum height on the extensible platform with maximum travelling

   1. Inside .... 150 kg

   2. Outside .... 100 kg

TELESCOPIC PLATFORM TRAILER

The assembly base must be mounted on four (4) wheels with tires for its transportation on highways.

Four (4) outriggers with manual jacks must be used to anchor the trailer in place for working purposes.

The four (4) wheels must be equipped with brakes.

A driving axle and a front towing rod must be provided.

A ladder must be placed on the base in order to reach the platforms when they are at the minimum height.

GENERAL

The equipment power supply will be 380 V/3 ϕ/50 Hz.

A telephone link between the platforms and the base level must be a part of the installation.

Control stations must be placed at three determined locations; ground, extensible platform and fixed platform.

The supplier shall provide a list of spare parts and their delivery time.

Assembling and putting into service shall be at the supplier expenses.

Acceptance tests will be performed by the Spanish Government.

Manual

Parts manual, maintenance manual and operator's manual must be supplied in three copies.

Specification deviation

The specification should be followed as closely as possible. However, some deviations are permitted, particularly if they lead to a reduction in price of the equipment. The reasons for any deviations should be mentioned in the tender.

STAIRWAY SCAFFOLD

This specification covers the Spanish Government's requirements for the supply of Stairway Scaffold.

Purpose: Stairway scaffold with vertical access for aerial erection.

Specification erection

General Characteristics

Description: Aluminium multiple sections scaffold provided for quick erection without the use of tools.
The structure includes one adjustable lower section and five upper sections equipped with interlock pins.

Dimensions: Height: 12.20 meters
Width: 1.75 meter
Depth: 1.25 meter
Total Weight: 200 kilograms
Load capacity: 600 kilograms in any point of the structure.

Adjustable Lower Section

The lower section must be equipped with swivel casters telescoping extension legs (for working on uneven surfaces) four adjustable outriggers. (To stabilise structure).

Lower Section Dimensions: Height: 2 meters

Width: 1.75 meter

Depth: 1.25 meter

Upper Section

The Lower and Uppers Sections include: stairway (slope of 45°), two supporting tubes, a non-skid platform board, diagonal brace and guard rail. The scaffold must be equipped with a guard rail section to prevent personnel from falling.

Section dimensions: Height: 2 meters

Width: 1.75 meter

Depth: 1.25 meter

Swivel Casters

Caster diameters should be approximately 13 cm. and they should be fitted with locking devices. All casters should be swivelled. The rims should be covered with a plastic material.

Guard Rail Section

The last upper platform must be equipped with a guard rail section.

Height: 1 meter

Transport:

To avoid structure vibration during transport the lower section must be mounted with one horizontal brace above the casters on each side.

GENERAL PURPOSE EQUIPMENT

HANDLING EQUIPMENT

This specification covers the Spanish Government's requirements for the supply of general purpose barrows and hand carts.

Goods hand-barrow

Two-wheel tubular steel hand-barrow required for handling boxed merchandise, cases, cartons, soft packed goods and an infinite variety of similar loads.

- One pneumatic heavy duty, capacity .... 270 kg

Gas Cylinder hand-barrow

Hand-barrow for transportation of compressed gas cylinders such as oxygen or acetylene cylinders.

Single cylinder hand barrow-welded steel construction equipped with four rubber tyred wheels
capacity ....360 kg

Platform hand-cart

Industrial rugged platform hand-cart built with pressed steel. The smooth deck must be reinforced for extra strength. Four pipe sockets must be built right into the body. Corners must be rounded. The tubular push handle 0.635 meter above the deck must be removable.

All fasteners must be rustproof. The wheels must be with roller bearings and rubber tires.

Deck size: 1 m. x 2 m.

Wheel size:

A) main: 35.5 cm. x 5.5 cm.

B) casters: 20 cm. x 5 cm.

capacity.................................. 1360 kg.

<u>Dolly</u>

Two open frame dollies for boxes, crates, etc... must be equipped with rubber wheeled swivel casters fitted with ball bearings. Supplied with bumper and towing eyes.

capacity.................................. 1360 kg.

TOOLS AND EQUIPMENT LIST

1. Lathe 50 cm @ 60 cm Swing 180 cm between center
2. Lathe 25 cm @ 30 cm Swing 90 cm between center
3. Universal or horizontal Milling Machine 2 to 5 H.P. with variable speed drive.
4. Heavy Duty Power Band Saw (Horizontal): cutting capacity 20 cm to 30.40 cm.
5. Band Saw (Vertical) Do All or equivalent : capacity 1 H.P., blade to blade 40 cm.
6. 15 to 20 cm Bench Grinder, capacity 1 H.P.
7. 30 cm Disk Sander, capacity 1 H.P.
8. 300 Amp Welding Machine
   with Tungsten inert gas attachments for aluminum and copper
9. Heavy Duty Press Drill (Capacity 4 cm)
10. Heavy Duty Nibbler Capacity 5 mm (Wolf or Equivalent)
11. Heavy Duty Bayonnet Saw Rockwell 548
12. Hand Grinder
13. 6 mm - 12 mm - 18 mm Hand Drills
14. 4 Hydraulic 35 tons Jacks
15. Hand Pullers and Winches
16. Portable air compressor 10 m^3/min.
17. Accessories for Spray Paintings: Spray Guns, Air Filters, Regulators, etc.
18. Radial 25 cm saw
19. Sheet metal bender 2 meters
20. Sheet metal roller 1 meter
21. Recipro-Saw (Skilsaw 474)
22. Heavy Duty Orbital Sander (Skil 992).

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MERCURY RELAY STEP GENERATOR

COMPRESSED GAS STANDARD CAPACITOR

RADIO NOISE METER

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PROPOSED EQUIPMENT:

TEKTRONIX

1 - Oscilloscope 7403 N Option 8 (P 11)

1 - Storage oscilloscope 7613 Option 3

1 - Dual trace amplifier 7A 12

1 - Dual trace amplifier 7A 18

1 - Differential amplifier 7A 22

1 - Time base 7B 50

1 - Time base 7B 53A

2 - Scope mobile carts 203-2

2 - Probes P 6052

2 - Probes P 6053A

2 - Probes P 6009

1 - Camera C50-P

DESCRIPTION

1. General oscilloscope 60 MHz (7403 N)

Cathodic-ray tube:

Accelerating potential 15 kV
Screen: phosphor P 11 (option 8)
Internal 8 x 10 div. graticule w/variable illumination

Vertical system:

Two plug-in compartments
Maximum band-width 60 MHz
Modes of operation: Left, alt., add., chop., right.
Chopped mode: repetition rate 1.0 MHz
Delay line permit viewing leading edge of waveform.

Horizontal system:

One plug-in compartment
Internal trigger made: left vert., right vert., vert. made.
Fastest calibrated sweep rate: 5 ns/div.

External Z-axix input (intensity of trace)
Full range of intensity 0-2 V
Only 20% of range of intensity for f > 10 MHz
Maximum input 10 V.

Camera power output:

3 prong connector provides power, ground and remote single sweep reset.

Calibrator:

Voltage rectangular wave, 40 mV to 4 V, accuracy 1%, 1.0 kHz
Current rectangular wave, 40 mA.

Power requirements:

220 V. 50 Hz, 130 W (max).

2. Storage oscilloscope 100 MHz (7613)

Cathode-ray tube:

Acceleration potential 8.5 kV
Phosphor P 31
Internal 8 x 10 div. graticule w/variable illumination
Store mode: writing speed - 5 div/μs
storage time - up to 60 min.
erase time: 0.5 s.
persistence: continuously variable

External Z-axix input:
full intensity range 0 - 2 V (D.C. to 2 MHz)
only 20% of range intensity at 10 MHz
maximum input 10 V

Vertical system:

Two plug-in compartments
Maximum band-width 100 MHz
Modes of operation: left, alt., add., chop., right
Chopped mode: repetition rate at 1.0 MHz
Delay line permits viewing leading edge of waveform.

Horizontal system:

One plug-in compartment
Fastest calibrated sweep rate: 5 ns/div.
Internal trigger mode: left vert., right vert. vert. mode.

Camera power output:

3 prong connector provides power, ground and remote single sweep reset.

Calibrator:

Voltage rectangular 1.0 kHz, 40 mV to 4 V, accuracy 1%
current rectangular 1.0 kHz, 40 mA.

Power requirements:

220 V, 50 Hz, 180 W (Max).

3. **Dual trace amplifier 7A 12 (can be used with both oscilloscopes)**

Band-width: 55 MHz (rise time 6.4 ns) w/oscilloscope 7403
80 MHz (rise time 4.4 ns) w/oscilloscope 7613

Deflection factor: 5 mV/div to 5 V/div in 10 steps

DC offset range: at least ± 500 div (5 mV/div to 5 V/div)

Max. input voltage:

350 V (AC or DC) for 5 mV/div. to 10 mV/div.
500 V (AC or DC) for 20 mV/div. to 5 V/div.

Display mode:

either channel, addition, chopped or alternate
(chopped repetition rate 500 kHz)

Input impedance:

1 MΩ : 24 pF

4. **Dual trace amplifier 7A 18 (can be used with both oscilloscopes)**

Band-width: 50 MHz (Tr = 7.0 ns) w/oscilloscope 7403
75 MHz (Tr = 4.7 ns) w/oscilloscope 7613

Deflection factor: 5 mV/div to 5 V /div. in 10 steps

Input impedance: 1 MΩ : 20 pF

Operating modes: CH 1, CH 2, ALT, CHOP, ADD

Max. input voltage: 250 V DC or AC (peak)

5. Differential amplifier 7A 22 (can be used with both oscilloscopes)

Band-width:

H F point at - 3 dB selectable 100 Hz to 1 MHz
L F point at - 3 dB selectable 0.1 Hz to 10 kHz

Deflection factor:

10 μV/div to 10 V /div.

Input impedance: 1 MΩ : 47 pF

Common mode rejection ratio: (AC coupled, 1.0 kHz)
20,000 : 1 for deflection from 10 μV/div to 10 mV/div.
1,000 : 1 for deflection from 20 mV/div to 10 V/div.

Common mode range: ± 10 V for 10 μV to 10 mV/div.
± 100 V for 20 mV to 0.1 V/div.
± 500 V for 0.2 V to 10 V/div.

Max. input: (AC coupled)

± 500 V d.c.

D.C. offset range: ± 1 V for 10 μV to 10 mV /Div.
± 10 V for 20 mV to 0.1 V/div.
± 100 V for 0.2 V to 1 V/div.
± 1000 V for 2 V to 10 V/div.

Displayed noise: (measured tangentially)

16 μV or 0.1 div. (which ever is greater)

6. **Time base 7B 50** (Can be used on both oscilloscopes)

Sweep:

Rate is from 0.05 μs/div to 5 s/div. in 25 steps
Magnifier (X 10) gives 5 ns/div.
Accuracy: 2 to 3%

Triggering:

Internal trigger coupling:
DC, AC, AC w/LF rejected, AC w/HF rejected
Internal trigger jitter: <1 ns at 75 MHz

External trigger input: max. voltage 500 V
input: 1 MΩ : 20 pF
level range: ± 3.5 V

External horizontal input:

90 mV/div to 900 mV/div.

7. **Dual time base 7B 53 A** (Can be used on both oscilloscopes)

Operating modes:

Normal: main sweep only
Intensified delaying: segment of main sweep intensified
Delayed: segment intensified displayed by delayed sweep
Mixed: main sweep and delayed sweep displayed.

Main sweep:

Rate is from 0.05 μs to 5 s/div. in 25 steps
Magnifier (x 10) gives 5 ns/div.
Accuracy: 2 to 3%

Triggering of main sweep:

Internal triggering coupling:
DC, AC, AC w/LF rejected, AC w/HF rejected

Internal triggering jitter: <1 ns at 75 MHz

External triggering: max. voltage 500 V
input: 1 MΩ : 20 pF
level range: ± 1.5 V.

7. (cont'd)

Delayed sweep:

Rate is from 0.05 μs/div to 0.5 s /div in 22 steps
Magnifier (x 10) give 5 ns/div.
Accuracy: 3 to 4%

Triggering of delayed sweep:

Internal triggering coupling:
AC or DC
Internal triggering jitter: <1 ns at 75 MHz

External triggering: max. voltage 500 V
input: 1 MΩ : 70 pF
level range: ± 1.5 V

External horizontal input:

10 mV/div to 1 V/div.

8. Scope mobile cart 203-2

Mobile tray designed for both 7403 N and 7613 oscilloscopes
Holds 4 plug-in compartments
3 AC receptacles located at rear
Front wheel brakes

9. Oscilloscope probes (Used for both oscilloscopes)

Probes	Attenuation	Frequency range	Input impedance	Probe risetime	DC max
P 6052	X 1 X 10	DC-40 MHz DC-40 MHz	1 MΩ 113 pF 10 MΩ 14 pF	60 ns 9 ns	500 V
P 6053A	X 10	DC-250 MHz	10 MΩ 9.5 pF	0.7 ns	500 V
P 6009	X 100	DC-120 MHz	10 MΩ 2.5 pF	7.1 ns	1500 V

10. Oscilloscope camera C 50 P

Lens: 57.6 mm w/ f/1.9 to f/16

Object to image ratio: 0.7

Shutter range: 4 to 1/60 s plus bulb and time

Focus ajustment: made with two vertical bars of light projected on CRT

Photometer: incorporated with the camera determines proper combination of shutter speed and f. number

Camera power and sweep reset:

3 pin connector provides + 15 V, ground and sweep reset (located on oscilloscope)

RECURRENT SURGE GENERATOR

REQUIREMENTS: 1 unit

PROPOSED EQUIPMENT: Haefaly Recurrent Surge Generator Type 48

DESCRIPTION:

- Output voltage impulse: positive, 0 - 500 V
- Triggering made: a) repetitive 25 Hz (3 Hz with external impulse capacitance)
  - b) single sweep by push-button
  - c) no pulse.
- Chopping impulse: chopping time 0.2 - 100 μs
- Trigger output for oscillograph:
  - delay adjustable from - 10 μs to 90 μs
  - signal level 10 V or 250 V
  - waveform: 0.2 /5 μs
- Circuit elements:
  - Impulse circuit capacitance: 4.7, 10, 10, 22, 47 nF
    0.1, 0.22, 0.47, 1.0 μF
    and extern.
  - Load capacitance: 0.47, 1.0, 2.2, 4.7, 10, 22, 47
    100 nF
  - Front resistance: 3.3, 4.7, 6.8, 10, 15, 22, 33, 47
    68, 100, 150, 220, 330, 470, 680,
    1000, 1500, 2200, 3300, 4700 Ω
    and extern.
  - Tail resistance: 10, 15, 22, 33, 47, 68, 100, 150,
    220, 330, 470, 680, 1000, 1500,

Tail resistance:	2200, 3300, 4700, 6800, 10000, 15000 and extern.
Inductance:	10, 20, 30, 40, 50, 60, 70, 80, 90, 100 µH

- Power requirement: 220 V, 50 Hz, 180 VA

R L C MEASURING BRIDGE

REQUIREMENTS: 1 unit

PROPOSED EQUIPMENT: General Radio bridge model 1608

DESCRIPTION:

Generator: internal 1.0 kHz provided with level control

internal D.C. provided with level control

external in the frequency range 20-20,000 Hz

Detector: internal or external and provided with sensitivity control.

Ranges of measurements:

Capacitance:	0.05 pF - 1100 μF	series or parallel
Inductance:	0.05 μH - 1100 μH	series or parallel
Resistance:	0.05 mΩ - 1.1 MΩ	
Conductance:	0.05 n℧ - 1.1℧	
D:	0.0005 - 1	(1.0 kHz, parallel cap.)
Q:	0.5 - 50	(1.0 kHz, series inductan

Accuracy of measurements:

At 1.0 kHz, ± 0.05% of full scale

In D.C., ± 0.05% of full scale except at extremes of range.

Power requirement: 210 - 250 V, 50 Hz, 10 W

ULTRASONIC DETECTOR WITH DIRECTIONAL MICROPHONE

REQUIREMENTS:	1 unit	
PROPOSED EQUIPMENT:	Hewlett Packard	
	Ultrasonic translator detector 4914 A	
	Ultrasonic reflector 18043 A	
	Headset 18017 A	
DESCRIPTION:	Response:	Ultrasonic frequency between 37 and 43 kHz translated to audible range.
	Output:	0.1 mW in 600 Ω
		1 V (rms) open circuit
	Battery operated (Eveready E 146 X)	
	Equipped with sight assembly	
	Headset impedance: 600 Ω	
	Weight: 2¾ lb.	

OSCILLOGRAPHIC RECORDING SYSTEM

PROPOSED EQUIPMENT:

1 Honeywell visicorder oscillograph 1508

7 Honeywell accudata amplifier 112 d.c.

7 Honeywell accudata amplifier 107 d.c.

7 Galvanometer M 5000 fluid damped type
+ galvanometer protector

7 Galvanometer M 600 - 350 electromagnetic damped type
+ galvanometer protector.

DESCRIPTION:

A - Visicorder Oscillograph 1508

- Recording fraquency: 0 - 13 kHz
- Recording channels: 12 or 24 channels
- Writing spead: greater than 1250 m/s with mercury lamp
  (300 m/s with Xenon lamp)
- Recording lamp: high pressure 100 watts mercury arc lamp
  (optional 75 watts Xenon lamp)
  trace intensity adjustable by a control
- Recording medium: 8 inches wide photo sensitive paper
  capacity is 30 - 50 m

- Record drive speeds: Option a: 25, 50, 100, 200 mm/s
  with multipliers x 0.1, x 1, x 10
  Option b: 25, 50, 100, 200 mm/s
  with multipliers x 0.01, x 0.1, x 1
  Option c: 12.5, 25, 50, 100 mm/s
  with multipliers x 0.1 x 1, x 10
  Accuracy: + 6%, - 2% at nominal line voltage

- Time lines:
  A - internal : intervals of 10, 1, 0.1, 0.01 s
  accuracy : ± 1% for 20°C ± 5 and 220 V ± 10
  B - external : input impedance is 100 Ω
  pulse should be positive 5 - 30 V
  minimum duration: 10 μ s, rate: 100 pps maximum.

- Grid lines: spacing of 2 mm with every fifth line heavy

- Power requirement: 220 V, 50 Hz, 550 watts

B - Amplifier 112 DC

- Input voltage: 2.5 mV to 2.5 V
  0.5 V to 250 V with attenuator 1/200
- Input impedance: 10 M Ω minimum (1 M Ω with attenuator 1/200)
- Input offset current: less than 10 n A

- Output impedance: less than 1 Ω (dc to 20 kHz)
- Output capability: (dc to 20 kHz)
  - a) Resistive load: ± 2.5 V at 65 mA
    ± 3.0 V at 40 mA
    ± 10.0 V at 1 mA
  - b) RC load: ± 2.5 V across resistance > 38 Ω (C < 20 nF)
    ± 3.0 V across resistance > 75 Ω (C < 20 nF)
- Output capacitive load: maximum 20 nF
- Gain: step control: 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000
  vernier permits continuous increase between fixed steps
  accuracy better than 1%
  linearity is better than 0.1% of full scale output
- Attenuator: 1/200 selectable by a switch
- Frequency response: ± 5% from dc to 20 kHz (no attenuator)
  ± 1 dB from dc to 20 kHz (with attenuator)
- Common mode voltage: Maximum ± 250 V ac or peak
- Common mode rejection: greater than 90 dB (dc to 60 Hz)
- Noise: less than 8 μ V (rms)
- Power requirement: 220 V, 50 Hz, 10 watts

C - Amplifier 107 DC

- Input voltage: 0.125 V to 2.5 V

  5 V to 250 V with attenuator

- Input impedance: 10 M Ω minimum (1 M Ω with attenuator)

- Input offset current: less than 10 nA

- Output impedance: less than 1 Ω (dc to 10 kHz)

- Output capability: (dc to 20 kHz)

  a) Resistive load: ± 2.5 V at 65 mA

     ± 3.0 V at 40 mA

     ± 10.0 V at 1 mA

  b) RC load: ± 2.5 V at R > 30 Ω and C < 100 nF

     ± 2.5 V at R > 1000 Ω and C < 10 nF

- Output capacitive load: maximum 100 nF

- Gain: step control: 0.01, 0.02, 0.05, 0.1, 0.2, 0.5,

  1, 2, 5, 10, 20

  vernier permits continuous increase between fixed steps

  accuracy better than 1%.

  linearity better than 0.05% at maximum output

- Frequency response: ± 5% from dc to 20 kHz

- Common mode rejection: 80 dB (dc to 60 Hz)

- Noise: less than 10 μ V (rms)

- Power requirement: 220 V, 50 Hz, 100 watts

D - Galvanometer

a) Fluid damped galvanometer M600 - 350

- frequency response ± 5% : 0 - 360 Hz
- nominal coil resistance: 320 Ω
- maximum current: 15 mA
- equipped with protector for fluid damped galvanometer

b) Electromagnetic damped galvanometer M 5000

- frequency response ± 5% : 0 - 3000 Hz
- nominal coil resistance: 39.5 Ω
- maximum current: 100 mA
- equipped with protector for electromagnetic damped galvanometer

ELECTROSTATIC VOLTMETER

REQUIREMENTS: 3 units

PROPOSED EQUIPMENT: W. G. P Y E & CO. LTD

1 - Electrostatic Voltmeter Model No. 11308

1 - Electrostatic Voltmeter Model No. 11310

1 - Electrostatic Voltmeter Model No. 11314

DESCRIPTION:

Electrostatic voltmeter	11308	11310	11314
Voltage ranges d.c.	1 - 5 kV	5 - 18 kV	40 kV
a.c. (rms)	1 - 5 kV	5 - 12 kV	40 kV
Maximum peak voltage permissible	8.0 kV	24 kV	56.7 kV
Input impedance	8 pF	8 pF	16 pF
Accuracy in % of full scale	± 2%	± 2%	± 2 %

Each voltmeter should be provided with zero adjustment and power supply 240 V, 50 Hz.

IMPULSE AND AC CREST VOLTMETER

REQUIREMENTS: 2 units (1 impulse and 1 AC voltmeter)

PROPOSED EQUIPMENT: Impulse and AC crest voltmeter.

DESCRIPTION:

Voltage range: 0 - 2000 V (AC peak or impulse)

5 scales with 90% over range capability

50, 100, 200, 500, 1000 V

Input impedance: 1 MΩ with 10 - 100 pF on scales 50, 100 and 200 V.

10 MΩ with 10 - 100 pF on scales 500 and 1000 V.

Measurable pulse width: DC - 50 n s

Polarity: positive, negative, or both

Accuracy: ± 1% of scale

Memory retains reading until reset or until higher input signal is applied.

Reset of memory: repetitive - automatically with a rate of 5 m s

single - manually

Efficient shielding against RFI - EMI interference -

Power requirement: a) 220 V, 50 Hz, 100 VA

b) battery operated with fail-safe battery indicator

OIL TEST SET

REQUIREMENTS: 1 unit

PROPOSED EQUIPMENT: Oil Testing Instrument

BAUR PGO 60 S

DESCRIPTION:

High Voltage: between electrodes 0 - 60 kV rms

electrodes to ground 0 - 30 kV rms

Rise of voltage: linearity of rise automatically controlled

4 rates: 0.5, 1.0, 2.0, 3.0 kV / s

Meter: measurement of test voltage and retention of breakdown value.

Electrodes: 4 types proposed: Rogowski

VDE - JEC

ASTM

BSS - SEV

- gap could be set at 2.5 mm precisely
- breakdown of electrodes at about 250 kV/cm

Breakdown limitation to prevent carbonisation:

tripping relay senses circuit current less than 10 mA

operates in less than half a cycle

Oil pump: shall move oil without aeration and distortion of electrical field

capacity: 4 cm^3/s (vessel contents 0.7 li).

Automatic test cycle:
- push button controls to start, hold and stop a test cycle
- separate controls operate the circulating pump

Automatic test cycle: - breakdown voltage indicated by the voltmeter until reset

Transparent hood covers the vessel and electrodes and switch off voltage when open

Operating power: 220 V, 50 Hz AC, 800 VA.

CAPACITANCE AND LOSS ANGLE BRIDGE

AND NULL INDICATOR

PROPOSED EQUIPMENT:

1 - Hartmann and Braun

C - tanδ - bridge 4241 - 313

Model EHCT

1 - Hartmann and Braun

Oscillographic null indicator 6912 - 112

with filter unit 6919 - 114

DESCRIPTION:

A - C - Tanδ - Bridge

Capacitance measurement:

1) Ranges with 100 pF standard capacitor:

1 pF - 1.1 μF at 30 kV

1 pF - 0.8 μF at 200 kV

1 pF - 0.53 μF at 300 kV

2) Value of Cx/Cn to be read directly on dials

3) Precision: ± 0.1%

Tanδ measurement:

1) Ranges: 0 to 1000 x 10^{-5}

0 to 1000 x 10^{-4}

0 to 1000 x 10^{-3}

0 to 1000 x 10^{-2}

2) Value of Tanδ directly to be read on dials

3) Limits of error for range 0 - 1000 x 10^{-5}

± 3 x 10^{-5} ± 0.02 tanδ for Cx/Cn : 0.1 - 200

± 7 x 10^{-5} ± 0.02 tanδ for Cx/Cn : 0.1 - 1000

± 30 x 10^{-5} ± 0.02 tanδ for Cx/Cn : 0.1 - 10000

Safety devices: 2 overvoltage arresters

Partial discharge measurement: built-in transformer

resonnant freq. 200 kHz

Maximum charging current: 60 A

Frequency: 50 or 60 Hz

B - Oscillographic Null Indicator

Vertical deflection: (Test voltage)

Input: floating via transformer

Sensitivity: 1 mm/0.1 - 0.5 - 2.5 - 25 - 250 μV

Input impedance: 1000 Ω (200 Ω for 1 mm /0.1 μV)

Automatic amplitude control: if input rises rapidly then alternator up to 10000/1 maintains deflection on screen.

Overload limit: 20 V

Horizontal deflection: (Reference voltage)

Internal voltage: 30 mm.

External voltage: 1 mm/4 μV (max. 0.04 V)

input impedance of 200 Ω

overload limit: 2 mV

External voltage through alternator:

1 mm/0.2 mV to 20 mV

Input impedance: 7 to 25 kΩ

Filter unit for 50 to 60 Hz (# 6019 - 114)

Supply requirement: 220 V, 50 Hz, 40 VA

MERCURY RELAY STEP GENERATOR

REQUIREMENTS: 1 unit

PROPOSED EQUIPMENT: Instrument Research Co.
fast pulser model MP

DESCRIPTION: Charging voltage: ± 2.0 kV

Relay wetted with mercury

Output pulse: 0 - 1.0 kV in 50 Ω load
(positive or negative)

Rise time: less than 0.5 n s into
a coaxial of 50 Ω

Pulse width down to 3 n s; upper limit dependent on cable length connected to output.

Pulse repetition:
1 - 100 Hz
50 Hz (Synchronise to line)
single shot

External drive mode available

Synchronise output for triggering.

COMPRESSED GAS STANDARD CAPACITOR

REQUIREMENTS: 1 unit

PROPOSED EQUIPMENT: Hartmann & Braun

Standard capacitor CLP 30

DESCRIPTION:

- Rated voltage: 30 kV (rms)
- Test voltage : 33 kV (rms) for 1 min.
- Nominal capacitance:
  - a) 100 pF ± 0.1%
  - b) measured value with precision better than ± 0.05%
  - c) variation with temperature less than 0.001% /°C
- Dissipation factor: less than 0.5×10^{-5}
- Output connector is coaxial type BNC UG 291/U
- Pressure indicator is provided on the base
- Corona free at rated voltage.

RADIO NOISE METER

REQUIREMENT: 1 unit

PROPOSED EQUIPMENT: Radio noise meter

Stoddard NM 25 T

DESCRIPTION: Measurement function

Field intensity: 600 ms charge and discharge time

Quasi-peak: 1 ms charge time and 600 ms discharge time

Peak: manually controlled

Frequency: 150 kHz - 32 M Hz (8 bands)

Voltage range: 0,1 µV - 1.0 V (6 bands)

(-20 to 80 dB above 1 µV)

Band-width: 5 kHz

Accuracy:	frequency	±	2%
	voltage	±	1.5 dB

Input impedance: 50 Ω

Image rejection: 50 dB or better

Shielding effectiveness 60 dB or better

Operating power: internal battery

220 V, 50 Hz AC

HIGH PRECISION RESISTANCE MEASUREMENT BRIDGE

REQUIREMENTS : 2 units

PROPOSED EQUIPMENT: Hartmann & Braun, model number EKPMTh-Wh
Catalogue number 4291-114

DESCRIPTION : a) Thomson arrangement

range: 10^{-9} to 10^{3} Ω

accuracy: 0.01 to 0.02 %

b) Wheatstone arrangement

range: 10^{-3} to 10^{6} Ω

accuracy: error less than or equal to 0,01%

GALVANOMETER FOR HIGH PRECISION RESISTANCE MEASUREMENT BRIDGE

REQUIREMENTS: : 2 units

PROPOSED EQUIPMENT: Hartmann & Braun, model number [illegible]
Catalogue number: 1691-216

DESCRIPTION : Movable coil instrument

Sensitivity: 10^{-4}, 10^{-5}, 10^{-6}, 10^{-7} and 10^{-8} A/div.

Scale range: 30 - 0 - 120

Scale length: 150 mm.

Illuminated spot indication

For use: horizontal ± 1°

Insulation level: 2 kV

STANDARD RESISTANCES FOR HIGH PRECISION RESISTANCE MEASUREMENT BRIDGE

PROPOSED MANUFACTURER: Hartmann & Braun

GENERAL DESCRIPTION : Accuracy class: 0.01

Deviation from nominal value: ± 30 x 10^{-6}

Temperature coefficient: Approx. 5°C/W

Maximum value of resistance from 30 to 35°C

TABLE OF REQUIREMENTS

REQUIRED	H & B MODEL Number	H & B CATALOGUE Number	RESISTANCE Value Ohm	CAPACITY in air AMP.
1	WLN - 6	4317 - 125	1.0	3
2	WLN - 7	4317 - 123	0.1	10
2	WLN - 8	4317 - 122	0.01	30
2	WLN - 9	4317 - 121	0.001	100
1	WLN - 10	4317 - 119	0.0001	300

POWER SUPPLY FOR HIGH ACCURACY RESISTANCE MEASUREMENT BRIDGE

REQUIREMENTS : 2 units

PROPOSED EQUIPMENT: Hewlett Packard, model 6269A
Specify: for 50 Hz operation at 220 Volts single phase

DESCRIPTION : Current range: 0 - 50 A

Voltage range: 0 - 40 V

Supply: (to specify) 220 Volts, single phase 50 Hz

Ripple and Noise: 1 mv

8 Hour stability: 0.03% + 2 mv

Voltage resolution: 3 mv

Overvoltage protection range: 4 to 48 V DC

TRANSFORMER RATIO BRIDGE

REQUIREMENT : 1 unit

PROPOSED EQUIPMENT: Hartmann & Braun, model METK 3
Catalogue number 4444-110

DESCRIPTION : Measuring range: 1 to 10, 10 to 100, 100 to 1,000

Accuracy: ± 0.1%

Test voltage: 100 to 250 Volts

Test frequency: 50 to 60 Hz

Null indicator: 50 - 0 - 50 div.

Protections: fuses on supply
spark gaps on voltage leads
spring return sensitivity potentiometer

LOW POWER FACTOR WATTMETERS

REQUIREMENTS	:	4 units
PROPOSED TEST EQUIPMENT	:	Hartmann & Braun, model [illegible] Catalogue number 1675-132
DESCRIPTION	:	Compensated for use on low power factor loads
		Accuracy class: 0.5
		Frequency range: 30 to 100 Hz
		Current range: 2.5 and 5.0 A
		Voltage range: 30 - 90 - 150 - 300 Volts
		Voltage coil load: 30 mA.
		Current coil load: 0.35 VA at 50 Hz
		Insulation test voltage: 2 kV
		Scale: 150 divisions
		Response time: 2 sec.
		Lighted spot indicator

PRECISION VOLTMETERS

REQUIREMENTS : 2 units

PROPOSED EQUIPMENT: Hartmann & Braun, Model ELPAV 2
Catalogue number 1672-122

DESCRIPTION : Accuracy class: 0.2

Voltage range: 30 - 75 - 150 - 300 - 600 Volts

Influence of frequency: 30 to 100 Hz, nil
100 to 1,000 Hz, less than 0.2%

Voltage coil load: 30 ma.

Lighted spot indicator

Insulation test voltage: 2 kV

[illegible]

REQUIREMENTS : 4 units

PROPOSED EQUIPMENT: Hartmann & Braun, Model [illegible]
Catalogue number 3672-112

DESCRIPTION : Accuracy class: 0.1

Current range: 3 and 6A

Influence of frequency: 30 to 100 Hz, nil
100 to 1000 Hz, less than 0.1%

Current coil load: 0.20 VA at 50 Hz

Lighted spot indicator

Insulation test voltage: 2 kV

AC VOLTMETER

REQUIREMENTS : 1 unit

PROPOSED EQUIPMENT: Sensitive Research Flux Voltmeter
Model FLVC

DESCRIPTION : Accuracy: 0.25%

Frequency range: 25 to 1,000 Hz

Voltage range: 30 - 75 - 150 - 300 Volts

Rectifier with permanent magnet coil

1000 Ohms per volt

Scale reading equivalent RMS value

NOTE: Siemens Co. should have an equivalent

[illegible]

REQUIREMENTS : 1 unit

PROPOSED EQUIPMENT: Weston Instruments
Model 1242 Digital Multimeter

DESCRIPTION : Accuracy: d.c. 0.03%
60 Hz to 10 kHz 0.2%
10 kHz to 20 kHz 0.3%

Digital display: 4½ digits

Voltage range: 100 mv to 1000 Volts dc
100 mv to 500 Volts a.c.
Resolution 10 μv

Current range: 100 μA to 1 A
Resolution 0.1 μA

Ohm range: 1 k Ohm to 10 M Ohm
Resolution 1 Ohm

To be operated on 220 Volts single phase 50 Hz supply

Out of range illuminated indicator

Lighted polarity indicator

Temperature influence: 0.004%/°C

A.C. VOLTMETER

REQUIREMENTS : 2 units

PROPOSED EQUIPMENT: Weston Instruments, model 341
Catalogue number 341-[illegible]

DESCRIPTION : Rated accuracy: 0.25%

Voltage range: 75 - 150 - 300 Volts

Frequency range: DC and 25 to 125 Hz

Horizontal position

Scale: 130 mm.

Type: Electrodynamometer

Shielded from External Magnetic Fields

Average power consumption: 4 VA

AC/DC AMMETER

REQUIREMENTS : 2 units

PROPOSED EQUIPMENT: Weston Instruments, model 370
(Catalogue number 370-200003)

DESCRIPTION : Rated accuracy: 0.25%

Current range: 2.5 and 5 A

Frequency range: DC and 25 to 125 Hz

Horizontal position

Scale: 130 mm.

Type: Electrodynamic

Shielded from External Magnetic Fields

Average power consumption: 4.5 VA

GENERAL USE INSTRUMENTS (AC/DC)

REQUIREMENTS : 2 units

PROPOSED EQUIPMENT: Weston Instruments
Model 310 form 1

DESCRIPTION : Accuracy: .25%

Voltage range: 50/100/200

Overvoltage capacity: 1.5

Current range: 2.5 - 5 A

Frequency range: DC to 125 Hz

Scale: 125 divisions

Type: Electrodynamometer

Shielded from external magnetic fields

Current circuit consumption: 0.88 Watt, 0.95 VA 60 Hz

Potential circuit consumption: 2.9 Watts, 2.9 VA 60 Hz

WAVE ANALYZER

REQUIREMENT : 1 unit

PROPOSED EQUIPMENT: General Radio
Model 1568-A
Cat. number 1568-9702

DESCRIPTION : Frequency range: 20 Hz to 20 kHz

1% constant bandwidth

80 dB rejection

Voltage range: 100 µv to 300 Volts

Input impedance: 100 k Ohm

Portable battery operated

Battery charger for operation at 220 Volts 50 Hz

NOTE: An equivalent could be the revised model FRA 2 or 3 a from Radio Meter, Copenhagen.

INSULATION TEST EQUIPMENT

REQUIREMENTS : 1 unit

PROPOSED EQUIPMENT: Megger, model number 35100
for use on 220 Volts
single phase 50 Hz supply

DESCRIPTION : Voltage range: 1000 - 2500 - 5000 Volts

Double scale indication

Specify: For use on 220 Volts single phase
50 Hz supply.

[illegible]

REQUIREMENTS : 1 unit

PROPOSED EQUIPMENT: Brüel & Kjaer Ltd.
Model number 2113
with accessories

DESCRIPTION : Frequency range:

i) Selective: 22 - 22000 Hz
ii) Linear : 2 - 200000 Hz

Third octave and octave bandpass filters

A, B, C and D weighting networks

Fulfills IEC 179 recommendation for precision sound level meters.

Fulfills DIN 45633 standard and the proposed IEC recommendation for impulse sound level meters.

220 Volts, single phase 50 Hz input

ACCESSORIES

(1) ea. 1" Condenser type microphone Cat. # 4145

(1) ea. Cable extension and pre-amplifier Cat. # 2619

(1) ea. Cable extension (10 meters) Cat. # AO-0028

(1) ea. Cable extension (30 meters) Cat. # AO-0029

(1) ea. Pistonphone for calibration Cat. # 4220

B-942

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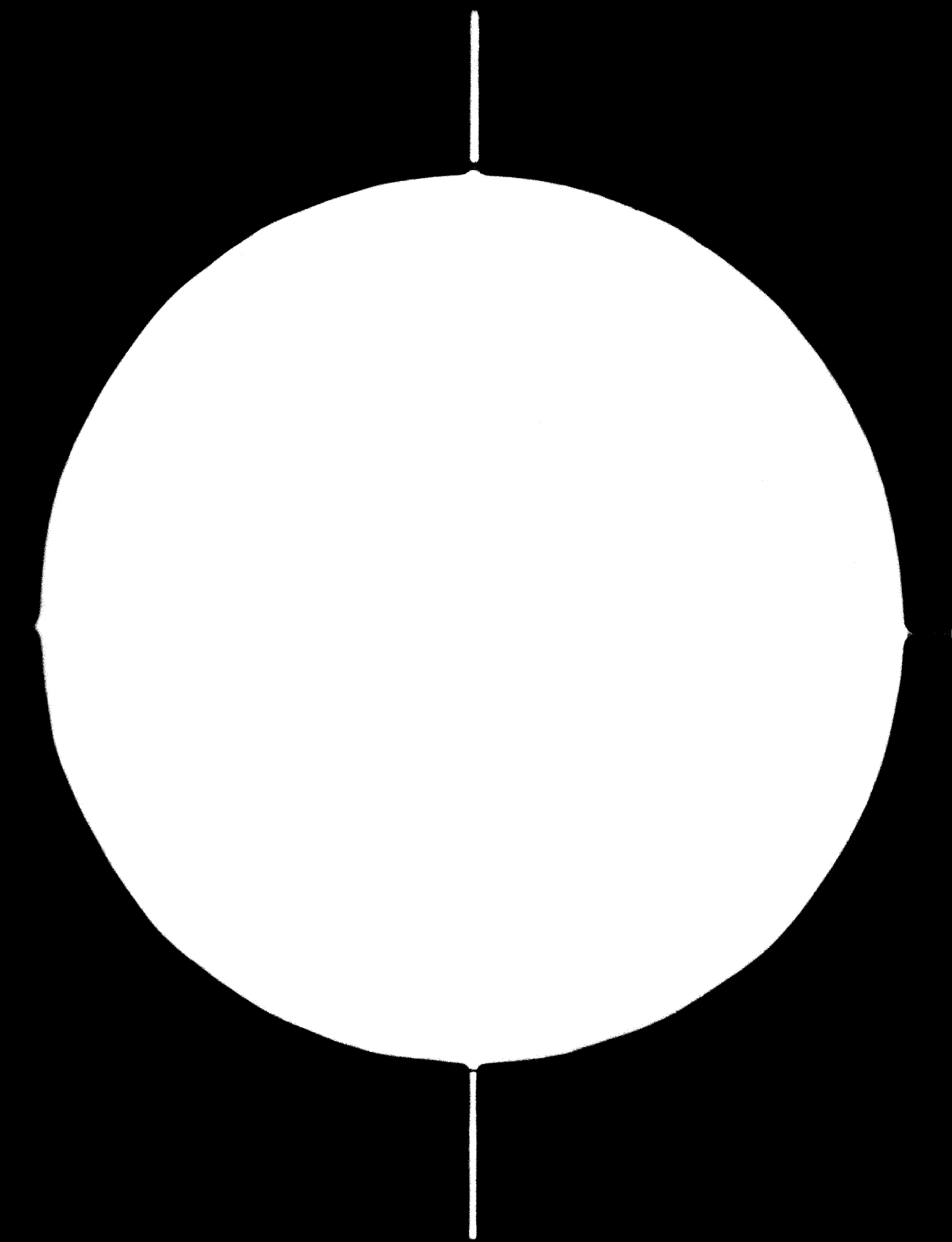

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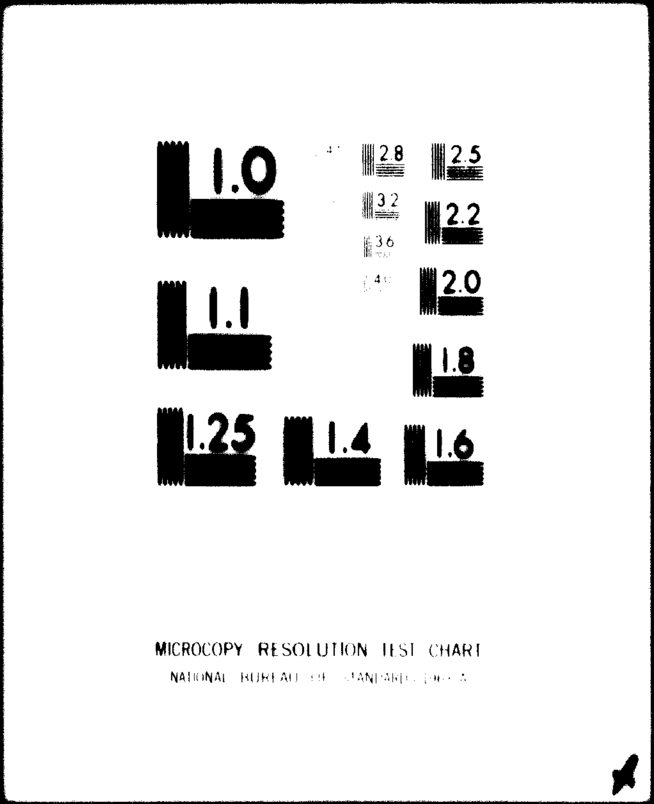
1.0
2.8
2.5
3.2
2.2
3.6
2.0
1.1
1.8
1.25
1.4
1.6
MICROCOPY RESOLUTION TEST CHART

24x

E

MULTIMETERS

REQUIREMENTS: : 4 units

PROPOSED EQUIPMENT: AVOMETER Model 8

DESCRIPTION : Current range: a.c. and d.c. 0 - 10 A

Resistance range: 0 - 20 M ohms

Voltage range: a.c. and d.c. 0 - 1,000 Volts

Impedance: 20,000 ohms per volt d.c.
1,000 ohms per volt a.c.

Automatic overload protection

Reversing polarity switch

Diode protected movement

PRICE LIST FOR SMALL EQUIPMENT

QUANTITY	DESCRIPTION	UNIT PRICE
2	High Precision Resistance Measurements Bridge.	$2,900.00
2	Galvanometer for High Precision Resistance Measurement Bridge.	500.00
8	Standard Resistences for High Precision Resistance Measurement Bridge.	250.00
2	Power Supply for High Accuracy Resistance Measurement Bridge.	1,000.00
1	Transformer Ratio Bridge.	2,200.00
4	Low Power Factor Wattmeters.	1,200.00
2	Precision Voltmeters.	950.00
4	Precision Ammeters.	950.00
1	Flux Voltmeter.	500.00
1	Low Range Multimeter.	750.00
2	AC/DC Voltmeters.	500.00
2	AC/DC Ammeters.	500.00
2	General Use Wattmeters (AC/DC).	575.00
1	Wave Analyser.	1,900.00
1	Insulation Test Equipment.	1,600.00
1	Spectrometer.	3,000.00
4	Multimeters.	115.00
1	Mercury Relay Step Generator.	850.00
1	Compressed Gas Standard Capacitor.	2,300.00
1	Radio Noise Meter.	5,000.00
1	Capacitance and Loss Angle Bridge and Null Indicator.	4,500.00
2	Double beam Impulse Oscilloscopes	12,000.00
1	Frequency meter	500.00

QUANTITY	DESCRIPTION	UNIT PRICE
1	Oil Testing Set.	$2,000.00
3	Electrostatic Voltmeters.	1,000.00
2	Impulse and AC Crest Voltmeter.	4,400.00
1	Oscillographic Recording System.	10,000.00
1	R L C Measuring Bridge.	2,000.00
1	Ultrasonic Detector with Directional Microphone.	450.00
1	Recurrent Surge Generator.	3,000.00
1	Oscilloscope 7403 N Option 8 (P 11).	1,050.00
1	Storage oscilloscope 7613 Option 3.	2,760.00
1	Dual Trace Amplifier 7A 12.	970.00
1	Dual Trace Amplifier 7A 18.	585.00
1	Differential Amplifier 7A 22.	630.00
1	Time Base 7B 50.	495.00
1	Time Base 7B 53 A.	920.00
2	Scope Mobile Carts 203-2.	220.00
2	Probes P 6052.	65.00
2	Probes P 6053 A.	65.00
2	Probes P 6009.	70.00
1	Camera C50-P	815.00
1	Negative Processing Equipment.	2,300.00
1	Paper Processing Equipment.	1,150.00
1	Accessories and Camera.	850.00
6	Resistive Shunts	

LIST OF SUPPLIERS

[illegible] INSTRUMENTS

Aupoca Spain
Schlumberger Espagnola Spain
Costarica No. 13
MADRID 16

MEGGER INSTRUMENTS

Evershed and Vignoles Ltd.
London
ENGLAND

HARTMANN & BRAUN INSTRUMENTS

Control y Electricidad, S.L.
Joaquin Costa 61
MADRID 6

HEWLETT PACKARD INSTRUMENTS

Ataio Ingenieros
Enrique Larreta 12
MADRID 16

SENSITIVE RESEARCH INSTRUMENTS

Electrical Instruments Service Inc.
25 Dock Street
Mount Vernon, N.Y.
USA

BRUEL AND KJAER INSTRUMENTS

Neotecnica, S.A.E.
Marqués de Urquijo 44
MADRID 8

GENERAL RADIO INSTRUMENTS

Ispano Electronica S.A.
Commandante Zorita 8
MADRID

CAPACITANCE AND LOSS ANGLE BRIDGE AND NULL INDICATOR

Hartmann & Braun
Control y Electrocidad S.L.
Joaquin Costa 61
MADRID

COMPRESSED GAS STANDARD CAPACITOR

Hartmann & Braun (1)

RLC MEASURING BRIDGE

General Radio Company
Hispano Electronica S.A.
Commandante Zorita 8
MADRID 20

ULTRASONIC DETECTOR

Hewlett Packard
Delcon Division
333 Logue Avenue
Mountainview
California 94040
USA

MERCURY RELAY STEP GENERATOR

Instrument Research Company
P.O. Box 231 Lincoln
Mass. 01773
USA

BIPOLAR AND AC CREST VOLTMETER

Micro Instrument Co,
13901 Crenshaw Boulevard
Hawthorne
California 90250
USA

RADIO NOISE METER

Singer Instrumentation
3211 South La Cienega Boulevard
Los Angeles
California 90016
USA

[illegible]

Baur

[illegible]

U.G. Pye and Co. Ltd.

[illegible]

Emile Haefely & Cie.
4000 Basel 28
SWITZERLAND

[illegible]

Honeywell S.A.
Pradillo 18
P.O. Box 2080
MADRID 2

[illegible]

Tektronix
C.R. Maros S.A.
Gaztambide, 60-1°
MADRID (15)

[illegible]

To be purchased locally.

[illegible]

Emile Haefely & Cie.
4000 Basel 28
SWITZERLAND

PHOTOGRAPHIC EQUIPMENT

A - NEGATIVE PROCESSING EQUIPMENT

	Processing Tanks	Kindermann #3000	$1,000.00
1	Film Dryer Cabinet	Kindermann #4371	1,100.00
1	Timer	Kodak	70.00
1	Safe Light System		30.00
	Darkroom accessories		100.00
			$2,300.00

B - PAPER PROCESSING EQUIPMENT

1	Enlarger	Beseler 45 Merx	$ 600.00
1	Lens set	Schneider Componon	80.00
1	Print washer	Kindermann 8555	100.00
1	Flat Bed Dryer	Kindermann 2952	260.00
6	Developping Trays	Kodak	50.00
1	Safety Trimmer	Honeywell / Nikkor	60.00
			$1,150.00

C - ACCESSORIES AND CAMERA

1	Reproduction Bench	Linhof Reprocord System	$ 200.00
1	Multiple illuminator bank		200.00
1	Exposure Meter	Gossen Lunasix	70.00
1	Electronic Flash	Honeywell Auto/strobonar	250.00
1	Lightweight tripod	Kodak	30.00
1	Camera Polaroid		100.00
			$ 850.00

PHOTOGRAPHIC EQUIPMENT

A - NEGATIVE PROCESSING EQUIPMENT

- Processing tanks set:

  Description: Tanks are made of non-corrosive material
  2 - Developer and fixer tanks with drain tap
  Approximate dimensions: 25 x 30 x 100 cm

  1 - washing bath
  Approximate dimensions: 25 x 30 x 100 cm.

  Capacity of this set of 70 li.:
  20 - 30 films.

- Film dryer cabinet:

  Description: Approximate dimensions of dryer: 45 x 80 x 130 cm.
  Power requirement: 220 V. 1700 W.
  Air input at top, filter and fan
  Thermostat and automatic switch
  U-bar for suspension of clips

- Timer system:

  Description: timer with luminous dial
  signal alarm
  time range: 1 s to 60 min.

- Safe light system:

  Description: lamp with 15 W bulb
  filter for general photo paper

- **Darkroom accessories:**

  2 - Mercury thermometer
  35 - 125° F.

  2 - Graduated measuring jars - 150 cc

  2 - Graduated measuring jars - 1000 cc

  4 - Funnels - 20 cm

B - PAPER PROCESSING EQUIPMENT

- **Enlarger unit**

  Description:

  Enlarger 100 x 120 mm.

  Film range: 25 x 35 mm to 100 x 120 mm.

  Power: 220 V. 50 Hz, 250 W.

  Max. enlargement: 5

  Lamp power: 200 W

  Negative carrier: 35 mm for enlarger

  Negative carrier: 100 x 120 mm for enlarger

  Easel: all size 35 x 45 cm.

- **Lens set (for enlarger)**

  Description:

  lens 50 mm, f/4 (w/lens support)
  lens 150 mm, f/5.6 (w/lens support)

- **Print washer**

  Description:

  Print washer content: 40 li.
  film range: up to 40 x 40 cm.
  capacity: 120 copies of format 7 x 10 cm
  dimension: 62 x 62 x 23 cm.
  transparent lid

- **Print dryer**

  Description:

  Print dryer 80 x 65 cm.
  Power: 220 V, 50 Hz, 700 W.
  Efficiency: 430 photo (7 x 10 cm) /hour
  Max. temperature: 100°C.
  Print roller
  Dryer plates 50 x 60 cm.

- **Developing trays** (6)

  6 - developing trays 40 x 50 cm.

- **Safety trimmer**

  Safety trimmer with
  40 cm cutting edge

6 - ACCESSORIES AND CAMERA

- **Reproduction bench**

  Axial height 125 cm.
  4 lamps 250 W (inclined at 45°)
  Dimension: 60 x 65 cm.
  Power requirement: 220 V, 50 Hz, 1000 W.

- **Photo illuminator**

  Description: Front panel: translucid plexiglass

  Dimensions: 50 x 150 x 15 cm
  (vertical position)

  Inside the illuminator:
  4 fluorescent lamps of 40 W
  approximate length 1.2 m.

- **Polaroid camera**

  Proposed equipment: Polaroid
  Camera # 440
  Pack film

  Description: General purpose polaroid camera
  with pack film

- **Exposure meter**

  Proposed equipment: GOSSEN
  Lunasix 3 exposure meter

  Description: exposure meter for incident or reflected light

  Computer ranges: 6 to 25000 ASA
  f/1 to f/90
  1/4000 s to 8 hrs.

- **Electronic flash**

  Description: Automatic strobe (setting of f/stop)
  Built-in light metering system stop flashes

  1000 - 1500 flashes
  rechargeable on AC or DC

- **Lightweight tripod**

  Proposed equipment: DAIWA
  Hi-ace 400 tripod
  Extended length approximately 150 cm
  Closed length approximately 50 cm

HIGH VOLTAGE LABORATORY

LIST OF APPROXIMATE PRICES AND POSSIBLE SUPPLIERS OF EQUIPMENT SPECIFIED IN SECOND EQUIPMENT REPORT

NOTE: Prices refer to 197[illegible] and include delivery to site.

HV 14	70·MVA 100 kV test transformer	$ 300,000.
HV 15	3 MVAR 3 phase 300 Hz reactor bank	23,000.

Manufacturers

Westinghouse	Spain
General Electric	Spain
ASEA	Sweden

HV 16	3.5 MV Voltage dividers	3[illegible],000.

Manufacturers

Haefely & Co. Ltd.,	Switzerland
Messwandler-Bau	West Germany
Ferranti	England

HV 17	Artificial rain apparatus	2[illegible],000.

Manufacturers

Haefely & Co. Ltd.,	Switzerland
Ferranti	England

HV 18	Six single phase current transformers	15,000.
HV 19	Six single phase potential transformers	40,000.

Manufacturers

Messwandler-Bau	West Germany
Brown Boveri	Switzerland

HV 20	Three 1.33 MVA single phase voltage regulators	80,000.
HV 21	Two 330 kVA single phase voltage regulators	2[illegible],000.

Manufacturers

Brentford Electric Ltd	Crawley, England
Ferranti	England
Haefely	Switzerland

HV 22	Two high voltage construction kits	$ 40,000.
	<u>Manufacturer</u>:	
	Messwandler-Bau — West Germany	
HV 23	1.33 MVA, 200 Hz rotating machine	80,000.
HV 24	350 kVA, 50 Hz, 60 Hz rotating machine	60,000.
	<u>Manufacturers</u>	
	Westinghouse — Spain	
	General Electric — Spain	
	Brown Boveri — Switzerland	
	ASEA — Sweden	
HV 25	350 kVA, 275 kV single phase test transformer	36,000.
	<u>Manufacturers</u>	
	Messwandler-Bau — West Germany	
	Haefely — Switzerland	
	Ferranti — England	
HV 26	Transformer bushing test tank	25,000.
	<u>Manufacturers</u>	
	Westinghouse — Spain	
	General Electric — Spain	
	Local steel constructors — Madrid	
HV 27	Impulse current shunts	2,000.
	<u>Manufacturers</u>	
	Haefely — Switzerland	
	Messwandler-Bau — West Germany	
	Ferranti — England	

UV 28 Oil treatment equipment $ 65,000.

Manufacturers

Keene of Canada Ltd., 9545 Cote de Liesse, Montreal

Micafil Switzerland

Transor-Filter AB Bredgrand 2, 11130 Stockholm, Sweden

UV 29 Transport and general purpose equipment 94,000.

Manufacturers

Local suppliers Madrid

UV 30 Instrumentation

Prices and suppliers given with each specification
in equipment report No. 2

DP/SPA/70/512

SECOND EQUIPMENT REPORT

FOR

HIGH POWER LABORATORY, Spain.

02252

(2 of 2)

UNIDO
CONTRACT
73/17

To
UNITED NATIONS
INDUSTRIAL DEVELOPMENT
ORGANIZATION

For
SPAIN ELECTRICAL TESTING AND
EXPERIMENTATION CENTRE

Prepared by
Lalonde Girouard Letendre & Associates Ltd
in Association with IREQ
Montreal, Canada

September 1973

To	For
SCO	AC[illegible]ON
DR	R[illegible]Y
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SPO	[illegible] UP
	[illegible]N
SCU	[illegible]ATION
S[illegible]	FILING
From D.C.N.	Date 14/9/72

SECOND

EQUIPMENT REPORT

TO

UNIDO (CONTRACT 72/17)

FOR

HIGH POWER LABORATORY

IN

MADRID

SPAIN

Lalonde Girouard Letendre & Associates Ltd
In Association with IREQ
Montreal, Canada

LALONDE, GIROUARD, LETENDRE & ASSOCIATES LTD.

CONSULTING ENGINEERS

8700 PARK AVENUE
MONTREAL 354, CANADA
TELEPHONE (514) 384-6410

Montreal, September 7, 1973

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Lerchenfelderstrasse, 1
Vienna, AUSTRIA.

Att.: Mr. D.C. Newton, Chief, Technical Equipment Procurement and Contracting Office.

Subject: SPAIN: Electrical Industry Test Experimentation Centre
UNIDO Contract No. 72/17 - Project No. SF SPA-012

Gentlemen:

Please find herewith the Second Equipment Report which covers the specifications of all other items of equipment for the laboratories that have not been included in the First Equipment Report dealing with equipment of long delivery.

This Report is presented in two volumes: one covering the High Voltage Laboratory, the other the High Power Laboratory. A list of basic instrumentation has also been added with suggested suppliers and approximate value.

As we have mentioned in other documents, these reports have to be read carefully in conjunction with the Final Building Report by the Consultants whose services will be retained for the final design for the construction of the building.

It was indeed a pleasure to perform this most challenging study on your behalf and we may assure you of our sustained interest in this project.

Yours very truly,

Jean-Paul Lalonde, Engineer.

JPL/cl

Copies: Unido - Vienna (6)
Project Manager in Madrid (2)
Spanish Government (10)

TECHNICAL SPECIFICATIONS

HIGH POWER LABORATORY

Three phase back-up circuit breakers	HP 2
Make switches	HP 7
TRV capacitors for test section No 1	HP 8
Measuring equipment and control room	HP 9
34 MVA Autotransformers	HP 10
Resistor sets	HP 11
Reactor coils	HP 12
Charging circuit	HP 13
TRV Capacitors for test section No 2	HP 14
Mecano-climatic chamber	HP 15
22 KV reactors	HP 16
16.6 MVA short-circuit transformers	HP 17
27 MW transformer rectifier set	HP 18
Reactances and resistances	HP 19
Synthetic test circuit	HP 20
30 KV condensers	HP 21
Inductances for the synthetic circuit	HP 22
Spark gaps	HP 23
Damping resistors	HP 24
Disconnect switches for the synthetic circuit	HP 25

NOTE: HP 2 and HP 7 replace same specifications formerly supplied in First Equipment Report.

HP 2

THREE PHASE BACK-UP CIRCUIT BREAKERS

The present specification covers the requirements of the Electrical Industry and Experimentation Centre for the supply of three (3) different types of three-phase back up circuit- breakers. They shall be of the air blast type and for indoor installation.

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6	Accidental making capacity	6
7	Operating cycle	6
8	Interval between two operating cycles	7
9	Operating times	7
10	Electrical endurance	8
11	Mechanical endurance	9
12	Tests	9
13	Construction	11
14	Grounding	13
15	Galvanizing	13
16	Alternative	14

2. DESCRIPTION

One circuit breaker, identified as article 1, will be located between the short-circuit alternator and the current limiting reactors. The two other circuit breakers, identified as article 2 and 3, will be located between transformers and current limiting reactors. The transformers will be fed by the network.

All circuit breakers shall be either three phase units or made of three single phase units. All characteristics not specified individually for each article shall be interpreted as common for all three articles.

3. STANDARDS

IEC, Publication 56 (Edition 1972): Specifications for Alternating current circuit-breakers.

IEC, Publication 60: High Voltage Techniques

The standards listed above apply except for modifications or additions contained in these specifications.

4. ELECTRICAL CHARACTERISTICS

		Article 1	Article 2	Article 3
Operating voltage	kV	3 to 14	10 to 25	12,5 to 25
Rated frequency	Hz	50 & 60	50 & 60	50 & 60
Withstand voltage to ground				
BIL	kV peak	95	125	125
50 Hz, 1 minute, dry	kV rms	45	50	50
Short time current, 1 second	kA rms	86	105	35
first peak value	kA peak	260	260	87

5. BREAKING CAPACITY

5.1 Three phase, symmetrical breaking capacity

Article 1: 105 kA rms at 14 kV

Article 2: 35 kA rms at 25 kV
105 kA rms at 10 kV

Article 3: 18 kA rms at 25 kV
35 kA rms at 12,5 kV

5.2 Three phase, asymmetrical breaking capacity

The breakers shall be able to clear the symmetrical breaking capacity with an asymmetry of 50%. This means that at the instant of contact separation, the aperiodic component shall not be less than 50% of the peak value of the symmetrical alternating component.

5.3 Transient recovery voltage (TRV)

Article 1:

frequency of TRV : 30 kHz

amplitude factor of TRV : 1.7

Article 2 and 3:

frequency of TRV : 20 kHz

amplitude factor of TRV : 1.5

It is preferable that the breakers be equipped with a TRV - damping device.

5.4 Capacitive Current Breaking

The breakers of articles 1 & 2 have to interrupt capacitive currents up to 500 A without restriking.

5.5 Small Inductive Current Breaking

All three circuit breakers have to interrupt small inductive currents reaching 100A while overvoltages do not exceed 60kV peak for article 1 and 80 kV peak for article 2 and 3.

In particular, the circuit breaker of article 1 will clear such an inductive current at each operation.

6. ACCIDENTAL MAKING CAPACITY

The breakers shall be capable to of supporting an accidental closing operation with the currents listed below. The breakers must be able to endure the closed currents for ½ second. After such a closing the breakers may be inspected and revised if necessary. In normal conditions closings will be made without current.

		Article 1	Article 2	Article 3
Making capacity	kA peak	260	260	87
	kA rms	105	105	35

7. OPERATING CYCLE

0 - 0.3 sec. - 0 - 3 min. - 0.

The compressed air supply from the test station high pressure tank will be sufficient to permit the circuit-breaker to receive the air required for the third 0 within 3 minutes.

8. INTERVAL BETWEEN TWO OPERATING CYCLE

The circuit-breakers shall be able to perform two (2) operating cycles in 15 min. The Tenderer gives the necessary recovery time for the circuit-breakers to be capable to perform again two (2) operating cycles in 15 minutes.

9. OPERATING TIMES

9.1 Breaking time

The arc time in the main breaking unit shall not exceed 14 ms.

The Tenderer shall give the mechanical opening time, i.e. the time between the electrical order of the operating coils and the separation of the contacts. The accuracy of the opening time shall also be given.

9.2 Closing time

The Tenderer shall give the mechanical closing time, i.e. the time between the electrical order of the operating coils and the touch of the contacts assuring the closure.

10. ELECTRICAL ENDURANCE

The circuit-breakers shall be able to perform any of the operations listed below, at any voltages within the values specified in article 4, and without inspection or maintenance.

a) A minimum of 6 breaking operations at 100% of the rated symmetrical breaking capacity.

b) A minimum of 15 breaking operations at 60% of the rated symmetrical breaking capacity.

c) A minimum of 30 breaking operations at 30% of the rated symmetrical breaking capacity.

d) A minimum of 80 breaking operations at 10% of the rated symmetrical breaking capacity.

e) A minimum of 4 breaking operations at 100% of the rated asymmetrical breaking capacity.

These minimum requirements are not cumulative.

11. MECHANICAL ENDURANCE

The circuit-breakers shall withstand mechanically 5000 opening and 5000 closing operations without any inspection nor maintenance.

12. TESTS

The manufacturer shall carry out all tests in accordance with this specification and the IEC Rules.

12.1 Type tests

12.1.1 Dielectric tests

Dielectric tests shall be made on one complete unit of each article. They shall be carried out in accordance with IEC Publication 60 and the values listed in article 5 of this specification.

12.1.2 Short-circuit tests

Short-circuit tests will be conducted to check the ability of clearing the short-circuits described in this specification. The tests will be carried out in accordance with the Standard IEC, Publication 56 (Ediction 1972).

12.1.3 Short-time withstand current test

In accordance with Standard IEC, Publication 56 (Edition 1972).

12.1.4 Mechanical endurance test

The mechanical endurance test shall be carried out in accordance with Standard IEC, Publication 56 (Edition 1972) and the following exceptions:-

- 5000 closing-opening cycles.
- No lubrification or maintenance is allowed.

12.1.5 Acceptance of test reports

UNIDO will accept as proof of conformity to articles 12.1.1 to 12.1.4 of this specification test reports covering tests made on a prototype breaker. All documents pertaining to the tests performed shall be enclosed in the tender.

UNIDO reserves the right to check any required characteristic mentioned in this specification.

12.2 Individual tests

Individual tests shall be carried out in accordance with IEC Publication 56 (Edition 1972).

13. CONSTRUCTION

The circuit breakers shall be indoor types, consisting of three (3) single phase, units or one three-phase unit, trip free, with antipumping device. For a single phase unit breaker, control and pneumatic diagram must be designed in a manner that it will be possible to operate two phases only while one is out of service. The three single phase units shall not trip in case of phase disagreement.

Accessories required for a three phase unit are:

- safety valve
- pressure switches. The contacts shall have an interrupting capacity at 125 V of

  0.04 A DC inductive
  0.25 A DC non inductive
  5. A DC inductive or not

The settings of pressure switches shall be for:

- normal operating pressure
- reclose lockout
- close lockout
- trip lockout
- emergency lock (loss of air)
- control of the air control valve (the latter will be supplied by UNIDO).

- filter

- pressure indicator

Accessories required for each unit in case of single phase circuit-breakers:

- position indicator
- operation counter
- check valve
- shut-off valve
- local control (mechanical or electrical)

- 4 extra "a" switches and 4 extra "b" switches. A type "b" is closed when the breaker is open and open when the breaker is closed. All these contacts shall be insulated from each other and from the ground.

- control coils:

  Each pole shall be provided with a closing and an opening coil. They will receive an operating voltage of 110 V DC.

  The control elements shall be arranged so that their characteristics can be checked on the site.

  The control equipment shall permit single phase and three phase operation of circuit-breakers.

- Consumption:

  The Tenderer shall indicate the maximum consumption of all control circuits.

14. GROUNDING

All the non-conducting metal parts shall be connected to the test station grounding system. The manufacturer shall supply the connectors that link the switches to the grounding system.

15. GALVANIZING

All steel parts shall be galvanized in conformity with European standards equivalent to ASTM Standards A-123 and A-153.

16. ALTERNATIVE

The manufacturer is invited to suggest any alternative that may save money or permit greater ease of installation or operation.

HP 7

MAKE SWITCHES

The present specification covers the requirements of the Electrical Industry and Experimentation Centre for the supply of three (3) different sets of make switches, each set consisting of three (3) single phase units.

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Article	Description	Page
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2	General Description	3
3	Standards	3
4	Quantity	3
5	Electrical Characteristics	4
6	Operating time, Accuracy	4
7	Electrical Endurance	4
8	Mechanical Endurance	5
9	Operating cycle	5
10	Interval between two Operating Cycles	5
11	Controls	5
12	Tests	7
13	Grounding	10
14	Galvanizing	10
15	Alternative	10

2. GENERAL DESCRIPTION

The make switches shall be of the compressed air or sulphur hexafluoride (SF_6) type, and for indoor installation. They are divided in three (3) sets of three (3) units each, identified as article 1, 2 and 3. Characteristics not specified individually for each article shall be interpreted as common for all three articles.

The make switches will be used to close synchronously the short-circuit in the High Power Laboratory. The power will be fed by an alternator for article 1 and by the network for articles 2 & 3. In both circuits, tests will be carried out single or three-phase.

3. STANDARDS

IEC Publication 56 (Edition 1972):
Specification for alternating current circuit breakers.

IEC Publication 60: High voltage test techniques.

The standards listed above shall apply except for modifications or additions contained in this specification.

4. QUANTITY

Article 1: Three (3), single phase, identical, interchangeable, for indoor installation.

Article 2: Three (3), single phase, identical, interchangeable, for indoor installation.

Article 3: Three (3), single phase, identical, interchangeable, for indoor installation.

5. ELECTRICAL CHARACTERISTICS

		Article 1	Article 2	Article 3
Operating voltage	kV	3 to 14	10 to 25	12,5 to 25
Rated frequency	Hz	50 and 60	50 and 60	50 and 60
Withstand voltage to ground:				
BIL	kV peak	95	125	125
50 Hz, 1 minute, dry	kV rms	45	50	50
Withstand voltage between contacts, during 5 cycles	kV peak	80	110	110
Symmetrical closing capacity (Duration: 5 periods)	kA rms	105	35 at 25 kV 105 at 10 kV	17,4 at 25 kV 35 at 12,5 kV
Asymmetrical closing capacity (½ period)	kA peak	260	90 kA at 25 kV 260 kA at 10 kV	43,5 at 25 kV 87 at 12,5 kV
Short-time current:				
1 second	kA rms	86	105	35
first peak value	kA peak	260	260	87

6. OPERATING TIME, ACCURACY

The tenderer shall give the mechanical closing time, i.e. the time between the electrical order on the operating coil and the touch of the contacts assuring the closure. The accuracy of this closing time shall be ±0.3 ms or better, for any condition described in this specification.

7. ELECTRICAL ENDURANCE

The tenderer shall guarantee that the switches can support the "closing" operations at the percentages of symmetrical and asymmetrical closing capacity specified below, without adjustment or maintenance, while maintaining the same accuracy for all closing operations.

% of symmetrical and asymmetrical closing capacity	Closing operations
100%	100
60%	The Manufacturer shall give the values at these capacities.
30%	
10%	

However, it should be noted that these performances are not cumulative.

8. MECHANICAL ENDURANCE

The switches shall be capable of supporting at least 5000 no-load "opening-closing" operations without adjustment or maintenance, while maintaining the same closing time and accuracy.

9. OPERATING CYCLE

C - 0.3 sec - C - 3 min - C
For compressed air make switches, the test station air supply will be sufficient to permit the make switches to receive the air required for the third closing operation, within 3 minutes.

10. INTERVAL BETWEEN TWO OPERATING CYCLES

The make switches shall be capable to perform an operating cycle every 15 minutes.

11. CONTROLS

The controls shall be supplied and installed inside a cubicle and connected to the latter by a control cable with removable plugs.

The cubicle shall be attached to the mounting frame of the switch and shall be large enough to permit all the control and auxiliary circuits to be connected on the terminal blocks. The cubicle shall be capable of being locked with a padlock.

The control elements shall be arranged so that their characteristics can be checked on the site.

The control equipment shall permit single and three phase operation of the make switches.

11.1 Control coils, voltage.

Each pole shall be provided with a closing and an opening coil. They will receive an operating voltage of 110 V DC.

11.2 Local control

A manual emergency control shall be provided near the make switches.

11.3 Operations counters

Each pole shall be equipped with an operation counter.

11.4 Auxiliary contacts

In addition to the contacts reserved for operation of the make switch, each pole shall be equipped with six (6) type "a" contacts and six (6) type "b" contacts. A type "b" contact is closed when the make switch is open and open when the make switch is closed. All these contacts shall be insulated from each other and from the ground.

11.5 Consumption

The tenderer shall indicate the maximum consumption of all control circuits.

12. TESTS

The manufacturer shall carry out all tests in accordance with this specification and the IEC Standards, in all that applies to make-switches, subject to the changes or additions contained in this document.

12.1 Dielectric tests

Dielectric tests shall be made on one complete make switch of each article. The voltage shall be applied:

a) to the ground, with the make switch closed and,

b) between current entry and exit, with the make switch open.

The tests shall be carried out in accordance with IEC Publication 60 and the values stated in Article 5 of this specification.

12.2 Closing tests

Closing tests shall be done on one complete unit of each article. The test procedure shall be in accordance with IEC Publication 56 as far as it applies for closing operations, with the test program listed below and with the values given in Article 5.

Test program:

a) ten (10) closings, i.e. five (5) symmetrical and five (5) asymmetrical with the rated current and the maximum available voltage. Duration: 5 periods.

b) ten (10) closings, i.e. five (5) symmetrical and five (5) asymmetrical with the rated voltage; and the maximum available current. Duration: 5 periods.

The closing time shall be checked in each test. Changing of parts will not be permitted during these tests.

The manufacturer shall also carry out thirty (30) no-load operations of the make switch under test and note the closing time after each operation.

In addition to the closing capacity, the acceptance standard of the make switch is also based on the closing time tolerance. The closing time for each test shall not exceed the tolerance guaranteed by the manufacturer.

NOTE:
The choice of the test station is left to the manufacturer, however the name of the station must appear on the Tender Form.

12.3 Short Time withstand current test

This test shall be carried out on one unit of each group in accordance with IEC Publication 56 (Edition 1972), and the values listed in Article 5. Exception: The make switch shall not be closed previously, it shall close on the short-circuit current.

12.4 Acceptance conditions

The acceptance of the switch is based on the following conditions:

a) The make switches meet the characteristics of this specification.

b) No sign of damage shall be evident during and after the tests, except the wear of the contacts.

12.5 Responsibility for conducting tests

The manufacturer is responsible for carrying out tests on one unit of each article only. Other units will be subjected to the same tests after they are installed.

12.6 Changes after tests

Any change or modification made to the first switch after testing shall also be made to the other units. If the Purchaser consider the changes major, the switch is considered to be new and all tests must be repeated.

12.7 Acceptance of test reports

UNIDO will accept as proof of conformity to article 12 of this specification test reports covering tests made on an identical unit as proposed in the tender. All documents related to tests made shall be enclosed in the tender.

13. GROUNDING

All the non-conducting metal parts shall be connected to the test station grounding system. The manufacturer shall supply the connectors that link the switches to the grounding system.

14. GALVANIZING

All steel parts shall be galvanized in conformity with European standards equivalent to ASTM Standards A-123 and A-153.

15. ALTERNATIVE

The manufacturer is invited to suggest any alternative that may save money or permit greater ease of installation or operation.

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TRV CAPACITORS FOR TEST SECTION NO. 1

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1. This specification covers the requirements of the Electrical Industry Testing and Experimentation Center, for the supply of the TRV control capacitors for test section No: 1 of the H.P. Laboratory.

These capacitors shall be designed for use also as the capacitive load during energizing and de-energizing tests on capacitor banks.

2. General description

The capacitors described in this specification will be used for regulating the transient recovery voltage produced across the terminals of circuit breakers under test when the short-circuit current is interrupted.

This voltage may be considered as the sum of two components: one periodic, at power frequency (50 Hz), the other oscillatory at one or several frequencies or non-oscillatory (exponential, for instance) or may be a combination of these, according to the characteristics of the circuit and the breaker.

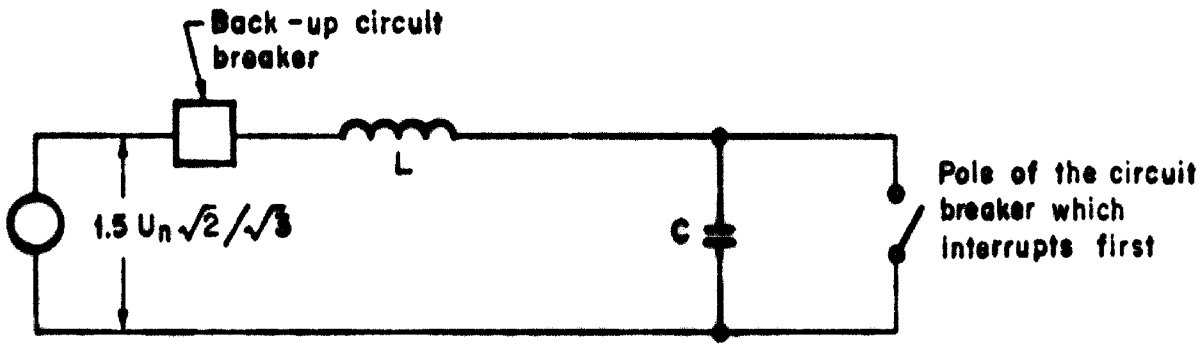
In three-phase circuits, the transient recovery voltage to be considered corresponds to the pole on which the arcs are first extinguished since this voltage is generally higher than that on the other two poles.

System frequency $f = 50$ Hz
f_o - transient frequency
When $U_n = 24$ kV rms f_o will be between 6 kHz and 28 kHz
The first crest may reach a value equal to $1.5 \times 1.8 \times U_n \sqrt{2}/\sqrt{3} = 53$ kV
When $U_n = 245$ kV rms $f_o = 1{,}5$ kHz through 6 kHz
The first crest may reach a value equal to $1.5 \times 1.8 \times U_n \sqrt{2}/\sqrt{3} = 540$ kV

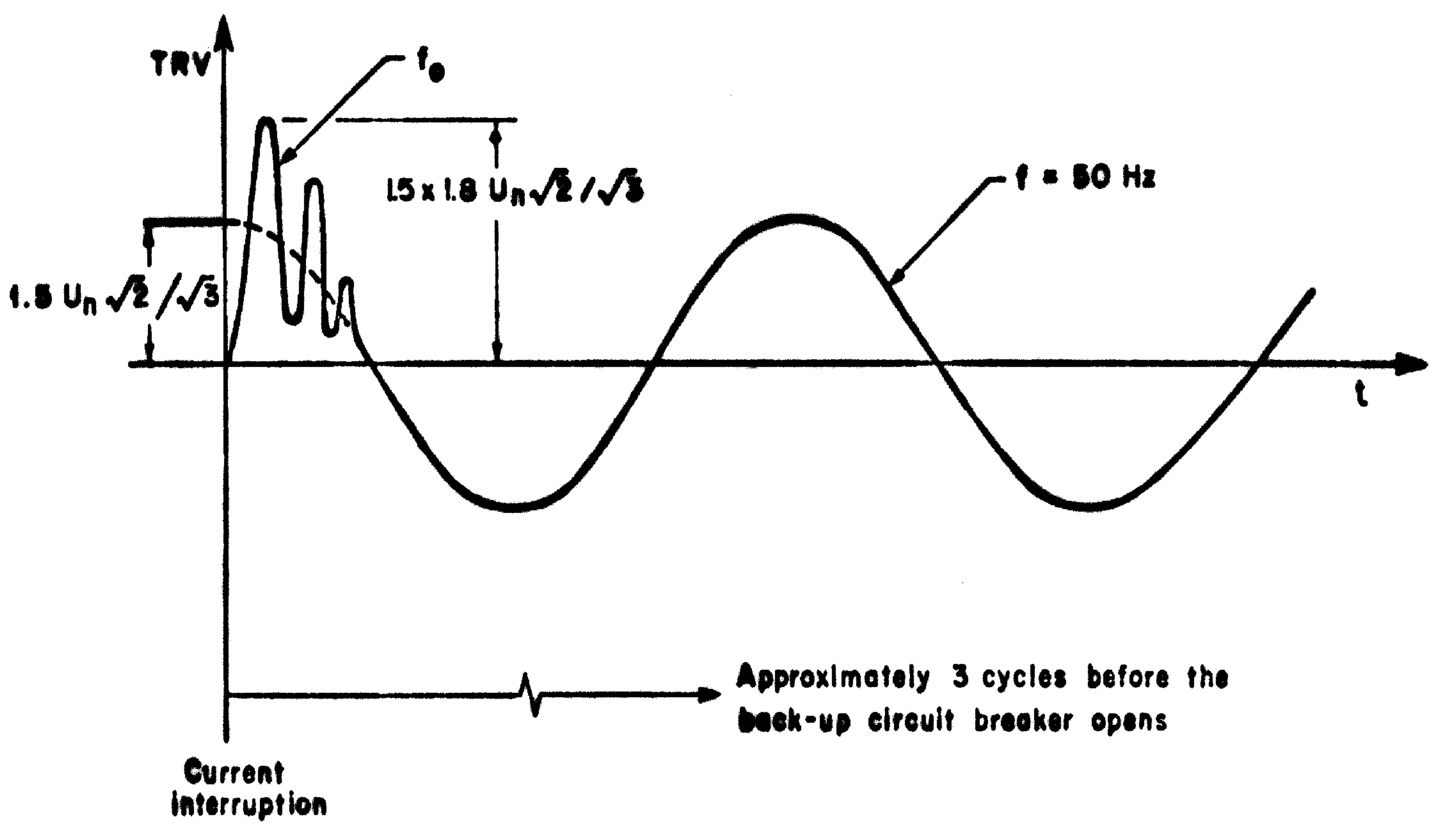
Reclosing cycle

In the case of rapid reclosing of the breaker, i.e. opening-θ-closing-opening, where θ is the opening dead-time of rapid-reclosing breakers (approximately 0.3 s), the capacitor remains energized at power frequency (50 Hz) for 0.3 seconds after which it is short-circuited for 0.15 to 0.30 seconds.

Simplified diagram of test circuit



When the break is successful, the transient recovery voltage TRV (t) takes the form below:



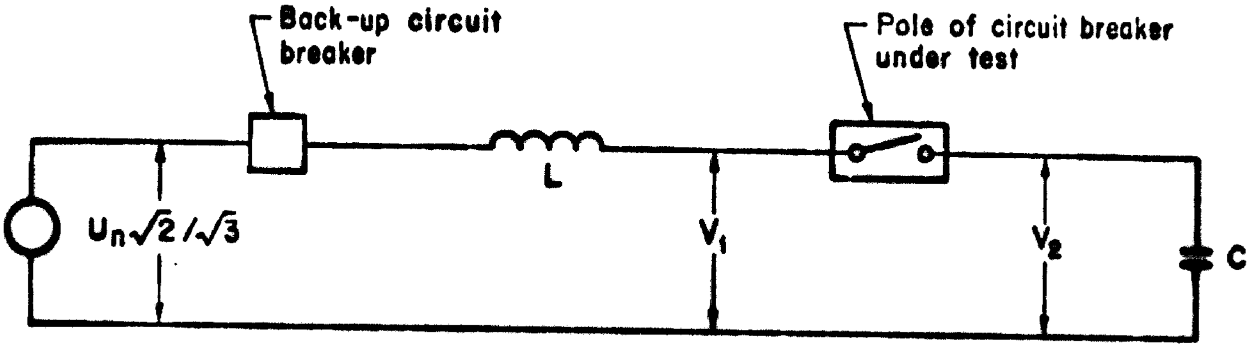
Failure to break

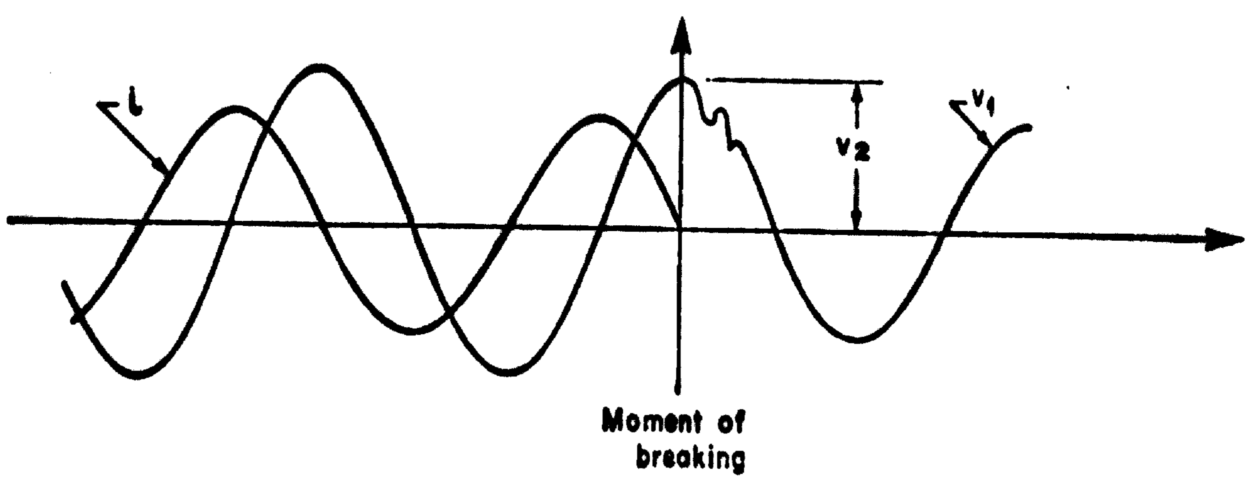
In the case of failure to break, i.e. if the breaker under test restrikes, at the moment the TRV reaches its first crest, the capacitor discharges into the breaker almost immediately. The discharge frequency can reach a value above 60 kHz.

Some fifty (50) short-circuit tests will be performed daily in the high-power laboratory.

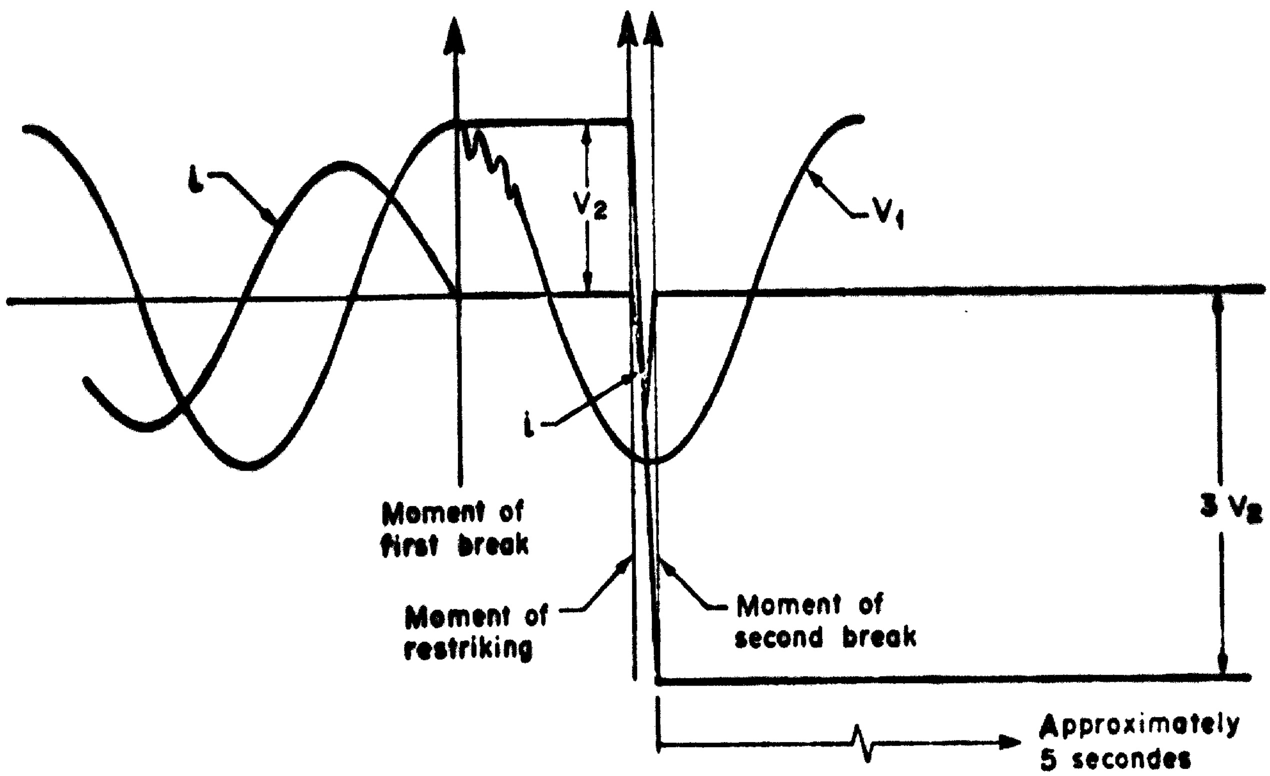
The capacitors will also be used as load for energizing and de-energizing tests on capacitor banks using circuit breakers and switches.

Below is the simplified diagram of a test circuit:





A restriking circuit breaker or switch, followed almost immediately by a second break in the capacitive current, would take the following form:



Approximately thirty (30) to fifty (50) energizing and de-energizing tests a day will be performed in the high-voltage test station during capacitor-bank switching tests.

Short circuit and capacitive-current breaking tests will be single and three-phase.

3. Standards

I. E. C. Publication 70 (1967) Power capacitors

The above standards are applicable, contingent on the modifications or additions specified herein.

4. General characteristics

The capacitors shall be single-phase, 50 Hz, for outdoor service.

4.1 Ambient temperature

The ambient temperature will vary between 0°C and +40°C, however during delivery, temperatures between -40°C and +40°C must be taken into account.

4.2 Technical characteristics

Capacitor unit: 1.2 μF (+ 10%) (- 5%)

Short-time voltage (≤ 0.30 s.): 10 kV rms

Short-time reactive power: 37.7 kVAR

Impulse withstand voltage with respect to container: 60 kV, crest

Withstand voltage at power frequency with respect to container: 30 kV rms

Withstand voltage between terminals: ± 45 kV d.c.

Rated voltage on bushings: 12 kV rms

Rated frequency: 50 Hz

Natural frequency: ≥ 60 kHz

Container: stainless steel, painted for outdoor use

Quantity required: 144 + 10 spare units = 154.

4.3 Installation of the capacitors

The total number of 144 capacitors will be divided in four groups, each having 36 capacitor units. Each group will be installed on an insulating support having a BIL of 550 kV.

Within the group of 36 units a system of manual connection will be provided permitting to put all 36 units either in parallel or in series or in any intermediate connection between the two extreme cases.

The maximum rated voltage of a group will be 144 kV and the insulation between the terminals of the units and collector bars will correspond to that voltage only.

It will be possible to create a three-phase capacitor bank using three of the four above mentioned groups either in star or in delta or a single phase group using all four groups. In the latter case the mid-point will be eventually earthed and the bank will be connected between two terminals of the test circuit.

4.4 Discharge resistors

Resistors are required for discharging the capacitors after testing. The type and values of these resistors shall be defined according to the number of capacitors in each group.

4.5 Continuous reactive power

The tenderer shall, in his tender, give the value of the permissible continuous reactive power for the capacitor. The continuous reactive power of a capacitor is defined as the product of the rated voltage multiplied by the permanent current that a capacitor can withstand indefinitely with a temperature rise not exceeding 35°C.

4.6 Discharge time

When removed from the charging unit, each capacitor must be able to lose not more than 10% of its initial voltage in 5 minutes.

4.7 Tangent of the loss angle

The tangent of the loss angle shall be equal to or less than $\frac{2\ \text{Watt}}{\text{kVAR}}$

5. Construction

The dielectric of the capacitors shall be chosen by the supplier to comply with the stipulated conditions.

The containers shall be of stainless steel and painted for outdoor installation.

The capacitors shall be equipped with external discharge resistors. Internally mounted resistors will not be accepted.

Each capacitor shall operate in either vertical or horizontal position according to the suggestion of the manufacturer.

6. Tests

6.1 Individual tests

The following tests shall be performed on each capacitor:

- measurement of the capacitance at rated voltage and frequency. Capacitors with values deviating by more than +10% or by less than -5% of the capacitance values stipulated shall be rejected.

- measurement of tangent of the loss angle at rated voltage and frequency.

- impulse withstand voltage (crest) with respect to the container.

- withstand voltage at power frequency (50 Hz) for one (1) minute between terminals.

6.2 <u>Withstand voltage test</u>

The following test shall be performed on each group of three (3) series-connected capacitors:

withstand voltage at power frequency (50 Hz) for 1 minute between the terminals of the first and third container.

6.3 <u>Thermal stability test and test for leaks</u>

The following tests shall be performed on one container of each type of capacitor:

Thermal stability: the temperature rise of the container of the capacitor supplying the continuous reactive output shall not exceed 35°C for an ambient temperature of 40°C.

Test for leaks.

6.4 <u>Discharge test</u>

The capacitor shall be short-circuited under a voltage of 20 kV d.c. This test shall be repeated five hundred (500) times. Before and after each series of 50 consecutive tests, the capacitance, tangent of the loss angle and ionization shall be measured.

These successive measurements shall show a definite tendency to stabilize. Any variation in capacitance and/or tangent of the loss angle and/or ionization will be acceptable on condition that it diminishes as the five hundred tests are carried out.

If the variation is constant or shows a tendency to increase, the capacitor will be rejected unless the Manufacturer prefers to continue the tests until the capacitance, tangent of the loss angle and ionization measurements are stabilized.

Rejection of any type of capacitor implies that before the others of the same type are accepted, the discharge tests have to be repeated on three (3) other capacitors of this same type.

6.5 Further condition of acceptance

Capacitors shall show no sign of damage either during or after the tests.

6.6 Responsibility for testing

The Manufacturer shall be responsible for carrying out all the tests.

6.7 Modifications following tests

Any modification that is made to a tested capacitor shall be made to the others of the same type. If, in the eyes of the Purchaser, these changes are major ones, the capacitors will be considered as new and all tests shall be repeated.

7. Additional prices

1. Special tools

Additional cost for special tools required for maintenance:
$..
A detailed list of these tools and their unit price is included.

2. Superintendents

If UNIDO requires one of our superintendents to be on the Laboratory site during assembly and acceptance tests, the rate per diem will be:

$..

Travelling expenses for the journey to and from the site from our plant:

$...

Pertinent technical data forming part of our tender

1) General description of the capacitors:
   Description enclosed...

2) Preliminary drawings of overall dimensions showing the electrical connections between capacitors (containers) and the racks supporting the capacitor assemblies.
   Description enclosed...

3) Indications of the capacitors' weight.
   Description enclosed...

4) Description of the dielectric of each capacitor.
   Description enclosed...

5) Maximum temperature rise of the dielectric of capacitors when producing continuous reactive power
   ....°C.

6) Loss in each type of capacitor:
   ....Watts.

7) Maximum current on closing at rated voltage (without residual voltage).
   ....A (crest).

8) Switching overvoltage between terminals during the capacitive-current interrupting tests, taking into account the possibilities of restriking by the breaking equipment under test.
....kV (crest).

9) Natural frequency of the capacitors.
....kHz.

10) Testing equipment at the Manufacturer's disposal.
Description enclosed...

11) List of accessories.
List enclosed..

12) Manufacturer's experience and list of capacitors he has already built.
List enclosed..

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MEASURING EQUIPMENT AND CONTROL ROOM

1. The measuring equipment for the 2100 MVA test section and 500 MVA test section is specified. The control system and the measuring cable layout is described with reference to the grounding system of the laboratory.
An outline of the measuring equipment and control system of the high current and direct current section as well as the synthetic test section is given.

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1. THE 2100 MVA TEST SECTION

1.1 Measuring equipment

1.1.1 Voltage measurements

As a basic equipment three voltage dividers are necessary, covering the measured voltage range from 15 kV peak, up to 150 kV peak value. The dividers will be permanently installed preferably on a framework gate structure, which supports insulators over the test yards.

The capacitive dividers having the high voltage arm capacitance of 500 pF are suggested. The high voltage capacitors must be housed in porcelain and must have stable capacitance value in the operating temperature range.

The divider output signal can be measured by various measuring instruments having high input impedance, but the cathode ray oscilloscope with multiple beams is recommended as a standard monitor. Concerning the oscilloscope parameters a reference is made to the instrumentation list which is enclosed in the report.

The frequency passbandwidth of such oscilloscope reaches 40 kHz and this determines the required passbandwidth of the capacitive divider. Presuming that the maximum voltage recorded by the oscilloscope equals 100 V peak, the voltage divider ratio is to be 150:1 and an additional attenuator should be provided. The attenuator must have calibrated division ratios from 10:1 to 1:1 in four steps and having the input impedance of a few megaohms.

The measuring cable connecting the divider with the oscilloscope has to be of the coaxial style, preferably type RG/218U or equivalent. Each cable has to be laid in a separate steel pipe and the outer shield of the cable must be grounded to the laboratory grounding net at the two ends. The steel pipe is connected to ground at these two points, as well.

1.1.2 Current measurements

The test current is to be measured by three current transformers permanently installed on the reactor building roof. The transformers are covering the measuring range up to 65 kA and their core should be large enough to assure undistorted measurement of the asymmetrical short circuit current. The degree of the current asymmetry is given by the time constant of the aperiodical component of the short circuit current. This time constant can be as long as 200 ms, and the amplitude of the aperiodical component can reach 100% of the short circuit current. The nominal power of the transformers should not be less than 20 VA, and their precision of 0.5 class. Transformers of such type are manufactured for instance by the Company Walter in France.

To cover the whole measuring range, the transformers are equipped with taps on their secondary windings and (preferably a remote controlled) switch changing the transformer ratio. The switch should be of the "make before break" type. The low impedance cables, which connect the transformers with the monitors located in the control room, should be laid in steel pipes, installed under the test yard grounding net, each cable in one pipe. It is recommended that each twisted pair of cables be installed permanently in a separate steel tube connected to the laboratory ground at the two ends.

In addition to the fixed measuring apparatus, there are also mobile ones and extra measuring cables must be provided for such devices. These cables should be terminated in a steel box or well located close to the expected grounding point of a test object within the test yard.

1.1.3 Additional equipment

The recording instruments are the most important and expensive part of electronic instrumentation. For the short circuit phenomena the conventional strip chart galvanometer (for instance the "Visicorder" type manufactured by Honeywell Inc.) is recommended in the instrumentation list.

The basic measuring devices, namely voltage dividers and current transformers should be completed by a set of shunts. The shunts are utilised for accurate measurements and their calibration can be easily checked with an ordinary Thompson bridge. Besides, their passbandwidth exceeds largely the one of an ordinary current transformer, making possible the faster transients measurements.

The recommended set of shunts contains three units, designed for nominal currents 100 kA, 10 kA and 1 kA. The shunts should stand the nominal current of 0.1s duration and the resulting temperature rise should not change their nominal resistance by more than 0.3%. The nominal output voltage of these shunts should be of 1V level.

1.2. Control room equipment

Two permanent structures will be located in the control room, namely a control panel for the operator and a console with cable terminals.

The control panel contains a system of switches enabling the operator to perform the test and to supervise the test area interlocks and protections.

The principal test switching operations are timed by an electronic programmer which is located in the control room. As an additional equipment a mechanical cam is recommended. The output signals of the programmer are transmitted to the breakers by a system of screened cables. Besides, the programmer gives a triggering signal to the oscilloscopes. There are different screening requirements concerning the cables used for measurements and for control circuits respectively, and it is important to design properly the layout of all cables coming into the control room.

A fixed steel console containing terminals of all cables is recommended. The console should assure an easy access to all cables and appropriate grounding of their shields to the control room ground.

The console should be composed of two collector plates. Terminals of the incoming cables are mounted on the first one and the terminals of the cables going to the oscillographs and the control panel are installed on the second collector plate. This system permits any desired connection between a measuring apparatus and an oscilloscope as well as an easy connection of the calibration signal source to the recording instruments which are located in the dark room next to the control room.

The control panel and the console should be installed in the control room in such a way that the operator sitting at the panel can visually control the test area. The control panel should contain a dial switch with a fixed sequence of switching positions. The consecutive dial positions correspond to the respective preparation operation's sequence. This could be as follows as an example:

Position No. 0 Circuit is earthed, green lights are on

1. Green lights off, orange lights on, evacuation of dangerous zones and un-locking signals received for further operation.
2. Earthing switches open, orange lights off, red lights on, generators speed-up.
3. Make-switch opens
4. Field switch closes

5. Back-up circuit breaker closes. Excitation raised up on specified value

6. Test position-control transferred to automatic programmer. At this position the test is made. The last automatic operation is the opening of the field switch, switching off the red lights and switching on the orange lights.

7. Earthing of the circuit, orange lights off, green lights on.

The advantage of such a system lies in the elimination of operator's mistakes and of the risk of missing some prescribed switching operations.

The control panel should contain only necessary switches and signal lights. The opening and closing of the main and the back up breakers and disconnecting switches as well as grounding switches have to be indicated on the panel. The voltage of the battery supplying the interlock circuits should also be indicated on the panel as well as the position of interlocks and grounding switches. The "stand by" stations should be also provided an additional signal which can be ordered by the operator.

The dark room beside the control room should contain the oscilloscopes and the equipment necessary for fixing and displaying the recorded paper strips. It is very useful to locate a small store room close to the control room. The measuring instruments and auxiliary cables will be usually kept in such store.

2. THE 500 MVA TEST SECTION

2.1. Measuring equipment

In the 500 MVA test section the highest voltage which can be obtained in the test cells is 28.8 kV and the maximum current reaches [illegible] kA.

The transient voltage measurements at that level can be performed with a set of capacitive or resistive dividers. The dividers can be mobile and designed for outdoor operation. Besides, sets of potential transformers (P.T.) should be provided for measurements of the industrial frequency voltage.

The P.T. must be of 0.5 class at least, 75 VA and they have to cover the measuring range from 2.1 up to 28.5 kV. The P.T. can be permanently installed at the bus bar entering the test cell. The current measurements can be performed by using a set of current transformers (C.T.) designed for the measuring range from 10 kA up to 109 kA, with the precision class 0.5 at least and 20 VA minimum power. The secondary winding of the transformers should have a system of taps for different current levels. The C.T. should be of a special design, having the magnetic core dimensioned for a high saturation level, in order to reproduce the aperiodical component of the short-circuit current. Such C.T. are manufactured by specialized companies, the Walter Co. for instance.

The C.T. should be located at the bus bar entrance to the test cell, preferably on the bushings. Due to a relatively short distance between the 500 MVA test cells and the control room, an automatized system of tap switching on the C.T. secondary windings can be considered as an option.

The current measuring equipment should be completed by a set of shunts, but these shunts can also be shared with the 2100 MVA test section. Their measuring range and measuring properties are basically the same and it can rarely happen that the two sections will use their shunts simultaneously.

The cables connecting the measuring equipment with the control room should be laid in steel pipes, one cable in each pipe. These pipes should be installed under the grounding net of the laboratory. One end of the measuring cables must be brought to a steel console in the control room, the second end of each cable should be terminated at the permanently installed measuring apparatus or in a steel well located in the test cell. The steel well should not interfere with the transportation or displacements of test objects in the test cell area, but it must be situated close to the principal grounding point of the test object.

The importance of these two requirement should be particularly emphasized in the case of high current measurement.

2.2 Control room equipment

The 500 MVA section control room equipment is basically the same as the 2100 MVA section. The recommended layout consists in a centrally located panel which also enables the operator to have a visual control over one of the two test cells. The console containing measuring cable terminals should be installed in such a way as to assure an easy access to the cables.

The test preparation should be ordered and controlled by the operator from the control panel. The dial system and an electronic programming network are the complementary devices assuring a proper sequence and timing of the test. The dial positions in the 500 MVA test section correspond to the grounding switches and disconnecting switches operation as well as the warning lights interlocked with them. The breaker operation is controlled by the electronic programming system.

The auxiliary equipment of the control room consists in the measuring instruments (as listed in the enclosed paper) which can be shared with the 2100 MVA section.

3. OUTLINE OF THE EQUIPMENT FOR THE HIGH CURRENT AND DIRECT TEST SECTIONS

Measuring equipment for the high current section consists of special current transformers having the measuring range extended up to 300 kA. In fact, only one transformer with such high rating is required for the single phase tests. For three-phase test a set of three current transformers is needed having a 200 kA measuring range.

Besides, a set of three tubular shunts is required for both high and direct current sections. These shunts should cover the measuring range of the short circuit current from 7.5 kA up to 45 kA. The duration of the short circuit is 0.5s and the shunt should keep its nominal value within 0.3% accuracy limits during the test. The maximum slope of the short circuit current is of 2.10^7 A/s order.

For thermal tests another set of shunts is required for the 700 A to 4.5 kA range, but their design should provide for a continuous operation. These shunts can be of the flat plate style which is known as " Weston type ".

4. OUTLINE OF THE EQUIPMENT FOR SYNTHETIC TEST SECTION

The measurements related to the operation of the synthetic test circuit consist in the simultaneous recording of relatively fast voltage and current transients. Consequently, the requirement concerning the measuring properties of the applied instruments are higher in terms of the response time and the efficiency of screening against interferences.

The maximum voltage to be measured is 1150 kV having a maximum slope of 5.10^9 V/S range. Consequently a 1200 kV divider is required with the response time not larger than 100 ns. This divider will be principally used for the short line test where high frequency components of the measured voltage should be recorded without distortion up to one megahertz.

In addition an auxiliary divider of 500 kV measuring range is needed for various measurements on the synthetic test circuit. For current measurements special current transformers are necessary having 7 kA rated primary current and 10 kV insulation. They should be of 20 VA power and 0.5 precision class.

For certain test shunts will be used but they can be borrowed from the 2100 MVA test section.

The synthetic test is controlled from the main control room. For this purpose the control panel should have an additional section. This section contains instruments indicating the charging voltages and a remote control of the grounding switches and interlocks. The position of these switches is signalized on the panel. Besides, a remote control and signalization should be provided for the laser which serves for triggering the main gaps.

PRICE LIST FOR SMALL EQUIPMENT
HIGH POWER LABORATORY

QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL
2	Oscilloscope "Baron" - EDF, FRANCE	$ 21,500.	$ 43,000.
1	Storage oscilloscope (Tektronix 7514)	5,000.	5,000.
2	Dual beam oscilloscope (Tektronix 565)	4,000.	8,000.
2	Oscilloscope camera, probes for high voltage and high current measurements & additional equipment	6,000.	12,000.
1	Galvanometer - Oscillograph (Visicorder Honeywell) (1508A)	8,000.	8,000.
1	Streak framing high speed camera (Dynafax 350)	12,000.	12,000.
1	Precision millivoltmeter 0,2%	800.	800.
1	Set of shunts for AC measurements (Weston)	1,600.	1,600.
1	Precision ammeter Sa 0,19 (Weston)	700.	700.
1	Precision current transformer 12000 - 10 A, 0,1% (H&B)	700.	700.
5	Multimeters (Multavi-Norma)	200.	1,000.
3	Portable capacitance-inductance meter (Kapavi-Norma)	300.	900.
1	Laboratory RLC bridge	1,000.	1,000.
1	Megger 1000 V	500.	500.
1	Thompson Wheatstone bridge & power supply	2,000.	2,000.
1	Resistance Standards 10 uΩ - 10 Ω	600.	600.
1	Null detector (,1 μA - battery supplied)	400.	400.
3	Wattmeters 0,2% with external shunts	1,000.	3,000.
1	Cosfi - meter	200.	200.
1	Frequency meter	200.	200.
1	Set of technical instruments 1% for voltage and current measurement	500.	500.
1	Resistance and capacitance decades	500.	500.
			$102,[illegible]

[illegible] MVA AUTOTRANSFORMERS

This specification covers the requirements of the Electrical Test and Experimentation Center for the supply of one three-phases autotransformer for the load breaking tests in the High Power Laboratory; rated voltage 25 kV, rated poer 34.6 MVA

The supply includes engineering, manufacturing, testing and shipment of the autotransformer along with auxiliary equipment specified herein.

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2. GENERAL DESCRIPTION

The autotransformer will be used in the Test Section No. 2 of the High Power Laboratory, mainly for tests on load switches, fuses, etc...

As shown on single-line diagram in Fig. 1, the autotransformer will be connected on the load side of the apparatus under test. The primary will be connected to the load terminals of the apparatus under test and the secondary will feed a combination of the load resistors and reactors.

The effective impedance of the load and its power factor, seen from the terminals of the tested apparatus, will be adjusted by using an adequate reactor and resistor connection and an adequate transformation ratio of the autotransformer.

The source feeding this autotransformer will be a short-circuit transformer set rated at 300 MVA three-phase short-circuit capacity.

3. GENERAL CHARACTERISTICS AND CONNECTIONS

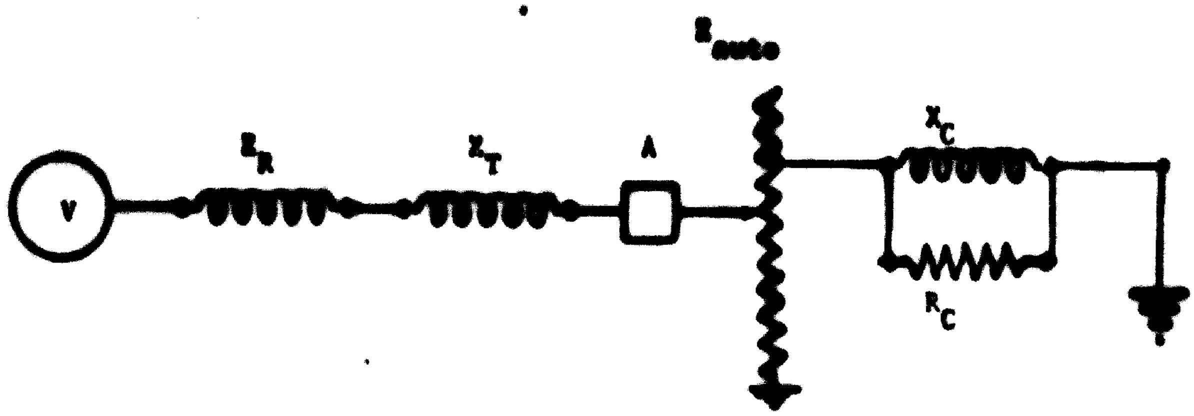
The autotransformer shall be three-phase , outdoor type, oil immersed, with a conservator tank. Rated frequency shall be 50 Hz.

Fig. 2 shows the connection diagram of one phase.

Fig. 3 shows the three-phase test connections.

Fig. 4 shows the singlephase test connections.

FIGURE #1



V: Supply.

Z_R: Supply impedance.

Z_T: Impedance to limit the short-circuit current in the apparatus under test.

A: Apparatus under test.

Z_{auto}: Autotransformer impedance.

X_C: Load reactor.

R_C: Load resistor.

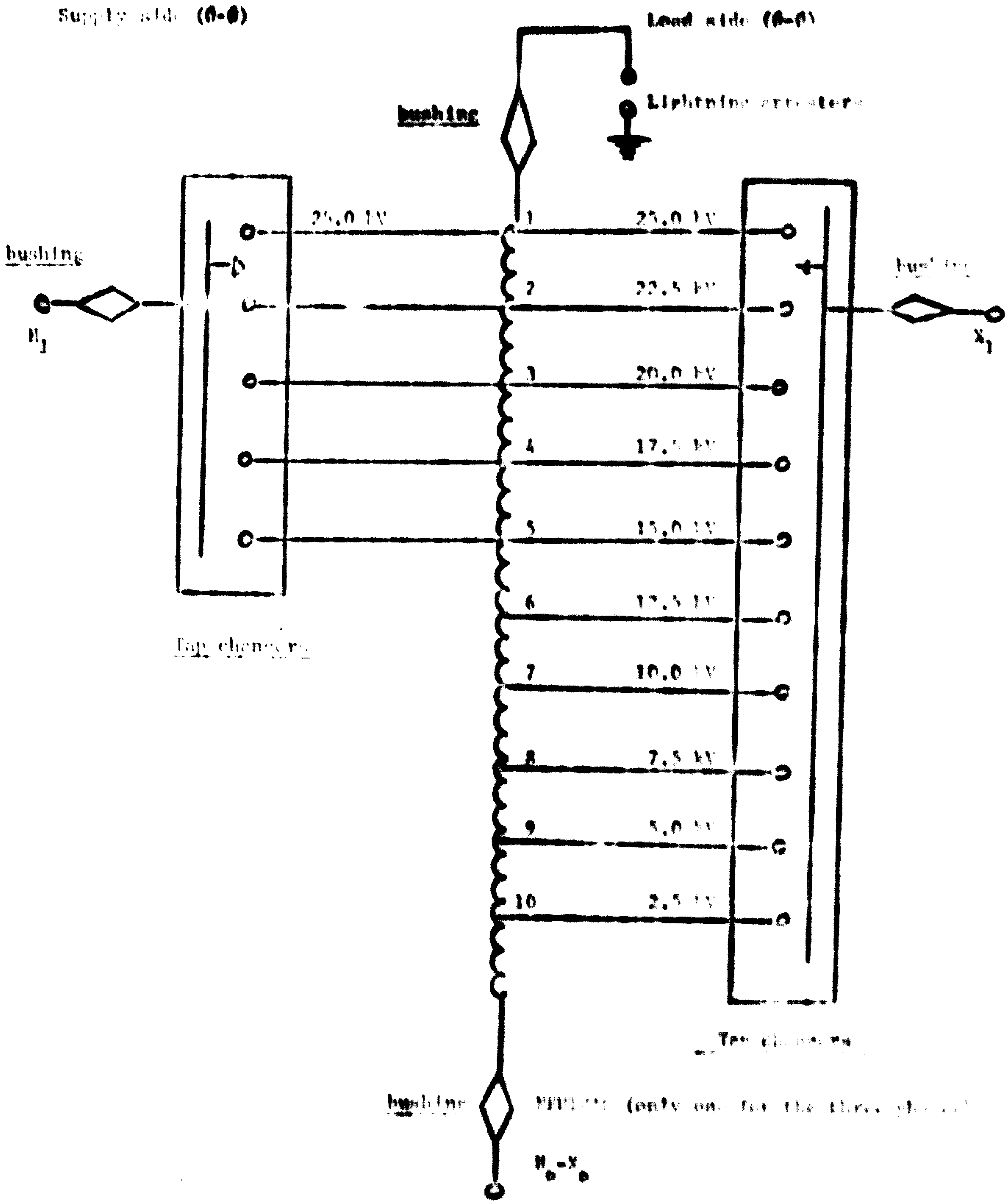
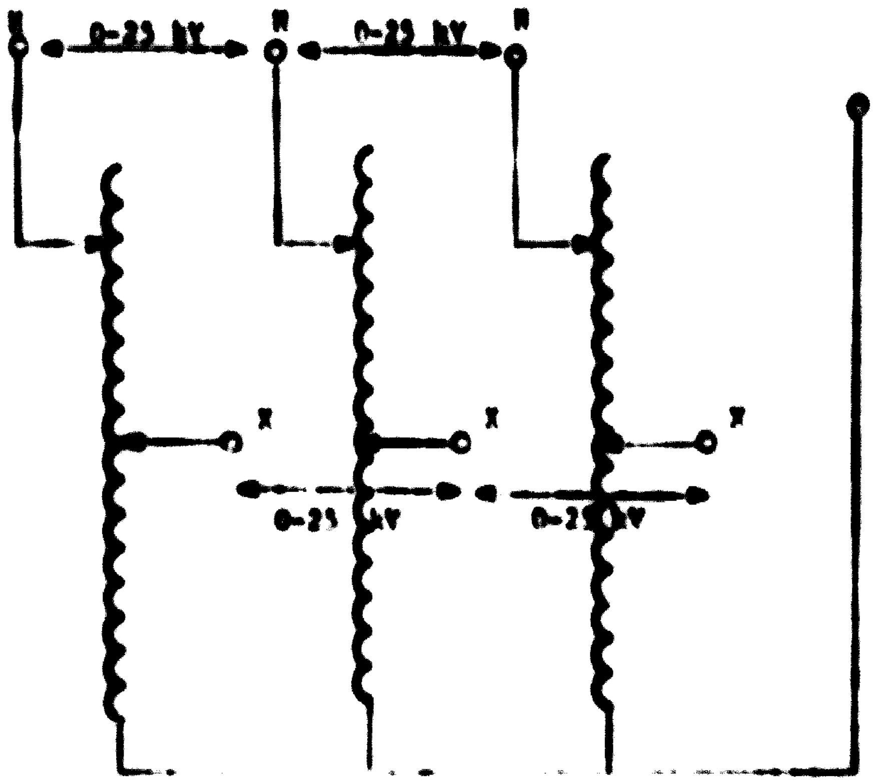

Supply side
Load side
bushing
Lightning arresters
bushing
H1
1
25.0 kV
2
22.5 kV
3
20.0 kV
4
17.5 kV
5
15.0 kV
6
12.5 kV
7
10.0 kV
8
7.5 kV
9
5.0 kV
10
2.5 kV
bushing
X1
Tap changers
Tap changers
bushing
(only one for the three phases)
H0-X0

Fig. [illegible]

Voltages which can be applied on the autotransformer.

1) Three-phases, insulated neutral



2) Three-phases, neutral to ground.

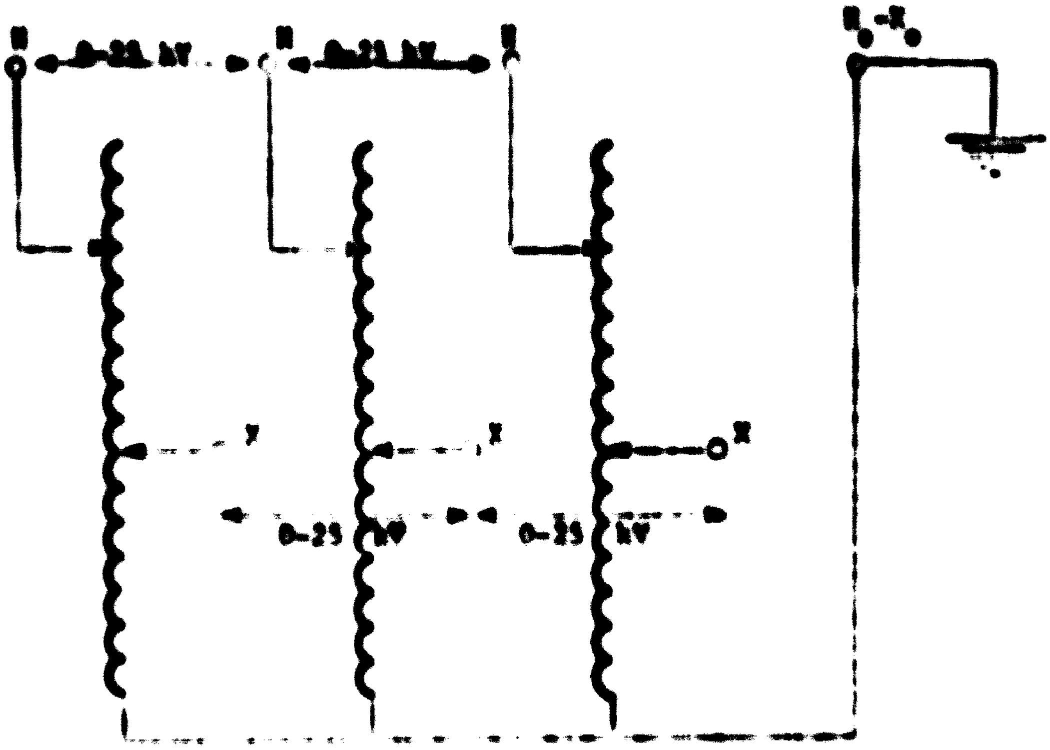
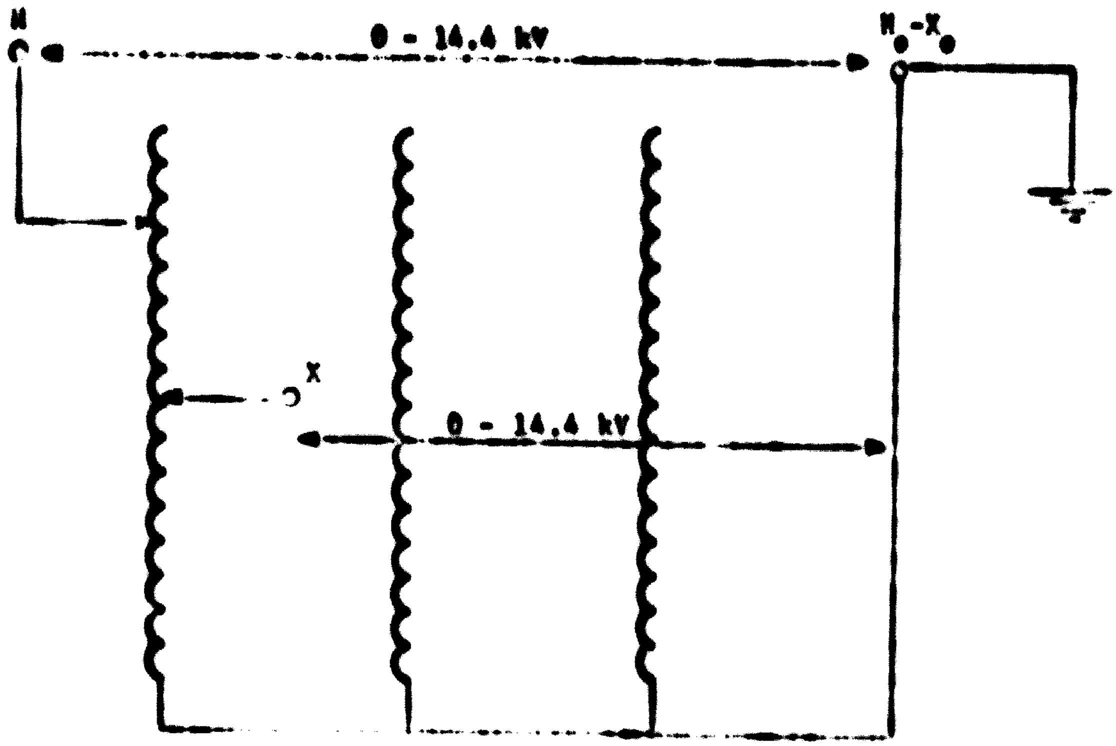


Fig. 3

3) Single phase, neutral to ground.



4) Single phase, one phase to earth (insulated neutral)
Maximum phase-ground voltage = 28 kV

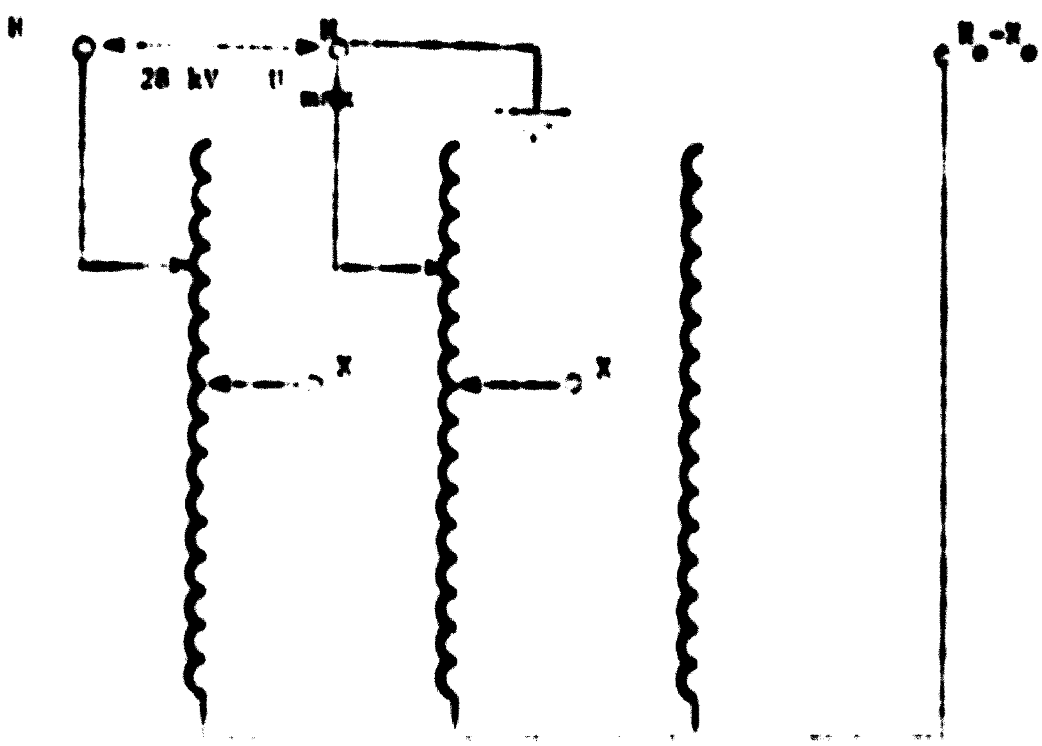


Fig. #4

4. RATINGS

4.1 Primary winding

4.1.1 Rated voltage:

$\frac{25 \text{ kV}}{\sqrt{3}}$ 14.4 kV phase-to-earth

The five (5) taps are: in terms of phase to phase

25.0 kV
22.5 kV
20.0 kV
17.5 kV
15.0 kV

4.1.2 Rated primary current

Two (2) types of duty cycles shall be available:

- 800 A for a period of 1 second a hundred and fifty (150) times with a period of three minutes between shots followed by a cooling-off period of ten (10) hours.
- 800 A for ten (10) consecutive seconds followed by a cooling-off period of ten (10) hours.

4.1.3 Insulation levels

a) B.I.L.

Taps and bushings

H_1 : 170 kV

H_0 : 170 kV

For the following taps:

25.0 kV: 170 kV

22.5 kV: 170 kV

20.0 kV: 170 kV

17.5 kV: 125 kV

15.0 kV: 125 kV

b) Switching surge withstand voltage (crest) 250/2500 μsec.

Taps and bushings

H_1 : 140 kV

H_0 : 140 kV

For the following taps

25.0 kV : 140 kV

22.5 kV : 126 kV

20.0 kV : 112 kV

17.5 kV : 98 kV

15.0 kV : 84 kV

c) One minute 50 hertz withstand levels (rms)

Taps and bushings

H_1 : 70 kV

H_0 : 70 kV

d) Induced voltage insulation

The autotransformer shall be able to withstand without damage an induced voltage of 2.0 times the rated voltage, that is 70 kV.

4.1.4 Short-time rated power

The rated short-time power is defined as the product of the rated no-load voltage by the rated current by $\sqrt{3}$.

Supply side: (for a maximum current in the winding of 800 A)

25.0 kV x 800 A x $\sqrt{3}$ = 34.64 MVA
22.5 kV x 890 A x $\sqrt{3}$ = 34.6 MVA
20.0 kV x 1000 A x $\sqrt{3}$ = 34.6 MVA
17.5 kV x 1140 A x $\sqrt{3}$ = 34.6 MVA
15.0 kV x 1330 A x $\sqrt{3}$ = 34.6 MVA

Two (2) types of duty cycles are possible:

- The rated current for a one second period, a hundred and fifty (150) times with a period of 3 minutes between shots, followed by a cooling-off period of ten (10) hours.
- The rated current for ten (10) consecutive seconds followed by a ten (10) hours cooling-off period.

4.2 Load side

4.2.1 Rated no-load voltage:

$\frac{25.0\ kV}{\sqrt{3}}$ = 14.4 kV phase-to-earth

The ten taps shall be: in terms of phase to phase.

25.0 kV
22.5 kV
20.0 kV
17.5 kV
15.0 kV
12.5 kV
10.0 kV
7.5 kV
5.0 kV
2.5 kV

4.2.2 Insulation levels

a) B.I.L.

Bushing X_1 : 170 kV

For the following taps:

25.0 kV	:	170 kV
22.5 kV	:	170 kV
20.0 kV	:	170 kV
17.5 kV	:	125 kV
15.0 kV	:	125 kV
12.5 kV	:	95 kV
10.0 kV	:	95 kV
7.5 kV	:	75 kV
5.0 kV	:	60 kV
2.5 kV	:	45 kV

b) Switching surge withstand voltage (crest) 250/2500 µsec.

Bushing X_1 : 140 kV

For the following taps:

25.0 kV	:	140 kV
22.5 kV	:	126 kV
20.0 kV	:	112 kV
17.5 kV	:	98 kV
15.0 kV	:	84 kV
12.5 kV	:	70 kV
10.0 kV	:	56 kV
7.5 kV	:	42 kV
5.0 kV	:	28 kV
2.5 kV	:	14 kV

c) One minute 50 Hertz withstand levels (rms)

Bushing X_1 : 70 kV

4.2.3 Short-time power

The rated short-time power is defined as the product of rated no-load voltage, by the rated current and by $\sqrt{3}$.

Load side: (for a maximum current in the winding of 800 A)

25.0 kV x 800 A x $\sqrt{3}$ = 34.6 MVA
22.5 kV x 890 A x $\sqrt{3}$ = 34.6 MVA
20.0 kV x 1000 A x $\sqrt{3}$ = 34.6 MVA
17.5 kV x 1140 A x $\sqrt{3}$ = 34.6 MVA
15.0 kV x 1330 A x $\sqrt{3}$ = 34.6 MVA
12.5 kV x 1600 A x $\sqrt{3}$ = 34.6 MVA
10.0 kV x 1600 A x $\sqrt{3}$ = 29.0 MVA
7.5 kV x 1600 A x $\sqrt{3}$ = 20.8 MVA
5.0 kV x 1200 A x $\sqrt{3}$ = 10.4 MVA
2.5 kV x 960 A x $\sqrt{3}$ = 4.2 MVA

4.3 Rated continuous power

There is no requirement for any specific rated continuous power. The one specified by the manufacturer shallbe accepted.

4.4 Rated duty

The autotransformer shall be designed in such a way that it can be continuously connected at no load.

The autotransformer must also be capable of delivering its short-time rated power for one (1) second (800 A in the winding) a hundred and fifty (150) times with a period of three minutes between the shots, followed by a cooling-off period of ten (10) hours. The autotransformer shall be capable of delivering its short-time rated power during a 10 second period, followed by a 10 hour cooling-off duration. These operating duties may be repeated continuously at a 35°C ambient temperature and the temperature rise of the winding copper shall not exceed 70°C.

The autotransformer shall be capable of a continuous power output specified by the manufacturer at an ambient of 35°C. The temperature rise of the copper shall not exceed 65°C. Cooling time shall not exceed 10 hours.

4.5 Electrodynamic forces

The currents used for determining the rated power are expressed in RMS values. Crest values of asymmetrical currents may, however reach the following maximum: the RMS value multiplied by a factor of 2.5.

4.6 Short-circuit impedance

The short-circuit impedance of this autotransformer, at 50 Hertz, seen from supply side at 25 kV tap, shall be 6 Ω, for the load side at 12.5 kV tap.

The manufacturer shall provide the short-circuit impedances of the autotransformer for all the transformation ratios. For a transformation ratio less than 2, for a power supply at 25 kV, the impedance shall be lower than 6 %.

The autotransformer shall be rejected for any impedance greater than the ones specified + 8%.

4.7 Tap changers

There are two (2) tap changers for each phase. They shall be located in the tank of the autotransformer or in a separate compartment.

Each tap changer shall be routed towards the outside of the tank through a single bushing. There will be also three other bushings which will permit the connection of the full winding to lightning arresters.

The neutral of the three windings shall be routed outside the tank by a single bushing. (see fig. #2).

The tap changers shall be always operated without voltage.

4.8 Accidental short-circuit current

The accidental current that the autotransformer has to withstand a few times in its lifetime without being damaged is 8 000 Amperes. The purchaser reservesus the right to perform a short-circuit test on the autotransformer at his laboratory in order to prove this rating.

4.9 Natural Frequency of the autotransformer

The natural frequency, at no load of the autotransformer shall be for all the supply side taps equal to 1 000 Hz or greater.

5. [illegible]

IEC Publication 76, "Power Transformers" shall apply, except for any modifications or additions contained in this specification.

The autotransformer shall be provided with:

a) A safety valve for internal over-pressure protection with an explosion vent.

b) Two (2) thermostats, one set at the alarm temperature and the other at tripping temperature.

These accessories should not be regarded as restrictive. The Manufacturer must supply a complete unit in perfect working conditions, offering maximum safety. He may add any equipment that he deems useful.

5.1 Gas relay

The autotransformer shall be equipped with an appropriate gas-detector relay. This relay shall be arranged to collect gas generated in the switch compartment unless a gas-detector relay is mounted on each compartment.

5.2 Cooling system

The cooling system needed to assure the continuous power output specified by the manufacturer shall preferably be ONAN type (natural cooling).

5.3 Magnetizing current

The unload magnetizing current expected is when fed at:

100% of rated voltage = 1.2 A

110% of rated voltage = 4 A

The flux in the core shall not be under saturation during successive closing and opening operations of one second duration at intervals of one minute.

5.4 Lightning arresters

Lightning arresters shall be mounted and coordinated in order to protect the windings against too high overvoltages. These lightning arresters shall not sparkover for switching surges equal or below 100 kV.

5.5 Overvoltage grading device

Devices for distributing the voltage surges between windings shall not contain any non-linear resistances. Linear resistances shall be permitted provided the change they cause in the recovery voltage is less than 1%.

If the manufacturer intends to use grading capacitors, it shall be specified in the tender.

6. TESTS

All tests shall be made under the responsibility and at the expense of the manufacturer.

IEC Publication #76 shall apply, except for modifications or additions thereto made by this specification.

6.1 Tests to be carried out before the 10 second rated power tests

The autotransformer ratio shall be measured at no-load for each supply side and load side tap.

The no-load ratio shall not vary more than 2% from the theoretical value. The autotransformer shall be rejected if the ratio differs by more than 2%.

No-load exciting current shall be measured on an oscillograph for each supply side tap.

Temperature rise at continuous power rating shall be done with the following taps.

Supply side	Load side
25.0 kV	12.5 kV

6.2 10 second rated power tests

The purpose of these tests is to check the transformer strength under electrodynamic forces and check also that the temperature rise does not exceed that stipulated in Item 4.4.

For the 10 second rated power tests the autotransformer shall not be put under voltage before doing the test.

1) For each tap specified, a hundred and fifty (150) tests of one (1) second with a period of three minutes between each test shall be performed. These tests shall be done at the 10 second rated power. (see table 1).

2) After these tests (number 1, 2 and 3) a test at the 10 second rated power for a period of 10 consecutive seconds shall be done.

Voltage supply

$\frac{25\ kV}{\sqrt{3}}$ = 14.4 kV phase to earth

Feeding tap: 25 kV in terms of phase to phase

Rated primary current: 800 Amperes.

Load tap: 12.5 kV, in terms of phase to phase

The instant of application of the currents as well as the ωL/R ratio of the test circuit shall be such that the current asymmetry is maximum for the first half-period. (1.8 x $\sqrt{2}$ x I r.m.s.)

The test parameters shall be measured by oscillographic recording of the supply current and voltage.

Transformer acceptance is based on the transformer leakage reactance and capacitance variations caused by displacement of the winding elements (called the low-voltage impulse method) during the 150 tests of one second with a period of three minutes between each test.

Leakage reactance shall be measured between each 30 tests and also after the 10 second test using an adequate bridge circuit, ensuring an absolute error of less than 0.5% and guaranteeing a minimum sensitivity of 0.06% between two successive measurements.

Successive measurements of reactance made after each 30 tests should exhibit a net tendency to stabilise, i.e. a variation in impedance will be acceptable if it decreases as the series of tests proceeds.

If the variation in reactance is constant or tends to increase, the autotransformer shall be rejected.

Recording of the variations in capacitance caused by displacement of the windings elements shall be carried out by the low-voltage impulse method.

This method consistsof applying low-voltage impulses on the primary winding and recording on an oscillogram the transient voltages that appear at the terminals of a resistance connected in series between ground and the short-circuited secondary winding of the autotransformer.

Comparison between oscillograms recorded before and after each 30 tests and after the 10 second test permits the evaluation of variations in capacitance which in turn indicate displacement of winding elements.

Oscillograms recorded before and after each 30 tests and after the 10 seconds should be identical. Otherwise, the autotransformer shall be rejected.

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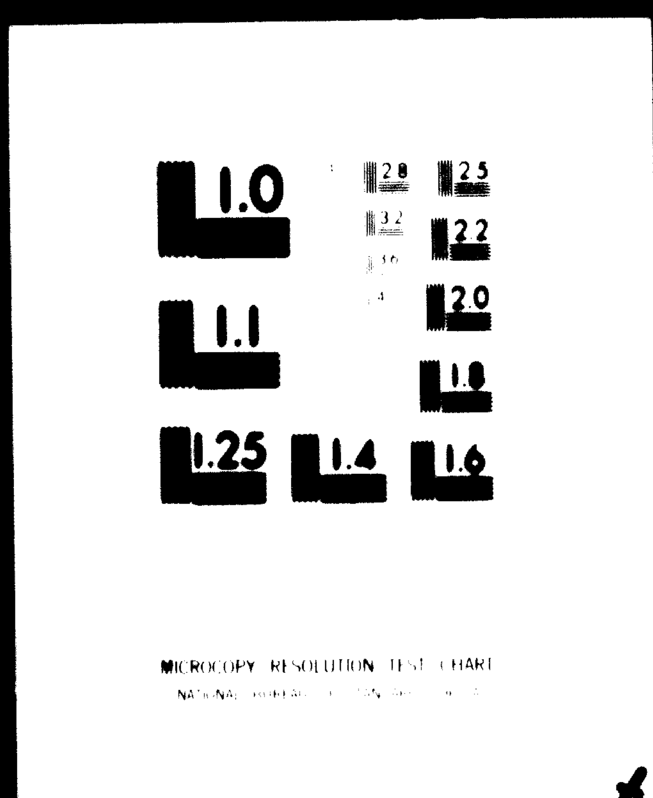
→

82.11.12


1.0
2.8
2.5
3.2
2.2
2.0
1.1
1.8
1.25
1.4
1.6
MICROCOPY RESOLUTION TEST CHART

24x

E

6.3 Tests to be carried out after the 10 second rated power tests

After the 10 second rated power tests, the following tests and measurements shall be carried out: autotransformer ratio at no load, for each tap on the supply side and load side, measurement of the resistance of the supply side for the 25 kV tap, oscillograph measurement of no-load exciting current for each supply side tap supplied at its rated voltage.

6.4 High-voltage tests

High-voltage tests shall be carried out after the 10 second rated power tests as indicated in paragraphs 3.2 and 3.3.

6.5 Conditions of acceptance

Acceptance of the autotransformer shall be based on the following conditions:-

a) Compliance with all test conditions according to this specification.

b) No sign of damage to the autotransformer during and after the 10 second rated power tests.

c) No inflammable gas found in the gas detector relay after each (10 second rated power) and each high-voltage.

d) Visual inspection of the interior of the autotransformer after all tests shall reveal no sign of damage to the bushings, connections and all other parts accessible without dismantling the autotransformer. A detailed inspection of the switching system shall be made in order to discover any sign of deformation, burning, cracking, wear or damage to the contacts, insulating parts, conducting parts, or the mechanism.

6.6 Changes after the tests

If the changes are judged by the Purchaser to be major ones, the autotransformer shall be considered as new and all the tests shall be repeated.

7. TECHNICAL DATA OF THE PROPOSED EQUIPMENT, WHICH DATA FORM PART OF OUR TENDER.

1) General description of the autotransformer and diagram of the tap changers.

   Description attached . . . .

2) Preliminary outline drawings showing principal dimensions of the autotransformer and details of the base and final positions of bushings on the cover.

   Description attached . . . .

3) Weight of the autotransformer, the largest shipping item, the longest item and the most difficult item to be transported.

   Description attached . . . .

4) Continuous power specified by the manufacturer at an ambient temperature of 35°C . . . .

5) Maximum temperature rise of the insulating liquid during no-load operation . . . . °C.

6) Copper loss at rated continuous power ....kW.

Copper loss at 10 second rated power ....kW.

7) Accidental current that the autotransformer can withstand a few times in its winding during its lifetime without being damaged ....kA.

8) Calculated curve showing the relationship between magnetizing current (I) and flux (Φ). The curve should reach twice the rated flux (which is obtained at the rated voltage of 25.0 kV/√3 i.e. 14.4 kV.

9) Iron loss ....kW.

10) Exciting current (supply side) at 100% rated voltage (25 kV)

....A.

at 105% rated voltage ....A.

at 95% rated voltage ....A.

11) Maximum inrush current ....A (crest).

12) Impedance from supply side for each supply and load tap of the autotransformer.

13) Ratio ωL/R of the autotransformer when in short-circuit.

$\frac{\omega L}{R}$ = ...

14) Description of the tap changers and diagrams of operation.

Description attached ....

15) Maintenance of switching equipment sealing of compartment, possibility of doing maintenance work without emptying the autotransformer.

Number of switching operations before maintenance.

Description attached ....

16) Indications concerning the possibility of operating the tap changer on no-load but alive.

Description attached ....

17) The quantity of oil required for each autotransformer ....imp. gals.

Type and characteristics of the oil ....

Manufacturer's oil name and/or number ....

18) Bushings' make, type, voltage rating, continuous current rating, short-time current (1 sec. 150 times with an interval of 3 minutes between each time) current for 10 seconds.

Description attached ....

19) Cooling system

type ....

Number of air circulating fan motor ....

Rating of each air circulating fan motor

HP ....

Phases ....

Volts ....

kW ....

kVA ....

Full load current ....A.

Starting current ....A.

20) Test facilities at the disposal of the Manufacturer to carry out the high voltage tests.

Description attached ....

21) Estimate of man/hours required to complete the assembly at site.

....man/hours.

22) List of accessories.

List attached ....

23) Manufacturer's experience and list of short-circuit autotransformers and transformers already built.

List attached ....

24) Natural frequency of the autotransformer for each supply side and load side tap ....

25) Tests facilities at the disposal of manufacturer to carry out the 10 second rated power tests and proposals for testing procedure.

Description attached ....

Test number	Number of tests of one (1) second with a period of 3 minutes between each	Supply voltage	Supply tap	Secondary tap
1	150	25.0	25.0 kV	12.5 kV
2	150	20.0	20.0 kV	10.0 kV
3	150	15.0	15.0 kV	7.5 kV

TABLE 1

HP 11

RESISTOR SETS

TABLE OF CONTENTS

1. Scope
2. General description
3. General caracteristics
4. Ratings
5. Design
6. Tests
7. Conditions of acceptance
8. Technical data.

1. This specification covers the technical requirements of the Electrical Test and Experimentation Center for the supply of three (3) resistor sets rated at 25 kV, each set including 75 resistor elements rated at 4 ohms, the total number of resistor elements being 225.

The supply includes engineering, manufacturing, testing and shipment of the resistor sets.

2. GENERAL DESCRIPTION

The resistors described herein will be used as ohmic load or as the ohmic part of the mixed load during switching tests of H.V. load switches. Normally the resistors will be connected to the terminals of the tested load switch via a regulation autotransformer, so that the adjustment of the effective resistance value, seen from the terminals of the switch, will be obtained by changing both resistor connections and transformation ratio of the autotransformer.

The resistance sets shall include the necessary basis, insulating supports against earth, terminals and interconnection bars as well as a rack supporting structure.

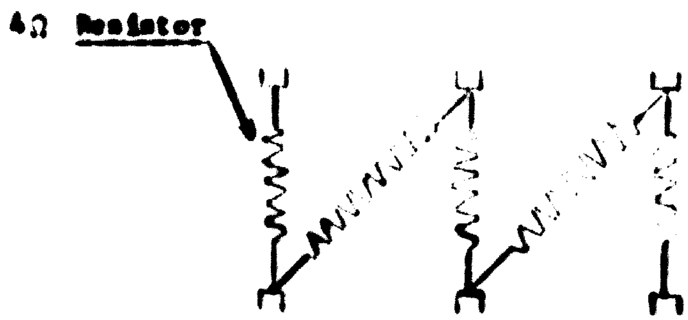
The autotransformer mentioned above does not make part of this specification.

3. GENERAL CHARA ERISTICS

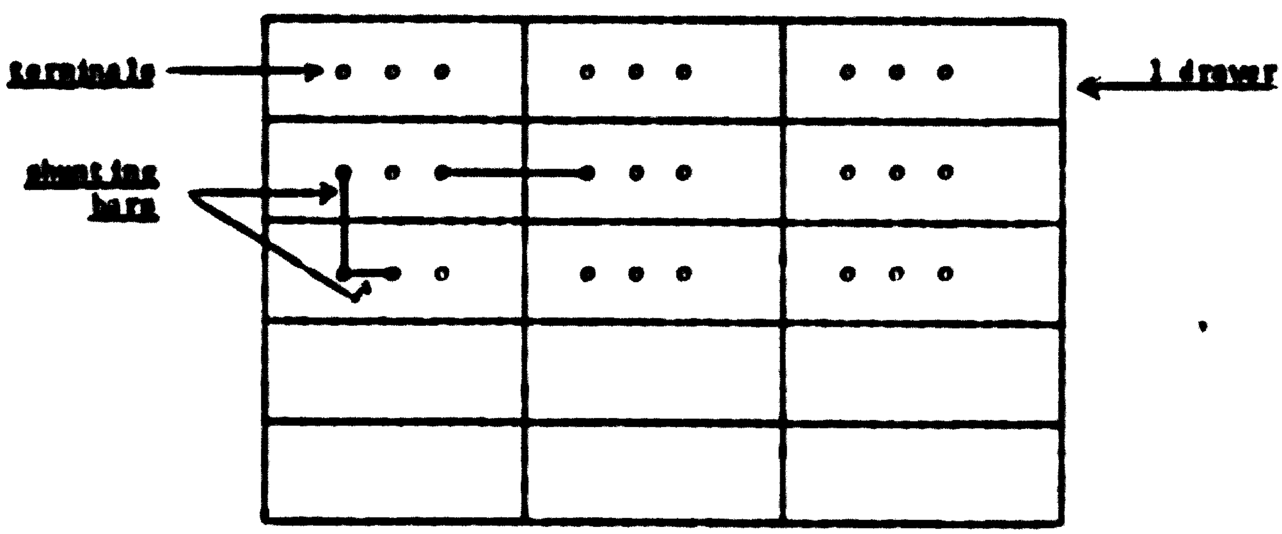
Three single-phase resistor sets shall be indoor type, 50 Hz, with very low inductance and capacitance, dry, naturally cooled by air.

The ambient temperature will be 0°C. to +40°C. During delivery, however, temperatures of -40°C. to +40°C. must be taken into account.

The tenderer shall present a tender for a three (3) group mountings, a group being a phase. A group is made of fifteen (15) drawers each having five (5) resistors of 4Ω with their terminals. These terminals shall permit to have in series or in parallel the resistors of one drawer or between drawers. A drawer with its terminals could be mounted like this:



The drawers could be mounted like this:



The shunting bars and the terminals are part of this contract.

The terminals could be, bolts with nuts and the shunting bars, copper bars with holes. The shunting bars shall be of the same length. The connections should be done manually and easily.

4. RATINGS

4.1 Individual resistor units shall have the rating shown hereafter:

Value of one resistor at 50 Hz & 35°C	rms applied voltage at terminals 50 Hz, 0.3 sec.	rms rated current 0.3 sec.	Power RI^2 0.3 sec.	Switching surge withstand voltage (crest) between contacts 250/2500 μ sec.
OHM	kV	Amp.	MW	kV
4±5%	1.28	320	0.41	12

4.2 The insulating support will have the following insulation level:

Impulse withstand voltage 170 kV

50 Hz withstand voltage 70 kV

4.3 Operating cycle

Resistors shall be able to withstand the rated current stipulated in the table, during a period of 0.3 second repeated one hundred (100) times with three (3) minute intervals between the the shots. The cooling-off period necessary after these one hundred (100) shots shall be indicated by the manufacturer but shall not exceed ten (10) hours. This cycle may be repeated continuously in an ambient temperature of 40°C. No damage must result from such an utilization and the value of each resistor shall not be changed by more than one percent (1%) during this utilisation.

It shall be possible to circulate at maximum 1 600 Amperes rms in the shunting bars and the terminals when five (5) drawers are connected in parallel.

5. DESIGN

A coating of a protective material shall cover the resistor elements in order to make them dust-proof.

The metallic parts shall be protected against corrosion e.g. by galvanizing.

Each resistor set shall have a name plate, on which measured values of resistances shall be shown.

6. TESTS

The manufacturer is responsible for carrying out all the tests. These tests shall be carried out on each resistor:

6.1 Measurement of the resistance

The resistance at 50 Hz and 35°C. must be measured; the resistors will be rejected for any resistance value over ± 5% of the specified value.

6.2 Insulation level of the resistor element

Switching surge withstand voltage (crest) between terminals 250/2500 μ sec. shall be made in accordance with the value given in paragraph 4.

6.3 Thermal withstand test

The following tests must be done on five (5) resistors, chosen at random. The cooling-off period specified by the manufacturer will be allowed between two tests series mentioned below:

a) Inject one hundred (100) times the current given in table of article 4. Each injection shall be of 0.3 second duration with three (3) minute interval.

b) Repeat the previous test immediately after the cooling-off period.

When these tests have been carried out, resistance of each resistor shall be measured; the obtained value shall not differ by more than ±1% of the value measured before the test.

7. CONDITIONS OF ACCEPTANCE

The resistors shall comply, individually and as a whole to the requirements of this specification.

The resistors shall not show evidence of damage during and after the tests according to clause 6.

8. TECHNICAL DATA

Technical data which applies to the tendered upon and which forms part of this tender is given as follows:

1. General description of the resistors

   Description attached ....

2. Preliminary outline Drawings indicating the main dimensions of the resistors with their terminals and support insulators

   Drawings attached ....

3. Information on the weight of the resistors

   Information attached ....

4. Temperature rise of the resistors at their rated power for 0.3 second, a hundred (100) times with a period of three (3) minutes between each time at an ambient temperature of 40°C.

   ....°C.

5. Test equipment available to the Manufacturer for carrying out the test

   Description attached ....

6. List of accessories

List attached ....

7. The Manufacturer's experience and a list of the resistors already built

List attached ....

8. Accidental current that each resistor can withstand several times during its lifetime without being destroyed

....kA

9. Continuous current that each resistor can withstand.............A

10. Rated current that each resistor is able to withstand for a period of 1 second this repeated a hundred (100) times with three (3) minutes intervals between each shot is ....A.

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REACTOR COILS

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1. SCOPE

2. GENERAL DESCRIPTION

3. STANDARDS

4. RATINGS

5. TESTS

6. QUESTIONNAIRE

1. **SCOPE**

This specification covers the requirements of the Electrical Test and Experimental Center for the supply of six reactor coils rated at 25 kV.

The supply includes engineering, manufacturing, testing and shipment of the reactors.

2. **GENERAL DESCRIPTION**

Two sets of three identical reactor coils will be used in the 500 MVA test section of the High Power Laboratory as a reactive load or as the reactive part of a combined load, during the switching tests of load-break switches.

The reactor coils will be connected to the load side of the tested switch via a regulating autotransformer so that the effective reactance value, seen from the terminals of the tested breaker will be adjusted by both connections of the reactor coils on the secondary and by using a suitable transformation ratio of the autotransformer.

The objects of the delivery are the six (6) reactor coils including their bases, insulation supports and terminals.

The autotransformer does not make a part of this specification.

3. **STANDARDS**

The reactor coils must comply with the IEC Publication No. 289, with the exceptions or additions specified hereafter.

4. RATINGS

4.1 The reactor coils will be used indoor.

The temperature limits will be 0°C, + 40°C.

During delivery, however, the limits -40°C, + 40°C must be taken into account.

4.2 The basic ratings are shown in the following Table I.

Coil No.	Quantity	Rated Voltage kV	Rated Impedance at 50 Hz Ω	Rated current during 1.0 sec A (RMS)	Asymmetrical current A (peak)
1	3	25	20 ±5%	722.5	2167
2	3	25	40 ±5%	361.2	1083

4.3 Insulation level

Impulse withstand voltage with respect to ground 170 kV

Withstand 50 Hz voltage with respect to ground 70 kV (RMS)

Switching surge withstand voltage 250/2500 μs between terminals of the coil 140 kV

4.4 Operating cycle

The reactor coils shall be able to withstand the current according to Table I, 100 times, with intervals of 3 minutes between 1 sec. shots.

This will be followed by a cooling period specified by the manufacturer, which, however, will not exceed 10 hours. This cycle may be repeated indefinitely.

4.5 Time constant

The time constant of the reactors shall not be less than 0.0795 sec, i.e. $\omega L/R \geq 25$, where ωL is the reactance at 50 Hz and R is the resistance at 50 Hz and $40^{\circ}C$.

5. TESTS

All tests shall be made under the responsibility and at the expense of the manufacturer.

5.1 Dielectric tests

These tests shall be made on each reactor coil, using the values specified in clause 4.3

5.2 The D.C. resistance, the 50 Hz resistance and 50 Hz reactance shall be measured and indicated individually on the name plate of each coil.

5.3 Rated current tests

One of each type of reactor coils selected at random by the purchaser, shall be submitted to one hundred shots of rated current, having at its beginning a peak equal to the asymmetrical current according to Table I. The duration of the shots will be 1 second and intervals between the shots 3 minutes.

At the end of this test series, the temperature rise must not exceed the value specified in IEC Publication 289.

The reactance shall be measured between each 25 tests using an adequate bridge circuit, ensuring an absolute error of less than 0.5% and garanteeing a minimum sensitivity of 0.06% between two successive measurements.

Successive measurements of reactance should exhibit a net tendency to stabilise, i.e. a variation in impedance will be acceptable if it decreases as the series of tests proceed.

5.4 Measurements to be taken after the rated current tests

After the tests, the dc resistance, the resistance and the reactance at 50 Hz, shall be measured. From these values, the ωL/R ratio shall be calculated, to check the compliance with clause 4.5

5.5 Conditions of the acceptance

The reactor coils must comply with the ratings and test conditions specified in this specification and IEC Publication 289.

After the tests no signs of damage must be visible.

6. TECHNICAL DATA QUESTIONAIRE TO BE COMPLETED BY THE TENDERER AS PART OF THE TENDER.

1) General description of the reactors

Description attached ....

2) Preliminary outline drawings indicating the main dimensions of the reactors.

Description attached ....

3) Continuous current at 40°C ambient temperature of the reactors ..... Amperes.

4) Loss in the copper of the reactor at rated current (1 sec.) ..... kW.

5) Accidental current that each reactor can withstand a few times during its lifetime without being destroyed .....kA.

6) Information on the weight of the reactors.

Description attached ....

CHARGING CIRCUIT

The present document describes the charging circuit for the high voltage source of the synthetic test circuit of the Electrical Industry and Experimentation Centre.

1. CHARGING CIRCUIT

The charging circuit is shown on Fig. 2 in the General Des-Description of the Synthetic Circuit (specs HP 20). The standard charging circuit with high impedance resistors, as used for impulse generators, cannot be used, due to the high capacitive energy installed which would cause extremely long charging times.

Instead, the circuit of Fig. 2, shall be used. It consists of low impedance resistors (100Ω) and a set of isolators.
In this case, the charging unit must be equipped with a current control in order not to exceed its rated capacity.

Some additional isolators and a second charging unit are necessary to respect the following criteria:

a) The high voltage source shall be disconnected from the local ground during the test phase.

b) The charging unit shall be disconnected, short-circuited and connected to ground during the test phase.

c) It shall be able to discharge all capacitors by means of the isolators and resistors.

d) It shall be possible to charge one or two stages with one voltage and the remaining four or three stages with a different voltage.

2. TEST SEQUENCE

While doing a synthetic test, three phases can be distinguished (concerning the high voltage source only):

a) **Charging phase:** The main capacitors are charged

b) **Test phase:** The high voltage source is ready for a test

c) **Discharging phase:** All capacitors are discharged.

The isolators between the stages as well as those separating the charging unit from the circuit have to be opened between phase a) and phase b). This operation has to be performed rapidly, so that the voltage of the capacitors does not decrease substantially.

3. MAIN CHARACTERISTICS OF THE ELEMENTS

3.1 Two Charging Units

Maximum voltage:	180 kV
Maximum current:	1 A

This current will only be drawn at voltages below 60 kV.

The charging units shall be equipped with an automatic current control and an automatic voltage cut-off at a pre-selected voltage. They shall also allow to charge the capacitors with either negative or positive polarity.

3.2 Isolators

The disconnecting switches type 11 of the specification H.P.-25 will be used (Impulse withstand voltage of the isolating distance: 600 kV peak) for all isolators shown in Fig.2 of H.P.-20. However, the isolators parallel to the control branch have to consist of two disconnecting switches in series connection, in order to withstand the transient recovery voltage.

3.3 Resistors

The charging resistors are of the type used for impulse generators.

Resistance:	100 Ω
Nominal voltage between terminals:	90 kV d.c.
Impulse withstand voltage between terminals:	300 kV peak, 1/50
Energy to dissipate:	1/2 Ecp

Ecp is the energy stored in the main capacitors of one stage.

The resistor on the positive side of C_p of the first stage shall consist of four single resistors in order to withstand 180 kV d.c. and Ecp.

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TRV CAPACITORS FOR TEST SECTION NO. 2

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1. This specification covers the requirements of the Electrical Industry Testing and Experimentation Centre for the supply of capacitors for regulating the transient recovery voltage in the High Power Laboratory, for the test section No:2.

These capacitors shall be designed for use also as the capacitive load during energizing and de-energizing tests on capacitor banks.

2. General description

The capacitors described in this specification will be used for regulating the transient recovery voltage produced across the terminals of circuit breakers under test when the short-circuit current is interrupted.

This voltage may be considered as the sum of two components: one periodic, at power frequency (50 Hz), the other transient. The latter may be either oscillatory, at one or several frequencies, or non-oscillatory (exponential, for instance) or may be a combination ofthese, according to the characteristics of the circuit and the breaker.

In three-phase circuits, the transient recovery volrage to be considered corresponds to the pole on which the arcs are first extinguished since this voltage is generally higher than that on the other two poles.

System frequency $f = 50$ Hz

f_o - transient frequency

When $U_n = 3.6$ kV rms f_o will be between 12 and 60 kHz

The first crest may reach a value equal to $1.5 \times 1.8 \times U_n \sqrt{2} / \sqrt{3} = 8$ kV

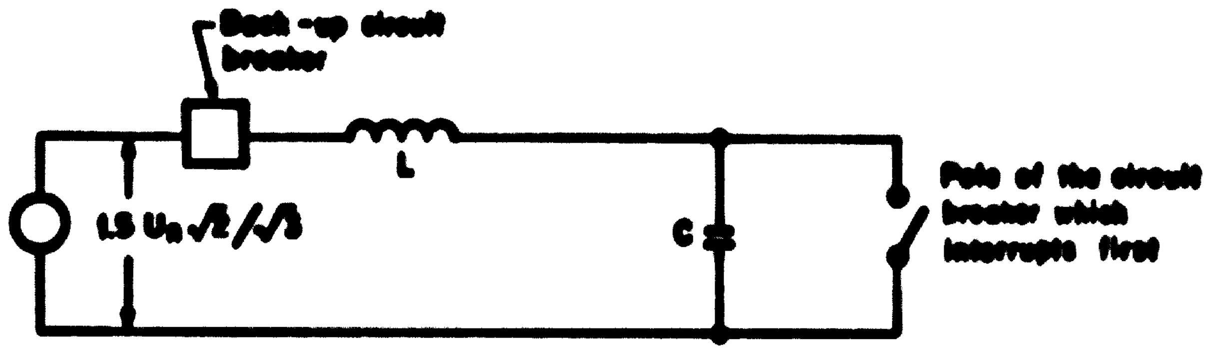
When $U_n = 24$ kV rms f_o will be between 6 and 28 kH2

The first crest can reach a value equal to $1.5 \times 1.8 \times U_n \sqrt{2} / \sqrt{3} = 53$kV

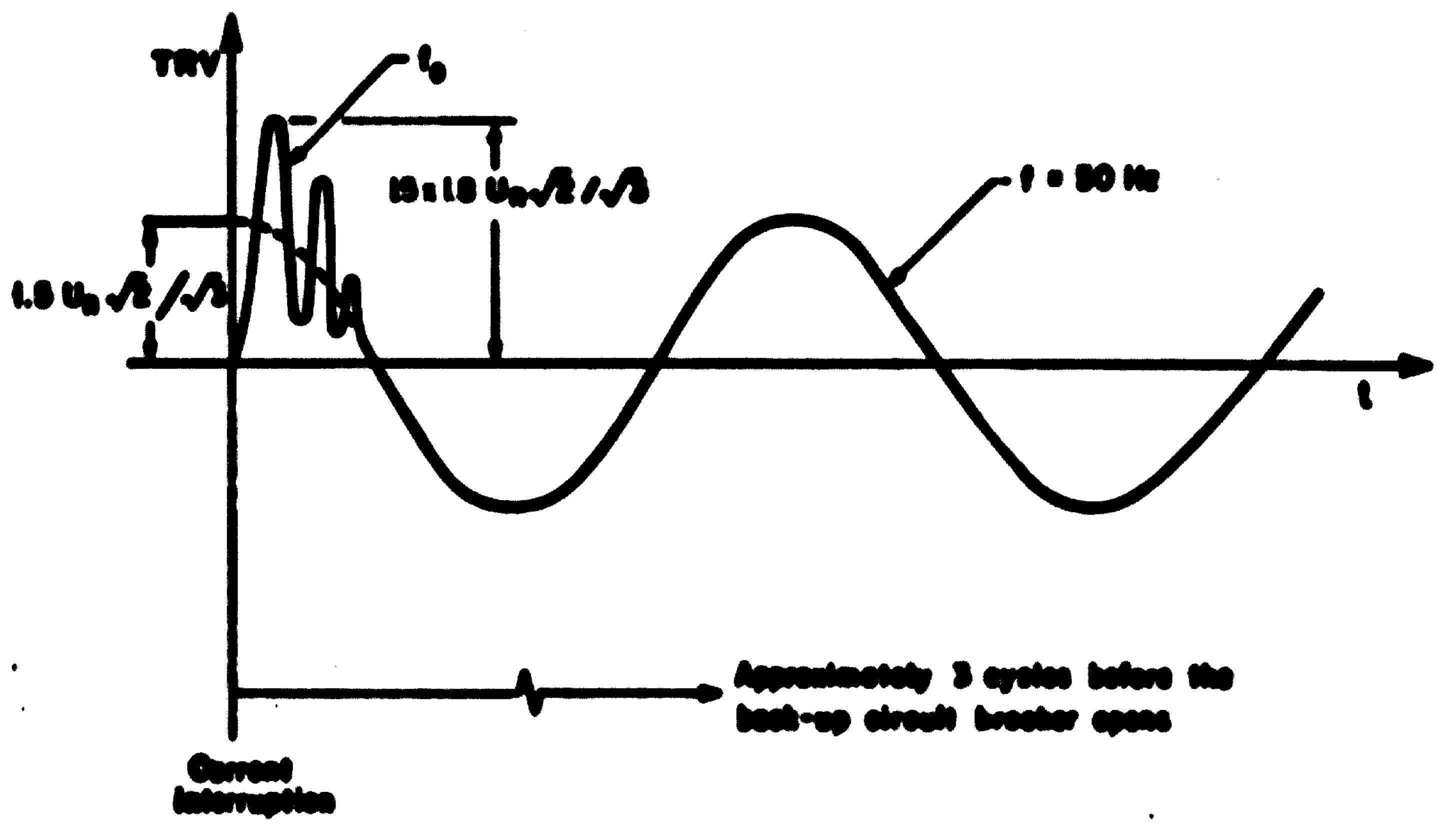
Reclosing cycle

In the case of rapid reclosing of the breaker, i.e. opening -0-closing-opening, where 0 is the opening dead-time of rapid-reclosing breakers (approximately 0.3 s), the capacitor remains energized at power frequency (50 Hz) for 0.3 seconds after which it is short-circuited for 0.15 to 0.30 seconds.

Simplified diagram of test circuit



When the break is successful, the transient recovery voltage TRV (t) takes the form below:



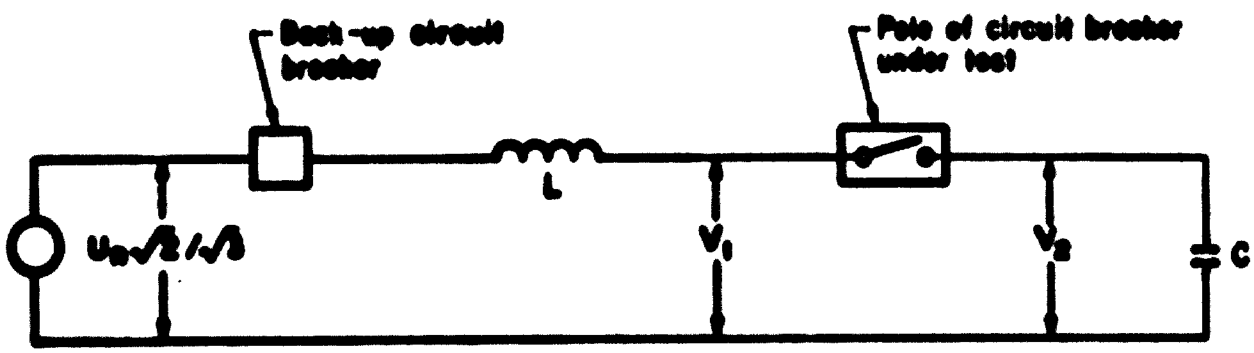
Failure to break

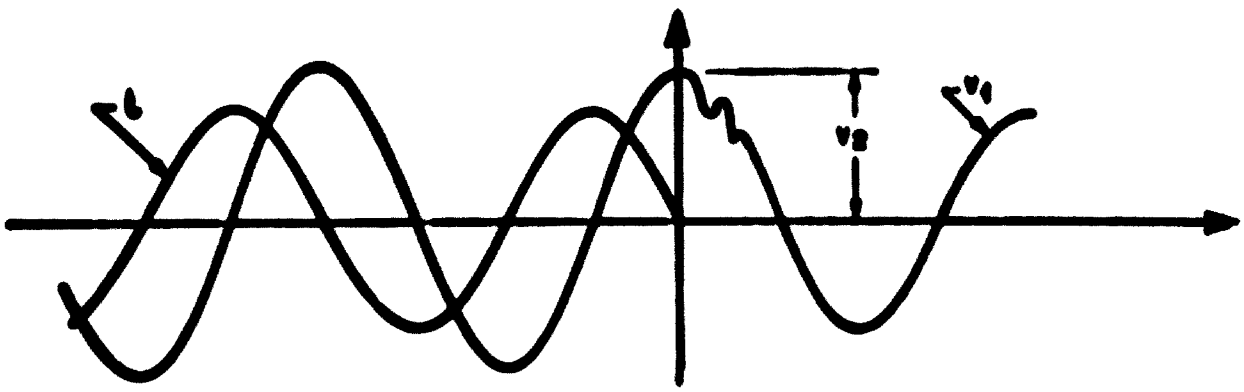
In the case of failure to break, i.e. if the breaker under test restrikes, at the moment the TRV reaches its first crest, the capacitor discharges into the breaker almost immediately. The discharge frequency can reach a value above 50 kHz.

Some fifty (50) short-circuit tests will be performed daily in the high-power laboratory.

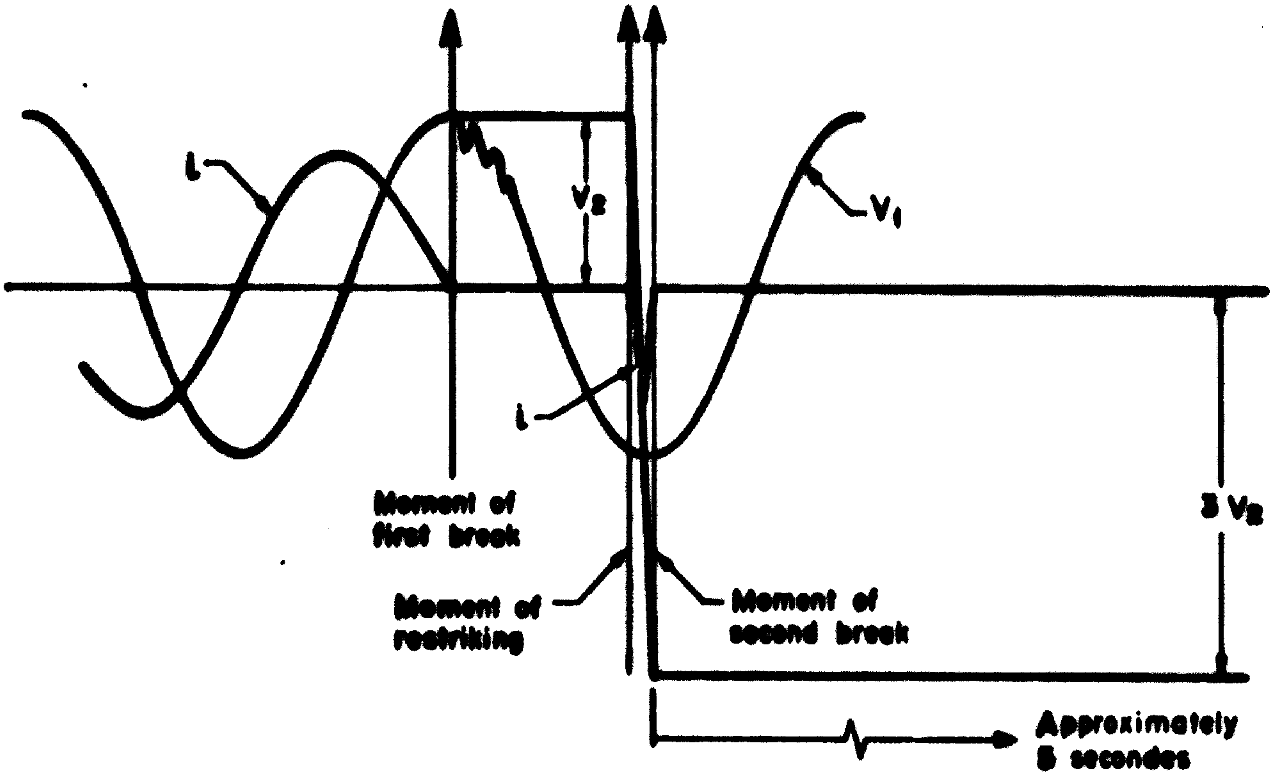
The capacitors will also be used as load for energizing and de-energizing tests on capacitor banks using circuit breakers and switches.

Below is the simplified diagram of a test circuit:





A restriking circuit breaker or switch, followed almost immediately by a second break in the capacitive current, would take the following form:



Approximately thirty (30) to fifty (50) energizing and de-energizing tests a day will be performed in the high-voltage test station during capacitor-bank switching tests.

Short-circuit and capacitive-current breaking tests will be single- and three-phase.

3. Standards

I.E.C. Publication 70 (1967) Power capacitors

The above standards are applicable, contingent on the modifications or additions specified herein.

4. General Characteristics

The capacitors shall be single-phase, 50 Hz, for indoor service.

4.1 Ambient temperature

The ambient temperature will vary between -0°C and +40°C. During delivery, however, the temperature between -40°C and +40°C must be taken into account.

4.2 Technical characteristics

Capacitor unit: 0.025 µF (+ 10%) (- 5%)

Short-time voltage ($\leq$ 0.30 s): 5 kV rms

Short-time reactive power: 196 VAR

Impulse withstand voltage with respect to container: 45 kV, crest

Withstand voltage at power frequency with respect to container: 21 kV rms

Withstand voltage between terminals: $\pm$ 22 kV d.c.

Rated voltage on bushings: 7.2 kV rms

Rated frequency: 50 Hz

Natural frequency: $\geq$ 60 kHz

Container: steel, painted for indoor use.

Quantity required: 54 + 5 spare units = 59.

4.3 Installation of the capacitors

The total number of 54 capacitors will be divided in three identical groups, each having 18 capacitor units. Each group will be installed on an insulating support having a BIL of 125 kV.

Within the group of 18 units a system of manual connection will be provided permitting to put all 18 units either in parallel or in series or in any intermediate connection between the two extreme cases.

The maximum rated voltage of a group will be 25 kV and the insulation between the terminals of the units and collector bars will correspond to that voltage only.

It will be possible to create a three-phase capacitor bank either in star or in delta or a single phase group using all three groups. In the latter case the mid-point will be eventually earthed and the bank will be connected between two terminals of the test circuit.

4.4 Discharge resistors

Resistors are required for discharging the capacitors after testing. The type and values of these resistors shall be defined according to the number of capacitors in each group.

4.5 Continuous reactive power

The tenderer shall, in his tender, give the value of the permissible continuous reactive power for capacitor. The continuous reactive power of a capacitor is defined as the product of the rated voltage multiplied by the permanent current that a capacitor can withstand indefinitely with a temperature rise not exceeding 35°C.

4.6 Discharge time

When removed from the charging unit, each capacitor must be able to lose not more than 10% of initial charging voltage in 5 minutes.

4.7 Tangent of the loss angle

The tangent of the loss angle shall be equal to or less than $\frac{2 \text{ Watt}}{\text{kVAR}}$

5. Construction

The dielectric of the capacitors shall be chosen by the supplier to comply with the stipulated conditions.

The capacitors shall be equipped with external discharge resistors. Internally mounted resistors will not be accepted.

The capacitors shall have two bushings on the upper part of the container. Each capacitor shall operate in the two positions: with vertical bushings and with horizontal bushings.

6. Tests

6.1 Individual tests

The following tests shall be performed on each capacitor:

- measurement of the capacitance at rated voltage and frequency. Capacitors with values deviating by more than +10% or by less than -5% of the capacitance values stipulated shall be rejected.

- measurement of the angle of loss tangent at rated voltage and frequency.

- impulse withstand voltage (crest) with respect to the container.

- withstand voltage at power frequency (50 Hz) for one (1) minute between terminals.

6.2 Withstand voltage test

The following test shall be performed on each group of three (3) series-connected capacitors:

withstand voltage at power frequency (50 Hz) for 1 minute between the terminals of the first and third container.

6.3 Thermal stability test and test for leaks

The following tests shall be performed on one container of each type of capacitor:

Thermal stability: the temperature rise of the container of the capacitor supplying the continuous reactive output shall not exceed 35°C for an ambient temperature of 40°C.

Test for leaks.

6.4 Discharge test

The capacitor shall be short-circuited under a voltage of 20 kV d.c. This test shall be repeated five hundred (500) times. Before and after each series of 50 consecutive tests, the capacitance, tangent of the loss angle and ionisation shall be measured.

These successive measurements shall show a definite tendency to stabilise. Any variation in capacitance and/or tangent of the loss angle and/or ionisation will be acceptable on condition that it diminishes as the five hundred tests are carried out.

If the variation is constant or shows a tendency to increase, the capacitor will be rejected unless the Manufacturer prefers to continue the tests until the capacitance, tangent of the loss angle and ionization measurements are stabilized.

Rejection of any type of capacitor implies that before the others of the same type are accepted, the discharge tests have to be repeated on three (3) other capacitors of this same type.

6.5 Further condition of acceptance

Capacitors shall show no sign of damage either during or after the tests.

6.6 Responsibility for testing

The Manufacturer shall be responsible for carrying out all the tests.

6.7 Modifications following tests

Any modification that is made to a tested capacitor shall be made to the others of the same type. If, in the eyes of the Purchaser, these changes are major ones, the capacitors will be considered as new and all tests shall be repeated.

7. Additional prices

1. Special tools

Additional cost for special tools required for maintenance:
$...
A detailed list of these tools and their unit price is included.

2. Superintendents

If UNIDO requires one of our superintendents to be on the Laboratory site during assembly and acceptance tests, the rate per diem will be:

$...

Travelling expenses for the journey to and from the site from our plant:

$...

Pertinent technical data forming part of our tender

1) General description of the capacitors:
Description enclosed...

2) Preliminary drawings of overall dimensions showing the electrical connections between capacitors (containers) and the racks supporting the capacitor assemblies.
Description enclosed...

3) Indications of the capacitors' weight.
Description enclosed...

4) Description of the dielectric of each capacitor.
Description enclosed...

5) Maximum temperature rise of the dielectric of capacitors when producing continuous reactive power
....°C.

6) Loss in each type of capacitor:
....Watts.

7) Maximum current on closing at rated voltage (without residual voltage).
....A (crest).

8) Switching overvoltage between terminals during the capacitive-current interrupting tests, taking into account the possibilities of restriking by the breaking equipment under test.
....kV (crest).

9) Natural frequency of the capacitors.
....kHz.

10) Testing equipment at the Manufacturer's disposal.
Description enclosed...

11) List of accessories.
List enclosed..

12) Manufacturer's experience and list of capacitors he has already built.
List enclosed..

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MECANO-CLIMATIC CHAMBER

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1. SCOPE

This specification covers the main characteristics and requirements for the purchase and complete installation of a mecano-climatic chamber for the HIGH POWER LABORATORY.

The units of this mecano-climatic chamber are the following:

- One (1) chamber with an antechamber.
- One (1) adjacent control room.
- All required production materials for meeting the necessary performances.

The agreement includes the supply and installation of:

- One (1) chamber with an antechamber.
- One (1) adjacent control room.
- All required testing equipment for meeting the necessary performances.
- A water demineraliser for the electric steam boiler.
- All equipment bases to be installed on the roof of Room F-124.
- The power supply for all the equipment and lighting from the main panel supplied by the Buyer.
- All the fluid cupply and exhaust pipes together with the required control valves and relays.
- Light in the chamber (antechamber included) and in Control room.
- Operation, control and signalling desks or cabinets in Control room.
- Recording devices and programmers for Control room.

- The temperature and humidity sensors for regulation and recording.
- All switches and relays required for the heating elements of doors, window, drain-pipes, etc..
- All equipments required for signalling.
- All the hardware.
- Means of storage and production of refrigeration water at a controlled temperature between 2°C and 20°C at ±1°C.
- All the material included in this specification or found useful by the Supplier for a complete installation meeting all the standards.

The supplier shall, in the location provided for this purpose, supply the client with a complete operative unit which meets the requirements of this specification. The extent of this supply is given in article 10.

2. STANDARDS

This installation shall be done in accordance with local standards of refrigeration, plumbing, welding, electrical apparatus and the ASME's standard for pressure vessels.

The above Standards are applicable subject to modifications or additions as herein specified.

3. LOCATION OF THE MECANO-CLIMATIC CHAMBER

The chamber, antechamber, control room together with all production equipment shall be installed in the following rooms of the High Power Laboratory (see drawing No. 1)

F-124: Machine room

F-125: Control room

F-126: Test chamber

F-127: Antechamber

The average temperature of these rooms is to be 16°C and relative humidity to vary from 30 to 80%.

4. DESIGN OF THE MECANO-CLIMATIC CHAMBER

The mecano-climatic chamber shall be designed as follows:

4.1 Dimensions and location

The clear inside dimensions required for Test Chamber, its antechamber and Control Room are shown on the following Table:

ROOM	DIMENSIONS (m)		
	LENGTH	WIDTH	HEIGHT
Test Chamber	6.6	4.75	8.0
Antechamber	1.5	1.5	2.75
Control Room	3.5	2.4	2.75

The remaining space of room F-124 shall be used for the machine room.

The arrangement of the rooms is shown on drawing No.2.

4.2 Construction of the Test Chamber (F-126)

The Test Chamber is built with prefabricated elements assembled in the field. The basic element is a sandwich panel. These panels shall not be painted.

4.2.1 Walls and ceiling

Walls and ceiling are built as follows from outside to inside:

- One (1) galvanized steel sheet, 1mm thick.
- One (1) polyurethane coating, 200 mm thick.
- One (1) stainless steel sheet, of quality V2A (similar to 18/10).

The assembly of these elements shall be made vapor-tight, water-tight as well as ice-resistant.

The rigidity of the assembly shall be maintained by fixing the elements to the four vertical corner supports and to the floor.

4.2.2 Floor

The chamber floor shall be made as follows from bottom to top:

- One (1) plywood sheet.
- One (1) polyurethane coating of approximately 200 mm thick.
- An electric heating system (see note)
- One (1) stainless steel sheet of quality V2A thickness such that the floor can withstand a 3 t. load distributed on $6m^2$ with a maximum sag of 3mm.

NOTE: This electric heating system shall be as follows:

- Cover the polyurethane coating with an asbestos sheet.
- Install the electric heating coil with each loop separated by an asbestos spacer.

The floor shall have a slope of 0.5% maximum for drainage towards a heated floor drain, see figure No.2, located on the edge of the floor at the side of the room opposite the door. This drain shall be connected to the main drain of the room.

The floor surface shall be smooth and uniform.

The electric heating system incorporated in the floor shall permit the:

1. Elimination of ice formation on the floor during ice formation tests on materials.

2. Rapid evacuation of accumulated ice during other types of tests. (see article No. 5.7).

4.2.3 Access doors to material

The front wall of the chamber shall be fitted with a door providing access to the electrical apparatus.
It shall be a single door, sliding type and rail-mounted.

If possible, opening or closing of this door shall be done manually.

If the construction of this type of door is not possible, two other types of opening shall be considered in the following order:-

Alternative No.1

A door made of one section with hinges.

Alternative No.2

A door made of two sections with hinges.

The operation of the locking device of this door shall be done from a single point.

These doors shall be perfectly rigid whatever the climatic conditions of the chamber.

They shall have such mechanical characteristics that all the joints on their periphery shall be hermetically sealed in accordance with the requirements.

The door thresholds shall not exceed the floor level.

A heating frame on the periphery shall provide a permanent de-icing of the joints.

When the doors are open, the opening clearance shall be 3.5m wide by 8.0m high.

These doors shall have an insulating material of the same thickness as the one of the walls and an interior finish with a stainless steel sheet of the same gauge and having a finish similar to that of the wall. The exterior finish shall be a galvanized steel sheet. The Supplier shall furnish all the hardware.

4.2.4 Observation window

A window located on the wall common to Test Chamber and Control Room shall permit the Engineer to supervise and control the tests.

This window shall consist of a minimum of six spaced glasses. The assembly shall be sealed and the space between the panes shall be filled with dry gas.

These glasses shall be heated by electrical resistors for eliminating blur and frost.

A window wiper, located inside the room and controlled from the Control Room, shall be included as an additional device against blur.

The window dimensions are 0,50m high and 1,00m wide. The location of this window shall be specified later by the Buyer.

4.2.5 Air circulation duct

4.2.5.1 Design

The air circulation duct made of one or several units shall contain all the heat exchangers.

This duct shall be made of stainless steel sheet of quality V2A and of appropriate gauge.

The design shall include removable panels for the maintenance or repair of the heat exchangers.

4.2.5.2 Waste water pan

A waste water pan shall be installed under the air circulation duct.

This pan, made of stainless steel, shall be designed in such a way that any waste water from the coils shall be rapidly drained away from the chamber.

One or several drains, of adequate size, shall be installed. Those drains shall be connected to the main drain of the room.

Pan and drains shall be equipped with electric heating elements.

Each power supply of those heating elements shall include a switch and fuses.

The control of each of those heating elements shall be done from the control room. The Supplier shall supply all the accessories required for this control.

4.2.6 Cableholes

Six (6) cable holes shall connect the Control room to the test chamber. They will be used for passing cables, control wires, pipes, etc. for the power supply and control of the material under test and the instruments for measuring the climatic conditions in the chamber.

The interior lining shall be made of stainless steel sheet.

The size of those portholes shall be:

- 3 of ∅ 50mm
- 2 of ∅ 100mm
- 3 of ∅ 200mm.

Their location will be specified later by the Buyer.

These holes, when not in use, shall be fitted with vapor-tight plugs easy to install and provided with a simple locking system. Their usage shall not be obstructed by icing phenomena.

4.2.7 Pressure equilibrium

To avoid a lowering of the pressure inside the test chamber during a cooling period or to avoid an overpressure during the operation of an air-blast apparatus under test, a device such as an adjustable check valve or the equivalent shall be provided in order to allow just enough air (in or out) to balance internal and external pressures.

4.2.8 Lighting fixtures

At 20°C and overall the floor surface, lighting shall be at least equal to 350 lux.

The lighting equipment shall be fed from a low voltage source, 24V.

The lighting equipment shall be adapted to the requirements imposed by the various test conditions in the chamber.

4.2.9 General

The tests in the climatic chamber could produce water vapor, water, ice, ozone, (produced during dielectric tests) as well as SO_2 in concentration equal to that in the ambient air.

4.3 Antechamber

The antechamber shall be made of prefabricated elements assembled in the field. The basic element is an unpainted sandwich panel.

4.3.1 Walls and ceiling

The construction of the walls and ceiling of the antechamber shall be identical to that described in article 4.2.1 except that the polyurethane coating shall be only 120 mm thick.

4.3.2 Floor

The antechamber floor shall be built as follows from bottom to top:

- One (1) plywood sheet.
- One (1) about 120mm thick polyurethane coating.
- An electrical heating system (see note article 4.2.2.)
- One (1) stainless steel sheet, quality V2A.

The floor shall be provided with a slope for drainage towards an heated drain.

The electrical heating system incorporated in the floor shall prevent ice formation.

4.3.3 Access doors

Two access doors are to be provided and they shall have the following dimensions H:2,10m, W: 0,80m.

These doors shall be made of sandwich panels similar to those used for the hall walls.

These doors shall be perfectly rigid in test chamber operating conditions.

Their mechanical characteristics shall be such that their joints are hermetically sealed.

A heating frame on their periphery shall provide a permanent de-icing of the joints.

The Supplier shall furnish all the hardware.

4.3.4 Lighting

Similar to the article 4.2.8

4.3.5 Cooling and heating

The cooling and heating of the antechamber shall be obtained through recirculation of air from the test chamber.

The Supplier shall provide to this purpose an adequate means of exchange between the two chambers.

4.4 Security of the personnel

In addition to the stipulation of article 2, the installation shall conform to the following conditions:

- opening of the eccess doors either for material or for personnel shall be possible from the exterior only when the vapor locking device is in the closed position.
Only the opening of the personnel entrance door shell be possible from the interior end only when it has been closed from the exterior.

- in the test chamber, a stop emergency button shall operate the general tripping of the installation and an ennuncietor bell simultaneously. The bell shall have a manual reset.

4.5 Control room

Dimensions of this room are given in the table of the article 4.0.

This room is adjacent to the test room and houses the control desk or cabinet. From this room, the test engineer can supervise end control the tests.

Its construction shall be made as follows.

4.5.1 Walls

The room walls shall be movable metel partitions of about 50mm thick. The color of the internal and external faces shall be white.

4.5.2 Door

The entrance door of metal construction similar to walls shall have the following dimensions: H; 2,20m, W: 0,80m.

A 0,50m x 1,00m High ordinary glass simple window shall be provided in the door at 150mm from its top.

The Supplier shall furnish all the hardware.

4.5.3 Ceiling

The ceiling shall be finished with perforated acoustic asbestos tiles of white color.

4.5.4 Floor

The floor covering shall be of thermoplastic tiles of uniform white and of uniform black colors, arranged in chess-board pattern.

Installation shall be made with an adequate adhesive on a clean and dry surface.

4.5.5 Lighting

Lighting shall be incandescent and equal to 400 lux everywhere on the floor surface.

The lighting system shall be flush mounted in the ceiling. The control switch shall be located near the entrance door.

4.6 Machine room

4.6.1 Installation

To facilitate maintenance, the testing equipment and accessories shall be easily accessible.

All equipment shall be fixed solidly to the floor. In addition, the load distribution on the floor shall be within the permissible limits: 1500 kg/m^2.

The installation of high or superposed equipment shall be made by means of a solid steel structure placed on the floor and firmly fixed.

For rotating machines as motors, compressors, etc., a resistant rubber cushion of adequate damping quality shall be installed between the apparatus and its base and/or the floor.

4.6.2 Ventilation

The supplier shall provide a ventilation system of adequate size for the total heat load installed.

This ventilation equipment shall be installed on the roof of room F-124.

The boring of holes through the roof, the construction of the bases, the supply and installation of all the asphaltic and metal flashings, the roof covering the electrical installation and all the materials required for completing this installation are included in this contract.

The air vent shall be designed so as to prevent any rain infiltration.

This ventilation system shall be controlled from the machine room and the control room.

5. PERFORMANCE OF TEST CHAMBER

5.1 Test types

The types of tests to be performed in this chamber will be the following ones.

- Fast temperature variations on HV and IV material.
- Accelerating ageing.
- Low temperature.
- High temperature (dry)
- Cool and ice tests.
- Condensation.

The performance requirements of material under test are to be as follows:

5.2 Nature of the object under test

The electrical material to be tested shall be limited to:

- Maximum dimensions: height: 6m
  width: 2m
  length: 6m
- Maximum weight including the mounting platform:
  a) Material (steel, porcelain, etc..) 3500 kg
  b) Metal platform 1200 kg

- Maximum sprinkled surface of equipment, plan view, shall be:
  a) 3 times: 0.5m x 2m
  b) 1 time: 0.5m x 6m

- Maximum power of motors (see note 1); 3kW.

Note 1: It is to be noted that the electrical motors are to operate only when the room is under steady state.

5.3 Temperatures

Any temperature between -25°C and +65°C may be required in the center of the room in the presence of the maximum weight of equipment and platform.

Three types of operation are provided:

a) from + 25°C to + 65°C: Taking between 20min. and 120 min. in rise or drop.
b) from + 25°C to -25°C: Taking 3 hours, drop.

Temperature rise for operation type b) shall be obtained through the electric heating elements used in type a) operation.

5.4 Humidity

Humidity shall be obtained by direct steam injection from a low pressure electric steam boiler.

Humidity variation covers the range between the relative humidity present at the initial ambient dry temperature and saturation at 65°C on the dry thermometer.

At dry bulb temperature above 0°C, temperature and humidity are entirely independant within their respective ranges of variation.

The maximum rate of humidity variation shall be based according to article 5.5.2.

5.5 Additional performances

In addition to the characteristics specified in the preceding article, the testing equipment shall be capable of performing the following cycles.

5.5.1 Icing cycle

The icing cycle is carried out as shown on drawing No.3

The maximum quantity of water sprayed at 2°C on the apparatus under test shall be 600 liters/hr. Of this quantity 60 liters turn into ice on the equipment and 540 liters drip on the floor of the chamber.

. . The floor heating element shall start to operate fifteen minutes before the final temperature drop.

5.5.2 Accelerated ageing cycle

This cycle is shown on drawing No.4. The basic cycle may be repeated for periods up to five (5) days.

Humidity is obtained by vapour spraying from an electrical low pressure steam generator. Hot temperature is obtained by the electric heating elements.

Temperature shall be lowered and raised within the specified times stated in article 5.3.

5.5.3 Low temperature test

The tested equipment may be submitted to low temperatures for periods from one (1) to eight (8) hours.

The temperature drop durations shall conform to those given in article 5.3.

5.6 Temperature and humidity tolerances

In steady state operation:

a) The set temperature inside the chamber shall be maintained at $\pm 1.5^{o}C$.

b) The relative humidity obtained by steam injection shall be adjustable at $\pm 7\%$ in the range defined previously.

These tolerances give the maximum deviations between the set value and those actually measured.

They take into account the accuracy and reliability of the equipment as well as the temperature variations inside the test area. They are required in a space defined by surfaces parallel to the walls and 0,75m away from these.

5.7 General

The lighting in the chamber and antechamber shall be connected throughout the testing period.

During tests below the freezing point of water, the following heating elements shall be brought into operation when the temperature reaches 3°C:

- Observation window
- Access to material door periphery
- Access to personnel doors periphery
- Antechamber floor
- Other elements which the Supplier deems necessary.

Except in case of icing tests, the heating elements in the floor of the test chamber are only brought into operation when the temperature rises and only when this temperature reaches or exceeds -25°C.

8. ENVIRONMENTAL EQUIPMENT

8.1 Heating system

Rises in temperature shall be obtained by electric heating elements mounted in the air circulation duct.

The power of those elements shall be based on the ageing cycle as described in article 5.5.2.

The electric heating elements shall be hermetically sealed with terminals brought to the exterior of the chamber structure to guard them against the humidity and breathing effects of cycling.

This heating system shall include appropriate control and regulation instruments so as to answer adequately to the required performances.

A high temperature security control shall de-energize the power supply of the heating elements if the temperature reaches a critical value.

The control of this heating system will be done from the control room. The signalling required on the panel is described in article No.8.6.

Fuses and switch shall be installed in the power supply circuit. The supply voltages available are given in article 9.2.

6.2 Steam boiler

6.2.1 Use

Humidity in the test chamber will be carried out by dry steam injection from a low pressure electric steam boiler.

The rating of this boiler shall be based on the variation rate and on the percentage of humidity required in carrying out the ageing cycle (article 5.5.2).

Its design and installation shall conform the local and/or A.S.M.E. standards.

6.2.2 Controls and accessories

This boiler shall be equipped with the following elements:

- monitoring controller of the water level.
- safety valve sized and installed in accordance with ASME standards.
- two pressure controls: first one as a working control and the second as a high limit.
- steam pressure gage.
- low water safety cut-off
- safety control thermostat which de-energises the power supply in case of high temperature of the elements.

The signalling required on the panel in the control room is described in article 8.6.

A special drain device described in article 7.2 shall be installed upstream of the electrovalve on the chamber steam pipe inlet.

It shall be impossible to operate this device when the inlet electrovalve is opened.

6.2.3 Makeup water

The water supplied to the steam generator (boiler) shall be filtered and demineralised.

Type and capacity of the water filter and demineraliser shall be chosen in accordance with the quality of the tap water. For this purpose, the Supplier shall make the required tests.

Should the need arise for a pump to supply water to the steam generator, it shall be supplied and installed with all the appropriate controls.

6.2.4 Miscellaneous

The Supplier shall also foresee an adequate means of draining the condensed water in the pipe between the boiler and the steam inlet electrovalve.

6.2.5 Power supply

The Supplier shall supply and install all the electrical circuit for the supply of the boiler and its accessories.

This installation include the connections to the main supply box which is furnished by the Buyer.

This boiler shall have its own switch and fuses.

6.3 Refrigeration system

This system may be composed of one or several units and shall be in accordance with the local standards.

6.3.1 Compressors

All compressors will be air-cooled.

Each compressor shall be driven by an electric motor with direct coupling or belts. In this last case, a belt-guard shall be installed.

Motors with starter shall be at one of the available voltages and shall have their own fused protection and disconnect switch.

Each compressor shall be equipped with low and high pressure controls of refrigerant and with a low-oil pressure control. A gauge and a manual maintenance valve shall be installed on the suction and discharge line of each compressor.

A running time meter shall be installed on each compressor unit.

6.3.2 Expansion tank

If an expansion tank is required, it shall be made according to ASME or local standards.

6.3.3 Evaporators

6.3.3.1 Number of circuits

The number of circuits of evaporators shall be choosen in such a way that the performances and the test cycles fore-seen in the chamber will be carried out adequately.

The evaporator cooling coils shall be made of dehydrated copper refrigeration tubing with aluminium fins.

Wide fin spacing shall be used due to frosting conditions expected during the icing test cycle on an electrical appa-ratus.

6.3.3.2 Defrosting

Evaporators subject to frosting shall be equipped with an electric defrosting-system.

a) One circuit of evaporators

The power supply of the electric de-frosting system shall be fused protected and shall have a disconnect switch.

This defrosting system shall be started manually and stopped automatically by a thermostat control on the evaporator tubing.

Also, throughout the defrosting operation, it shall be impossible to operate the ventilators and the compressors.

b) Two circuits of evaporators

If two evaporator circuits are required, automatic control shall be provided for the setting in operation of one circuit and the defrosting time of the other circuit.

It shall not have any air circulation on an evaporator during its defrosting.

The closing of the air inlet baffles or the stopping of the corresponding ventilator shall be coupled to the defrosting control circuit.

6.3.3.3 Starting control after defrosting

Independently from the number of evaporator circuits choosen, a thermostat control shall prevent the ventilator from restarting or the louvres from re-opening until the evaporator temperature has reached a certain value.

This temperature value shall permit the frosting of the remaining water on the evaporator coils.

6.3.4 Liquid to suction heat exchanger

The liquid to suction heat exchanger should be carefully chosen in order not to cause compressor overheating due to high suction superheat.

Pressure drop should be kept as low as possible in the suction line interchanger.

6.3.5 Condenser

The condenser shall be air-cooled and shall be installed on the roof. Nevertheless, any other type of cooling could be considered.

A concrete base as described in article No.9.3.3 shall be constructed by the Supplier on the roof of room F-124.

The construction of this base, the drilling of the roof slab to allow the refrigerant inlet and outlet piping and the electrical tubing to pass through are also included.

Condenser, ventilators and motors shall be firmly fixed to a galvanised steel frame covered with a galvanized steel sheet.

This steel frame shall be bolted to the concrete base.

All the electrical supply together with the controls shall be contained in a steel watertight box with a removable front panel.

If an heating system is required inside that box, it shall be supplied. This heating system will be electric with thermostat control. The power supply shall be properly protected by fuses.

The starter, the overload protection and the disconnect switch of the ventilator motor shall be supplied and installed in the watertight box.

Modulating of ventilators and/or flow of refrigerant entering the condenser shall take into account the outside span temperature (-5°C to + 35°C) and the liquid refrigerant pressure at the outlet of the condenser.

All the accessories required for an adequate operation of the condenser shall be supplied.

The air inlet of the ventilator shall be protected with a removable grating.

6.3.6 Receiver

This receiver shall be constructed in accordance with the ASME or local standards. Its size shall be large enough to hold all the refrigerant.

This receiver shall be equipped with fusible plug and service valves on the inlet and outlet of the liquid refrigerant line.

6.3.7 Air movement

6.3.7.1 Fans

Fans used for air circulation within the chamber shall have steel galvanized vanes.

6.3.7.2 Motors

To eliminate corrosion and minimize heat transmission, stainless steel shafts shall be used on the motors.

Motors may be mounted inside or outside the chamber with preference to the last installation.

A) Internally mounted

Motors mounted inside the chamber shall be of the totally enclosed type. Their construction shall be adapted to the full range of environmental conditions within the chamber.

B) Externally mounted

In externally mounted motors, vapor seal joints shall be installed in order to eliminate or minimize heat transmission from or toward the ambient air.

Internal bearings must withstand the full range of environmental conditions with a reasonable life expectancy.

C) Starting and protection

Whatever may be the mounting, motors shall be equipped with starter, disconnect switch and fuses protection. In addition, the control system shall be installed outside the chamber.

6.3.8 Piping

All piping shall be of copper with the minimum flared or flanged fittings as all piping shall be of the highest quality.

All joints shall be silver brazed with an inert gas such as dry nitrogen flushed inside to avoid internal oxydation.

All piping shall be adequately supported to ensure a rigid installation.

All lines and components shall be separated and secured with nylon clamps or brackets with nylon inserts.

Vibration eliminators shall be incorporated in the system on all lines to and from the compressors.

Where the installation is subjected to low temperature, flared nuts shall have holes to prevent any internal freezing.

For proper oil return, suction lines should be run either horizontally or pitched down toward the compressor. If equipment height does not permit this, they shall be carried to a trap and a reduced diameter riser shall be used near the compressor.

6.3.9 Miscellaneous

This refrigeration system shall be installed with all the control and regulating instruments and with other equipments like:

- oil separator
- thermostatic expansion valve
- filter and drier
- valves
- electrovalves preceeded by a filter
- liquid indicator sight glass with an internal humidity detector, and also,

all the other equipments required for an adequate, secure and effective operation of the entire system.

7. RELATED EQUIPMENT

7.1 Water spray equipment

The water spray equipment constitutes an integral part of this contract and shall be installed in the Machine Room.

The specifications of this spray equipment shall be as follows:

7.1.1 Storage tank

- Capacity : determined in terms of the equipment and the required rate of spray water.
- Material : stainless steel covered with thermal insulation.
- Access to inside : movable cover to facilitate maintenance.
- Drainage : a valve located at the lower part of the tank will allow draining.
- Overflow : an overflow pipe of adequate size shall be provided and connected to the room central drain.
- Piping : the Supplier shall supply and install all piping from the tap-water valve supplied by the Buyer.
- Filter : a 120 mesh filter shall be installed on the line before

the tank. This filter shall be of the interchangeable cartouche type.

- Filling water : it shall be done automatically.

7.1.2 Water supply in the room

Flow : variable from 110 to 600 liters/hr.

Piping: - from the tank up to 0,30 m inside the room; adequate size.
- the input inside the room shall be made at three (3) different levels: 4 m, 5 m and 7 m above the floor.
- the inputs may be used separately or simultaneously.
- piping inside the room shall be adapted to the climatic conditions which could exist in it.
- piping ends inside the room shall be terminated by a union or a thread.
- all the piping shall be adequately supported with nylon clamps.

7.1.3 Pumping system

It shall provide the required flow with a minimum pressure of 4 bars inside the test chamber.

This pumping system shall be equipped with a safety control which de-energizes the electric motor if the flow is suddently stopped.

This electric motor shall be equipped with a disconnect switch and fused protection.

7.1.4 Water quality

Untreated but filtered.

7.1.5 Controls

a) a control for the required flow.
b) a electrovalve for stopping water admission in the room and installed on the main pipe. This electrovalve shall be located between the special drainage device and the pump (see the article 7.2).
c) an electrovalve on each water inlet in the room for stopping water admission. These electrovalves shall be installed on the upstream side of the special drainage device and outside the room.
d) operation of all these elements shall be controlled from the control room.

7.1.6 Testing equipment

The sise of the refrigeration system and of the heating system shall be based on the following data:

- Water temperature:
  a) tank supply : 7.5°C to 15.5°C
  b) spray in the room : variable between 2°C and 20°C to ±1°C.
- Rate of production : required maximum of 600 liters/hr.

The heating shall be provided by a stainless steel electrical element installed in accordance with local standards.

The refrigeration system shall be air-cooled, although any alternative could be considered.

Control installation and other specifications shall be as stipulated in articles 6.3.1, 6.3.3, 6.3.4, 6.3.5, 6.3.6, 6.3.8 and 6.3.9.

Regulation shall be incorporated and shall enable the temperature of the spray water to be set from the control room.

7.2 Special drainage device

A special drainage device shall be installed to each spray-water and steam pipe before it enters the test chamber.

This device shall operate on 4 bar compressed air as shown on drawing No. 5.

This device includes the supply and installation of all the electrovalves and piping from a regulator, supplied by the Buyer, and whose outlet sise shall be specified later.

Each special device is controlled from the control room by means of a momentary-action push-button.

It shall be impossible however to operate the air inlet electrovalve if the corresponding water or steam inlet electrovalve is not in the closed position. Provision shall also be made for a similar locking of the opposite operation.

8. OPERATION AND CONTROL OF THE EQUIPMENT

All the equipment shall be controlled and operated from the control room.

All operation and control instruments shall be installed inside one or two control cabinets.

8.1 Temperature and humidity sensors

Sensors used for regulation and monitoring shall be separated.

For monitoring, the Supplier shall supply:

a) for the test chamber
   - two (2) temperature sensors
   - two (2) humidity sensors

b) for the spray water
   - one (1) temperature sensor.

The sensors shall be capable of covering all temperature and humidity ranges as described in article 5. They shall be supplied with their calibration curves.

These sensors shall be of the platinum type and they shall have an accuracy of at least ±0.6°C throughout the entire range.

The supply of a two-thermometer psychometric sensor shall include all the required accessories.

8.2 Programmer and controllers

In the test room, humidity and temperature shall be obtained either with a programmers or by manual control after the desired values have been displayed.

For the spray water system, water temperature shall be selected from an heat/cool controller equipped with a set point selector.

8.2.1 Programmer

A programmer with combined or separate controllers shall enable the temperature and humidity settings to be varied. Two (2) plastic cams shall be used for this purpose.

These cams 160 to 200 mm in diameter shall be graded from 0 to 24. The indications shall permit all the temperature and humidity cyclic variations within the performance limits of the chamber.

Change gears shall permit time cycle variations between 0 and 24 hours per revolution.

8.2.2 Controllers

Temperature and humidity controllers shall be equipped with a "remote/local" switch to permit either remote programmed control or manual control of the climatic conditions in the test chamber.

The accuracy of each control selector shall be within the required tolerances of the spray water system.

The smallest scale division of the water temperature controller shall be 1°C minimum.

8.3 Recorder

The recorder shall be ELECTRONIK 112 of HONEYWELL or the equivalent. This Honeywell's recorder shall have the following characteristics:

- printing cycle: 2 sec.
- chart-drive speeds: 2.5 cm/hr and 25 cm/hr.
- change gears for chart speeds of 1/2 and 2 times basic speed.
- 12 registers with multicolor printing.
- "SELECT-O-PRINT" option
- Fluorescent illumination.

8.4 Temperature indicators

Two (2) temperature indicators shall be supplied; one for the test chamber and one for the spray water.

These indicators shall be of Rosemont Inc., Model 430T or the equivalent.

These indicators shall be graduated in °C. The temperature scales and the smallest divisions shall be respectively:

a) -30°C to +70°C, 1.0°C for the test chamber
b) -5°C to +25°C, 0.5°C for the spray water.

Both indicator shall be mounted on the control cabinet and shall have their own sensor.

8.5 Accessories

Accessories required for the efficient operation of control and recording equipment shall be supplied and installed.

8.6 Signalling

8.6.1 Lamp indicators

A mimic panel representing the entire system shall comprise signalisation points which will provide the test agent with an excellent supervision of the operations.

The signalisation system shall be as follows:

- a white lamp indicator to show which piece of equipment is in operation.
- a red lamp indicator with an alarm-bell to indicate a fault.

This alarm-bell shall be supplied with a reset button.

TABLE 8.6.1 - SIGNALLING

PANEL DIVISIONS		INDICATION		
o.	CONSTITUTION	EQUIPMENT	WHITE BULB INDICATOR	MEANING OF THE RED BULB INDICATOR
1	Refrigeration system of the test chamber	- compressor (see note 1)	1 ind.'R/comp.'R	- low refrigerant pressure suction side - high refrigerant pressure discharge side - low oil pressure
		- condenser on the roof	1 ind.'R/motor	
		- fans' motors of the air circulation duct	1 ind.'R/motor	
		- evaporator defrost (see note 2)	1 ind.'R/system	
B2	Air heating system of the test chamber	- electrical element	1 ind.'R/unit	1 ind.'R/high temperature control element
B3	Steam system	- steam boiler (see note 3)	1 ind.'R	- high steam pressure - low water level - high temperature of the element
		- special drainage device	(see note 4)	
C	Watering system	- electrovalves on each of the 3 levels	1 ind.'R/electrovalve (see note 5)	
		- special drainage device	(see note 4)	
		- pumping system	(see note 6)	
		- testing equipment a) electrical heating element	1 ind.'R	
		b) refrigeration system	idem to B1 for compressor and condenser (if required)	idem to B1 for compressor and condenser (if required)

Notes:

1) The gauges for each compressor shall be installed in the corresponding division on the panel.

2) If defrosting is started manually, the white lamp indicator shall be combined with the operating knob on the panel.

3) - Steam pressure gauge shall be installed in this division.
   - If the steam generator requires a water feeding pump, a white lamp indicator for this pump shall be installed in division B3.

4) A white lamp indicator shall be associated with the momentary action push-button of the special drainage device which shall be installed in this division.

5) One (1) white lamp indicator shall be associated with each operating push-button of each electro-valve. These three buttons shall be installed in this division.

6) A white lamp indicator shall be associated with the pump flow control installed in this division.

8.6.2 Identification of the lamp indicators

Each lamp indicator shall be provided with a nameplate giving the name of the equipment and the nature of the fault.

The wording shall be in Spanish.

8.6.3 List of lamp indicators

The mimic-panel shall be in six (6) divisions.

Divisions A1 and A2 shall correspond respectively to the test room accessories and to the machine room accessories.

In division A1 a switch with a white lamp indicator shall be installed for each of the following equipment:

- drainage and floor heating system of the test chamber
- drainage and floor heating system of the antechamber
- heating system in the frame of the antechamber's doors
- heating system in the frame of the chamber's access door
- heating of the drain and the pan of the air circulation duct inside the chamber
- heating of the observation window
- wiper of the observation window
- test chamber and antechamber lighting.

In division A2 a switch with a white bulb indicator for the ventilation system in the machine room.

The signalisation system for the other divisions is described in table No. 8.6.1.

8.7 Panel and cabinet(s)

8.7.1 Panel

This panel shall contain all the signalisation and control equipment for the accessories distributed among the six compartments described in the preceding article and shown schematically in drawing No. 6.

8.7.2 Control cabinet(s)

The regulation and control cabinet(s) shall contain:

- the temperature and humidity programmer
- the temperature and humidity controllers of the test chamber
- recorder
- temperature controller of the spray-water system
- temperature indicators for the test chamber and the spray water.

8.7.3 <u>Construction and installation</u>

This panel and these cabinets shall be made of steel sheet with corners and edges rounded.

The construction and the installation of this furniture in the control room shall be made in such a way as to procure an easy access for reparation, maintenance or modifications to some instruments.

8.7.4 <u>Painting</u>

Painting of the panel and cabinets shall be done by the Supplier.

The Buyer will decide later on the exact color.

9. <u>MISCELLANEOUS</u>

9.1 <u>Piping</u>

The pipes supplying the water and the steam into the chamber as well as those supplying the refrigerant (suction side) shall be covered with heat-insulation material with a vapor seal.

The piping for all systems: water, steam, refrigerant and air shall be marked with the type of fluid and the flow direction.

9.2 <u>Available voltages</u>

Available voltages for the power supply of the testing and other equipment are at 50 Hz:

380 V - 3Φ
220 V Φ/ground

9.3 Work on roof of room F-124

9.3.1 Scope

The work includes:

- construction of reinforced concrete base(s) for the air-cooled condenser(s)
- construction of the wood bases for the ventilation system
- boring of the roof for the passage of all pipes and ventilation duct.
- the covering work includes insulation, asphaltic and metallic flashings, etc.

The location of the various equipment components shall be approved by the Engineer.

9.3.2 Protection

The Supplier shallprovide the building and the work of other trades with proper and effective protection against falling material.

No circulation of personnel or work will be allowed on the roof unless the surfaces involved are suitably protected. This protection shall be approved by the Engineer.

All exposed or partially completed surfaces left unattended for more than eight (8) hours, shall be protected with polythene sheets or waterproof canvas.

All canvas or sheet joints shall be sealed with a strong sealing tape. This canvas or sheet cover shall be firmly attached so that no wind can lift it up totally or partly. During this cover installation, pockets formation which could retain water shall be avoided.

9.3.3 Concrete base

9.3.3.1 Quantity

This concrete base may be done in one or several sections depending on the type of footings used for the condenser supports.

9.3.3.2 Construction

The concrete base shall be of reinforced concrete anchored to the roof slab by means of anchor bolts of suitable sizes.

The roof slab shall be primed with cement grouting.

9.3.3.3 Covering

The Supplier's drawing showing the base covering shall be approved by the Buyer before the Supplier proceeds with his work.

9.3.3.4 Piping

Pipes may be passed either through the concrete base and roof or through a separate hole in the roof slab.

For this last case, a creosoted-pine casing shall be nailed to the roof slab.

Asphalt and metal covering and flashing shall be in accordance with article 9.3.3.3.

9.3.4 Base and duct for the ventilator unit

The Supplier shall furnish the shop drawings of the base and duct hole for the ventilator unit. These drawings shall be approved by the Engineer before work execution.

Asphalt and metal covering and flashing shall be in accordance with article 9.3.3.3.

The passage of pipes for the electrical supply together with the covering and insulation shall be done by the Supplier.

10 SUPPLY LIMITATIONS

10.1 Engineering

The Supplier shall perform all the engineering work required for completing the work stipulated herein.

10.2 Water

The Supplier shall specify the quantity of water required for:

- vapour generator
- spray-water
- other equipment.

The Supplier shall supply all the piping, valves, fittings, etc., required for completing the water supply system. The water supply shall be obtained from a stop valve which will be provided by the Buyer but in accordance with the Supplier's specifications.

10.3 Electrical installation

All electrical installations form parts of the supply up to the distribution cubicle. The connections to the cubicle also forming part of this contract.

The Supplier shall inform the Buyer of the required voltage and power facilities for each voltage.

The Buyer will supply the power and voltage cables up to the distribution cubicle, which he will also supply.

If a d.c. voltage or a.c. voltages others than the voltages available are required, the Supplier shall supply and install the equipment required to procude this d.c. voltage or others a.c. voltages.

10.4 Compressed air

The distribution and control circuits for the supply of compressed air at 4 bars form parts of this supply.

The Supplier will obtain the compressed air supply from a valve, which will be supplied and installed by the Buyer.

10.5 Location of various supply inlets

The Supplier will choose the most convenient location, with the agreement of the Buyer, for the installation of water inlet, electrical power distribution cubicle and compressed air inlet required for the testing equipment.

It is understood that the locations chosen shall take into consideration the out-line dimensions and/or physical impossibilities due to the construction of the premises and/or to equipment.

10.6 Water drainage

The Supplier shall provide the water drainage system up to the sewer, fittings included.

10.7 Handling and mounting

Material and equipment included in this contract shall be unloaded by the Supplier in the Laboratory hall. A 10-ton crane can be used for this purpose within its travelling limits.

The hall access is possible by a road.

Vertical and horisontal handling facilities inside and outside the laboratory and in the rooms provided for the construction of the climatic test chamber and the installation of the equipment shall be supplied by the Supplier.

10.8 Commissioning

The Supplier shall be responsible for the commissioning of his installation.

The commissioning includes:

- purge and cleaning of the refrigerant piping
- test under pressure of the whole system for leaks detection
- balancing of the refrigeration system
- adjustment of all the controls: temperature, humidity, pressure, etc.
- inspection of all the electrical circuits
- etc.

10.9 Manuals and special tools

The Supplier shall supply in five (5) copies all the maintenance and operating manuals of the whole supply.

If any special tools are required for maintenance or repair of some pieces of equipment, they also shall be supplied.

11. ACCEPTANCE TEST PROGRAM

11.1 General

The acceptance tests will require from the Supplier:

- 6 probes for measuring the dry temperature and 6 probes for measuring the humidity. They shall be located within the test area defined by the surfaces parallel to the walls and 0.75 m apart from them.
- the Buyer shall supply the other supplementary probes.

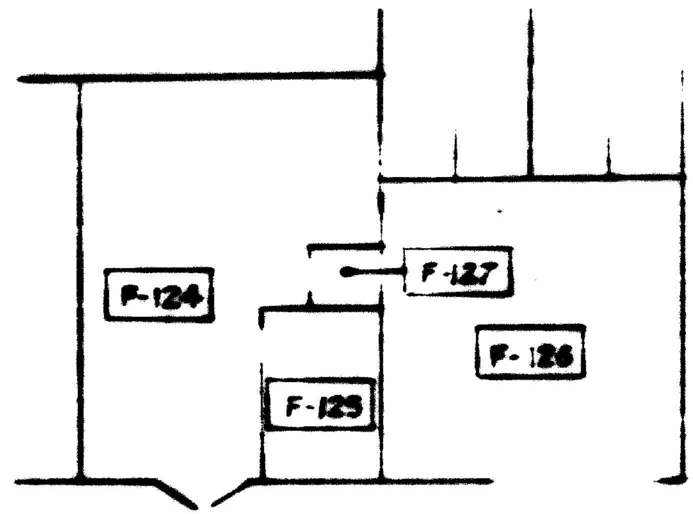
11.2 Test cycles

The performance of mecano-climatic chamber shall be checked by carrying out temperature and humidity cycles as specified on drawings Nos. 7 and 8.

These tests shall be performed with 3 tons of material in the chamber.

However, if these tests are inconclusive, the Buyer reserves the right to demand additional tests in order to prove that the chamber is satisfactorily operational.

The performance of the spray water equipment shall also be checked.



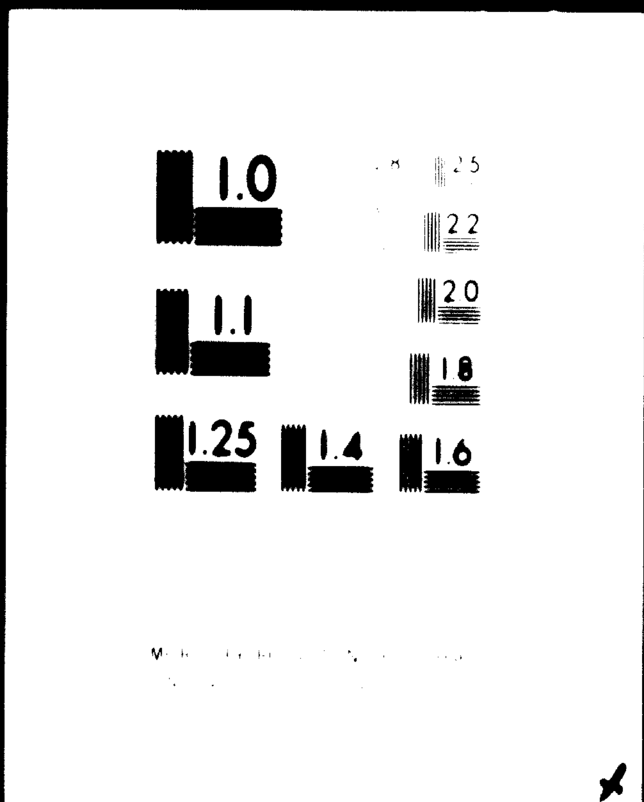
F-124 MACHINE ROOM
F-125 CONTROL ROOM
F-126 TEST CHAMBER
F-127 ANTECHAMBER

REFERENCE: DRAWING NO-22 OF THE HIGH POWER LABOTARY

DRAWING No. 1 MECANO-CLIMATIC CHAMBER LAY-OUT

B-942

82.11.12



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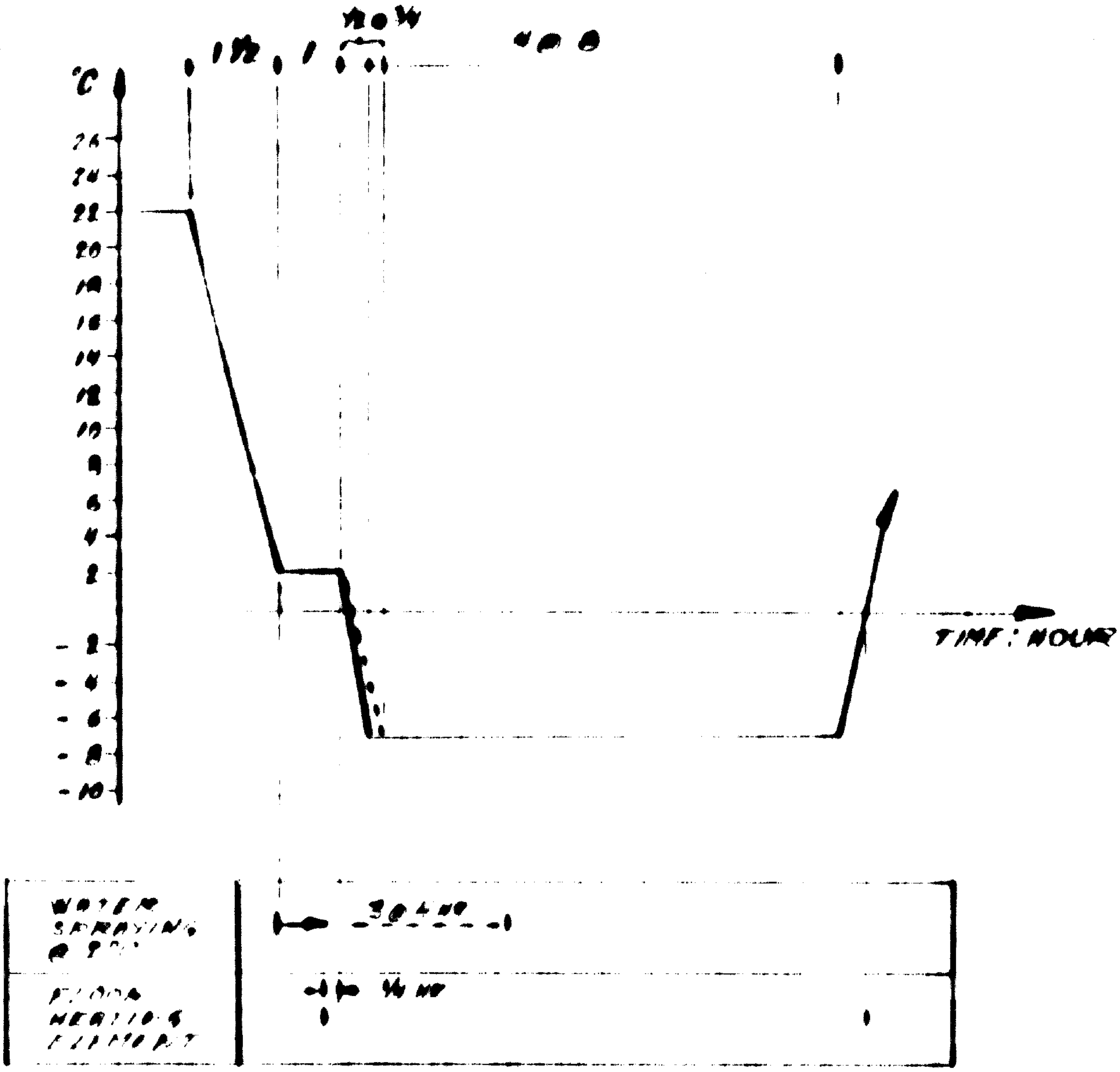
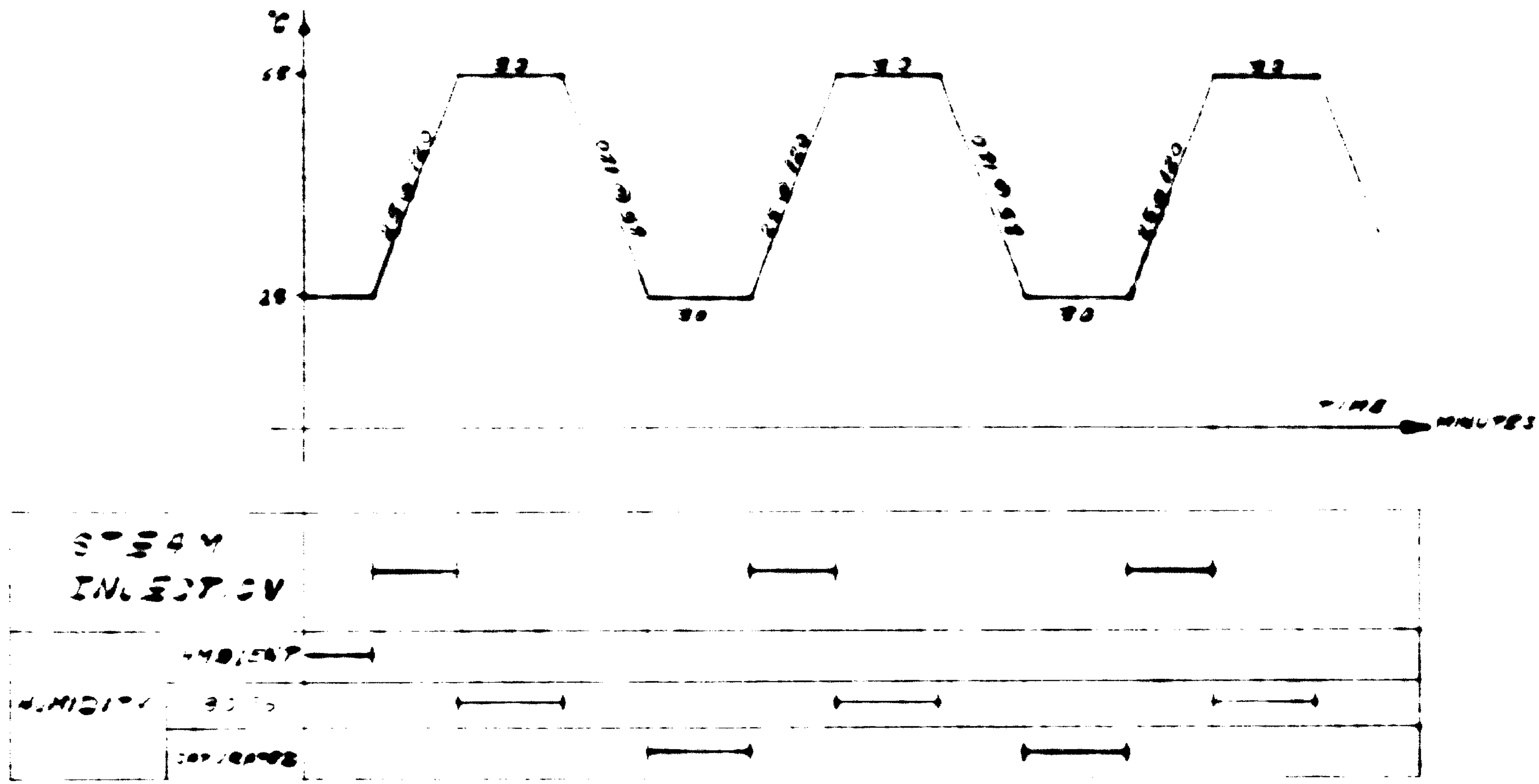
DRAWING NO. 2 : FLOOR SLOPE

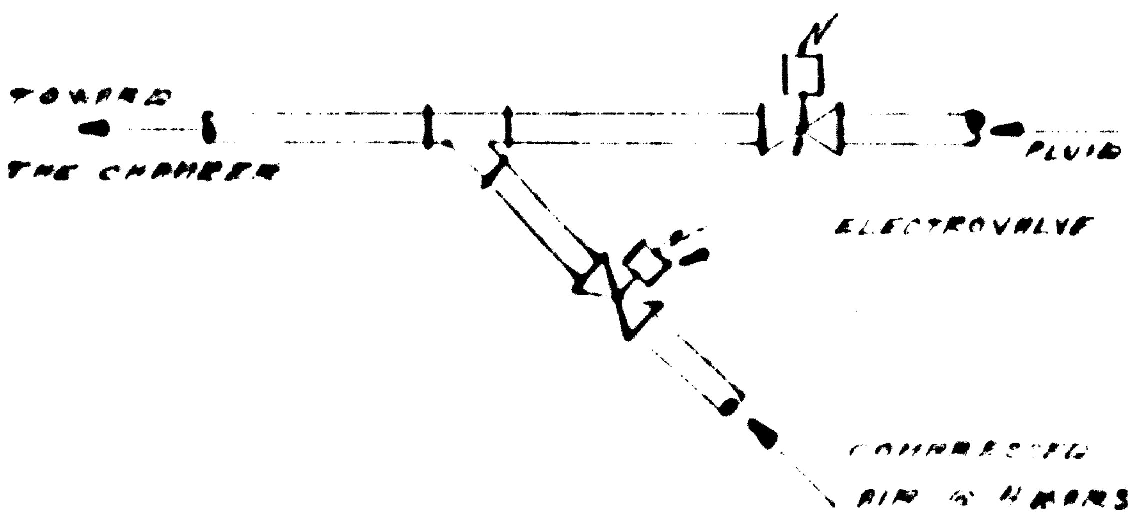
MP 15



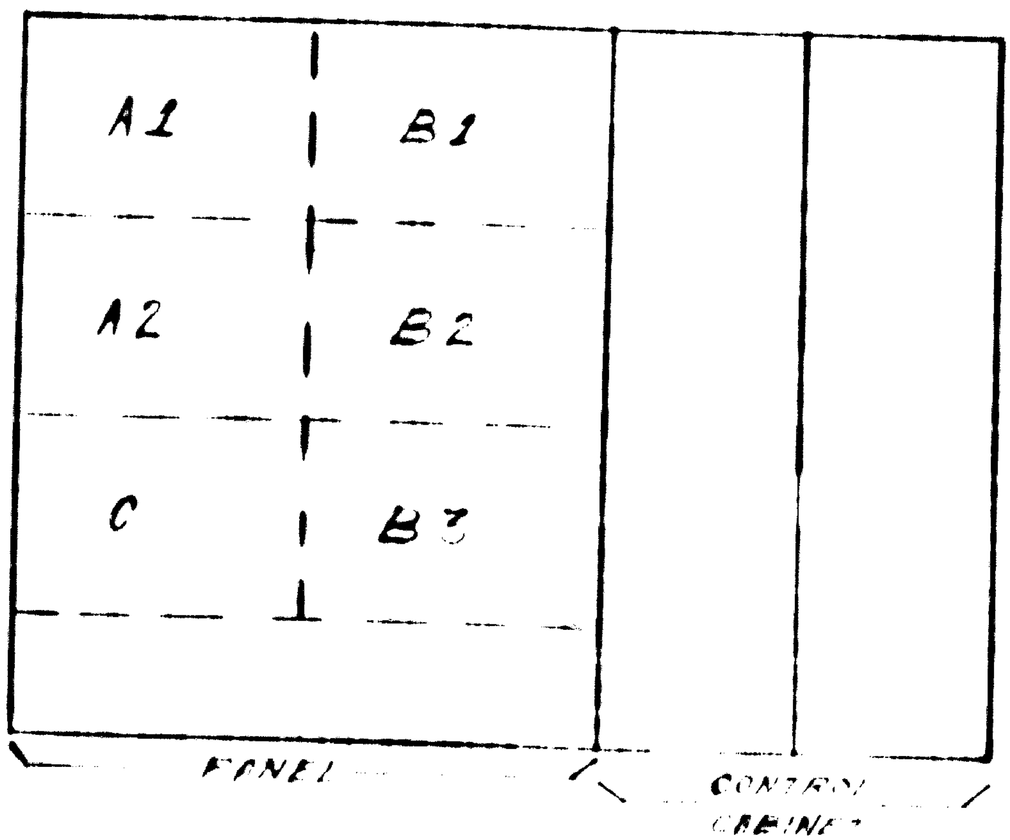
DRAWING No. 3: STANDARD ICE TEST



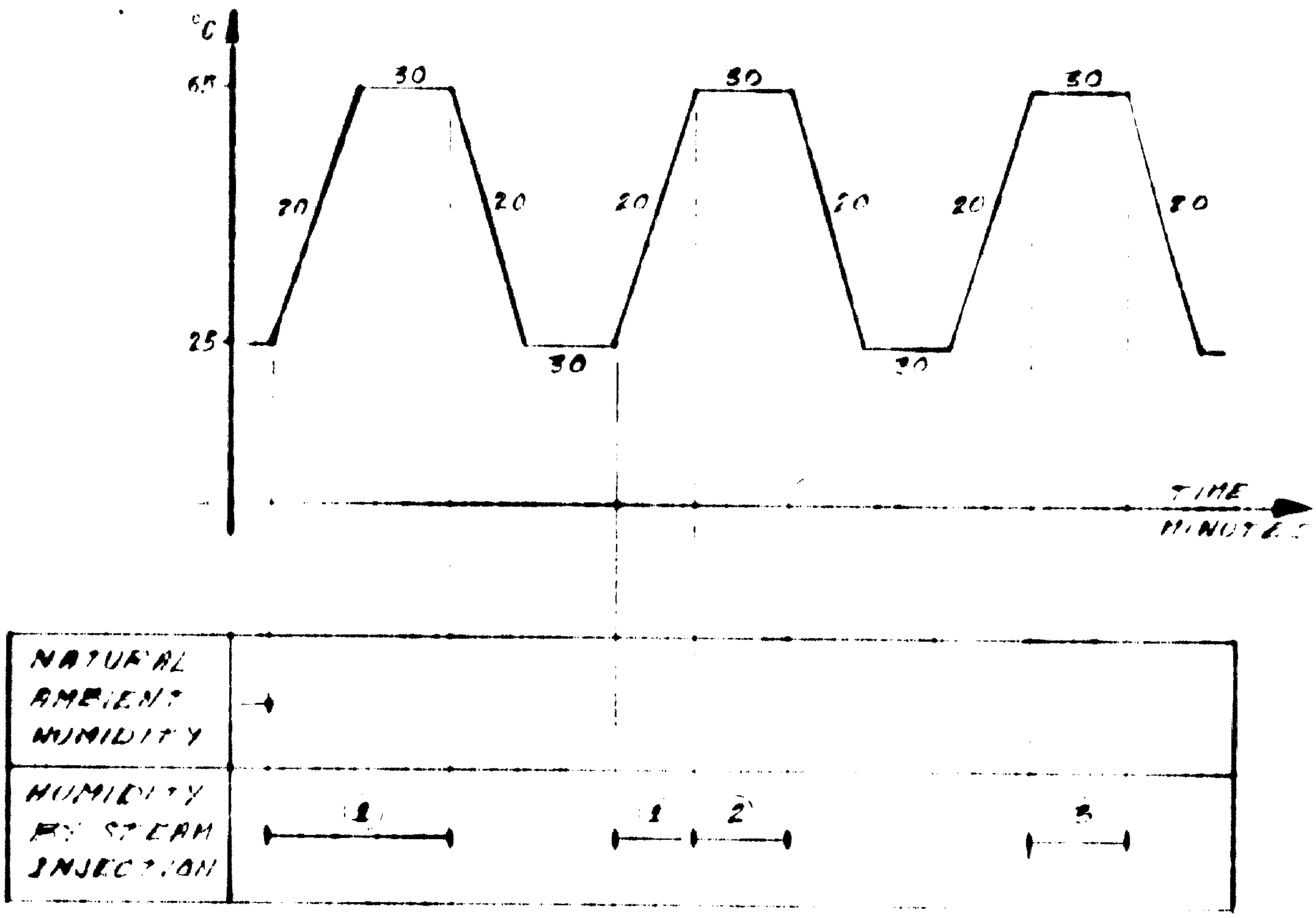
DRAWING No. 4 : ACCELERATED AGEING CICLE



DRAWING No. 5: DRAIN SPECIAL DEVICE



DRAWING No. 6 : SCHEMATIC LAYOUT OF THE CONTROL CABINET AND PANEL



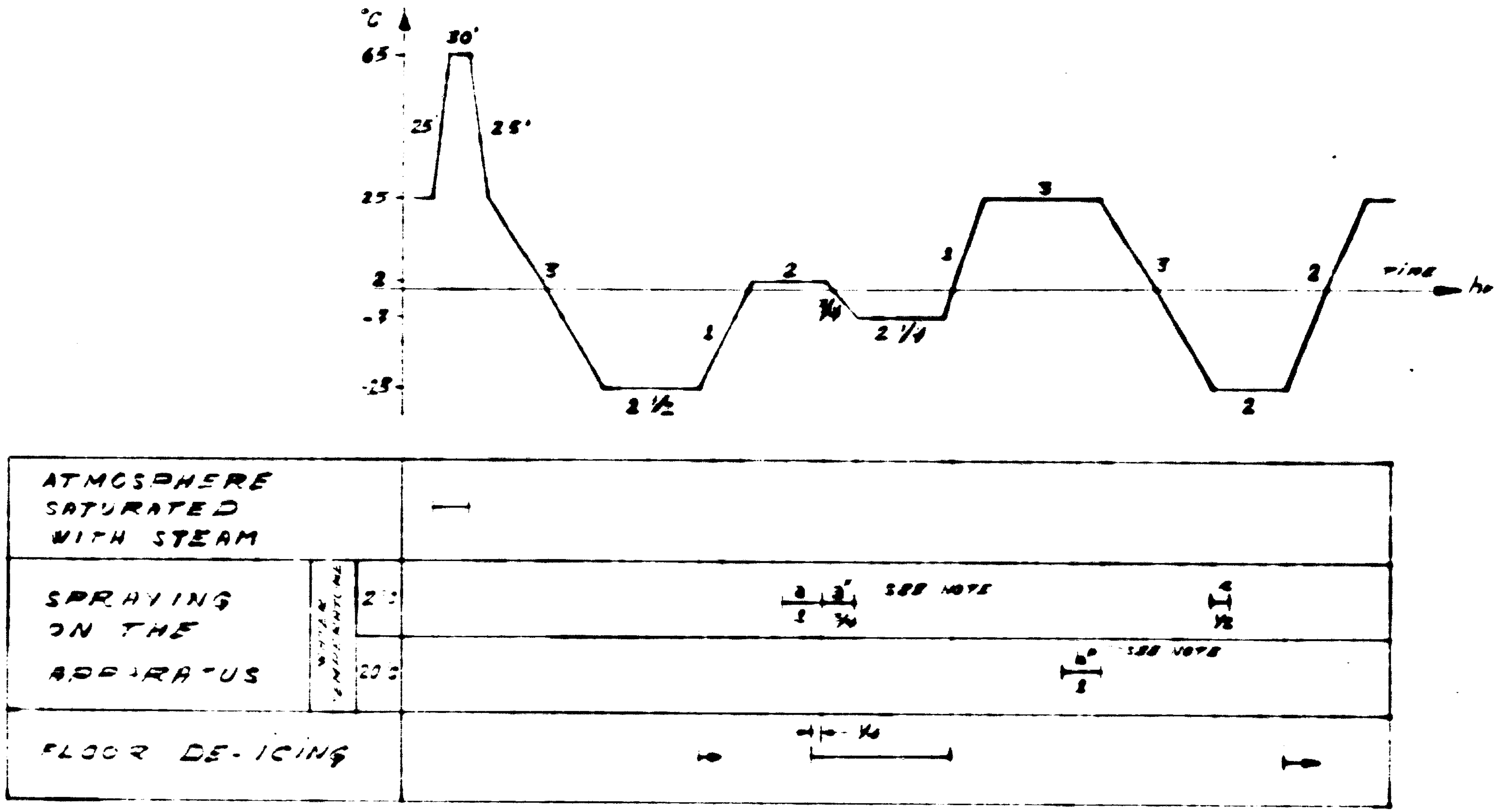
NOTES

(1) ATMOSPHERE SATURATED

(2) " WITH 80 % R.H.

(3) " " 40 % R.H.

DRAWING NO. 7: ACCEPTANCE TEST NO. 1



NOTE: WATER SPRAYING ON THE APPARATUS AT A RATE OF | a 600 | b 300 | c 150 LITERS/HR

DRAWING NO. 3: ACCEPTANCE TEST NO. 2

HP 16

22 KV REACTORS

This specification covers the requirements of the Electrical Industry Testing and Experimentation Center for the supply of thirty (30) 22 kV reactor coils and their shunt disconnect switches, for the A.C. high-current and direct current section of the High-Power Laboratory.

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1.0 GENERAL DESCRIPTION

The reactor coils described herein will be used for adjusting short-circuit current to the desired value for every test in the High Power Laboratory of Electrical Industry Testing and Experimentation Center, Madrid, Spain.

These reactor coils will be arranged in series, each being shunted by a disconnect switch, which when disconnected will insert into the test circuit the impedance of the reactor in parallel with it, and which, when connected, will remove from the test circuit the impedance of the reactor thereby short-circuited.

Impedance values of the individual reactor windings shall be a geometric progression with a multiplier of 2.05, so that when several reactors are put in series a fine control of the short-circuit current will be achieved.

Tests will be three-phase or single-phase. They will be carried out on circuit breakers, fuses, switches, disconnect switches, current transformers, reactors, wave traps, bus bar systems and other types of equipment used in electrical distribution and transmission systems.

Short-circuit current will be supplied by a 250 MVA short-circuit source. These reactor coils will regulate the power supplied to the A.C. high current transformer and the D.C. section.

2.0 STANDARDS

IEC 289-1968	Reactors
IEC 129-1961	Alternating Current Isolators (Disconnectors) and Earthing Switches (Including Admendment No. 1-1963).
IEC 60-1962	High voltage test techniques
IEC 168-1964	Tests on indoor and outdoor post insulators for systems with nominal voltages greater than 1000 V.

The standards listed above shall apply, except for modifications or additions contained in this specification.

3.0 VALUES OF IMPEDANCE OF THE DIFFERENT REACTOR COILS

The short-circuit current is varied by adding to the total impedance of the source, of bus bars and of the short-circuit transformers, the impedance resulting from the combinations in series of the different reactor coils.

X_1 = 0.300 ohm

X_2 = 0.615 ohm

X_3 = 1.26 ohm

X_4 = 2.58 ohm

X_5 = 5.30 ohm

X_6 = 10.9 ohm

X_7 = 22.4 ohm

X_8 = 46.0 ohm

X_9 = 94.5 ohm

X_{10} = 194.0 ohm

4.0 REACTORS

4.1 Electrical characteristics

Reactors shall be single-phase, indoor type, dry, air core, cooled naturally by air and arranged in series. Rated frequency shall be 50 Hz.

The impedance values vary from 0.300 ohm to 194 ohm forming a geometrical progression having a common ratio of 2.05.

These values, as well as quantities, tolerances, rated continous current, rated short-circuit current, rated short-circuit power, WL/R ratio, and insulation levels are listed in table I.

The reactors shall be able to withstand for three (3) consecutive seconds the rated rms short-circuit currents listed in column 4 of the table I, followed by four hours of cooling off.

This cycle may be repeated continually in an ambient temperature of 40°C. The reactors must also be connected to switches and bus bars in such a way as to be capable of withstanding indefinitely the mechanical forces induced by a 6.4 kA rms current and a peak 16.6 kA, in these switches and bars.

4.2 TABLE I - 22 kV reactors

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
Quantity	Impedance 50 Hz for each reactor	Tolerance on reactance	R.M.S. rated short-circuit current (3 sec)	Current peak ½ cycle	R.M.S. rated continuous current (24 hours at 40°C ambient temperature)
	OHM		AMP.	AMP.	AMP.
3	0.300	± 5%	5520	14400	400
3	0.615	± 5%	4860	12500	400
3	1.26	± 4%	4170	10800	400
3	2.58	± 4%	3340	8700	400
3	5.30	± 3%	2360	6150	400
3	10.9	± 3%	1470	3800	400
3	22.4	± 2%	835	2170	400
3	46.0	± 2%	440	1140	400
3	94.5	± 2%	224	580	224
3	194.0	± 2%	111	288	111

4.2 Table 1

Column 7	Column 8	Column 9	Column 10	Column 11	Column 12
Rated short-circuit power of each reactor (3 sec.)	ωL/R ratio of reactor at 50 Hz	Impulse test between entry and exit terminals	Tests between turns	Power frequency withstand voltage to ground 1 min R.M.S.	Impulse test voltage (peak) to ground
MVAR		kV	kV	kV	kV
9.15	15<ωL/R<20	110	90	50	125
14.6	15 20	110	90	50	125
22.0	15 20	110	90	50	125
29.0	15 20	110	90	50	125
29.6	15 20	110	90	50	125
23.6	15 20	110	90	50	125
15.6	15 20	110	90	50	125
8.9	15 20	110	90	50	125
4.75	15 20	110	90	50	125
2.4	15 20	110	90	50	125

4.3 Electrodynamic forces

The reactors must be designed in such a way as to be capable of withstanding indefinitely the mechanical forces induced by the maximum peak values of symmetrical and asymmetrical currents.

4.4 Proximity conditions

The distances between coils shall be such that the mutual coupling between two or several coils does not introduce a resultant impedance variation greater than 1%.

The forces resulting from mutual coupling shall not exceed:

a) in the vertical direction, the weight of each coil involved

b) in the horizontal direction, the weight of the coils, which must withstand these forces without deformation or damage, since they are fixed to the ground.

It is acceptable for the Manufacturer to place spacers to absorb these horizontal forces, whether they are positive or negative.

4.5 Handling

Each reactor shall be provided with a ring or other device to facilitate handling by hoist or crane.

4.6 Terminals

All terminals shall be designed to withstand the stresses resulting from electrodynamic forces that occur during short-circuits.

The terminals shall be capable of carrying the rated short-circuit currents for three (3) consecutive seconds without causing a temperature rise greater than 30°C, at an ambient temperature of 40°C.

4.7 Winding

To avoid any deformation, the windings shall be solidly clamped.

4.8 Tests to be carried out before the short-circuit tests

For each of the thirty (30) reactors, the following quantities shall be measured: dc resistance, and the 400 Hz reactance. The error of the reactance value being limited to ±0.1%.

4.9 Dielectric tests

The following dielectric tests shall be carried out on one reactor of each group. There are 10 groups.

Standard lightning impulse withstand voltage to ground:	125 kV
Power frequency (50 Hz) withstand voltage, 1 min., to ground:	50 kV
Standard lightning impulse withstand voltage across terminals	110 kV
Tests between turns (discharging a capacitor into the reactor:	90 kV

Lasting for 7200 cycles.

Unsatisfactory results of the dielectric tests will mean automatic rejection of the faulty reactor or reactors.

4.10 Short-circuit tests

One 2.58 ohm reactor and one 0.300 ohm reactor shall be subjected to thirty (30) short-circuit current shots equal to 120% of the rms current indicated in column 4 of Table 1.

The 30 shots will be made at a rate of one shot per 3 minutes.

The test circuit $\omega L/R$ ratio, and the instant when the short-circuit currents are established, shall be such that the asymmetry of the current is at least 1.8 x $\sqrt{2}$ x 120% of the rms short-circuit current, for the first half-cycle.

The duration of each short-circuit shall be at least 0.1 sec.

The acceptability of a reactor will be based on the variation of its own reactance during the series of short-circuit current tests.

Measurement of a reactor coil reactance shall be made between each test using an adequate bridge circuit that ensures an absolute error lower than 0.1% and guarantees a minimum sensitivity of 0.06% between two successive measurements.

Successive measurements of reactance after each of the first fifteen (15) short-circuit current tests must show a net tendency to stabilize, i.e., a variation in reactance will be acceptable provided it decreases as this series of tests proceeds.

If the variation in reactance is constant or if it tends to increase, the reactor coil will be rejected unless the Manufacturer continues the tests until the reactance becomes stable.

Successive reactance measurements after each of the last fifteen (15) short-circuit tests shall not show any variation in reactance.

Otherwise, the reactor coil will be rejected.

The reactance measured after the last fifteen (15) short-circuits shall be a value located within the tolerances indicated in column 3 of Table 1.

Otherwise, the reactor coil will be rejected.

4.11 Tests to be carried out after the short-circuit tests

The dc resistance and 400 Hz reactance of the 2.58 ohm and 0.300 ohm reactor coils that has undergone the thirty (30) short-circuit tests shall be measured.

These measurements will enable the $\omega L/R$ ratio of each reactor coil to be determined.

Reactor coils with a $\omega L/R$ ratio of less than 15 or of more than 20 will be rejected.

4.12 Other conditions of acceptance

In addition , acceptance of the reactor coils shall depend on the condition that no sign of damage to the reactors be evident during and after the short-circuit tests and the dielectric tests.

5.0 DISCONNECT SWITCHES

5.1 Electrical characteristics

Switches shall be single pole, indoor type. All switches shall be manually operated.

The switches shall never be operated when alive.

The switches shall be able to withstand for three (3) consecutive seconds the rated rms short-circuit currents, followed by four hours of cooling off.

This cycle may be repeated continuously at an ambient temperature of 40°C and the copper temperature must not rise more than by 30°C.

5.2 Disconnect switches

Frequency:	50 Hz
Quantity:	30
Rated voltage:	22 kV
Rated short-circuit current for 3 seconds:	6.4 kA rms
Continuous current:	600 A rms
Short-circuit current peak (½ cycle):	16.6 kA
Standard lightning impulse withstand voltage to ground:	125 kV
Standard lightning impulse withstand voltage across isolating distance:	125 kV
Withstand voltage applied at 50 Hz, 1 min. in relation to ground	50 kV
Withstand voltage applied at 50 Hz, 1 min. across the isolating distance:	50 kV

5.3 Mechanical endurance

The contacts must not rub during a switch opening or closing operation. The pressure of the contacts shall be applied only when the disconnect switch is in the close position.

The disconnect switches must be capable of making 5000 closing operations and 5000 opening operations at no-load without any wear, deformation, cracking, malfunction or damage.

No lubrication is allowable during these 5000 operations.

5.4 Contacts and terminals

The fixed and movable contacts, as well as the terminals or current outlets shall be capable of supporting the rated short-circuit currents for three (3) consecutive seconds, without experiencing a temperature rise of more than 30°C at an ambient temperature of 40°C.

The terminals or current outlets shall be designed so as to withstand the stresses caused by the electrodynamic forces during short-circuits.

5.5 Tests

The switches tested shall be completely finished and mounted on their insulator supports.

All the following tests shall be carried out, on one (1) disconnect switch.

5.6 Mechanical endurance

The switches shall carry out 5000 closing operations and 5000 opening operations.

During the tests, no adjustments or repairs may be carried out.

After these 5000 openings and 5000 closings there shall be no evidence of wear, deformation, vibration, maladjustment, looseness, and deterioration that might affect the proper functionning of the switch.

After the endurance test, the switches must still be capable of satisfying the requirements for dielectric properties, ability to withstand electro-dynamic forces, temperature rise of contacts, mechanical functioning, and protection against oxidation and electrolytic effects. Otherwise the switch shall be rejected.

Acceptance of the switches shall be based on the variation in their dc resistance before the mechanical endurance tests and after the mechanical endurance tests.

The dc resistance shall be measured with a bridge, and under the same temperature conditions as the tested switch. The variation in the dc resistance measured before the mechanical endurance tests and after the short-circuit tests shall be less than 10%, otherwise the switch will be rejected.

5.7 Dieleelectric tests

The following dielectric tests shall be carried out on each switch tested:

- B.I.L. (crest) with respect to ground and between the opening distance.
- Applied voltage at power frequency (1 min.) with respect to ground and between the opening distance.

The tests shall be carried out using the values given in article 5.2 . Failure to pass the dielectric tests shall mean automatic rejection of the switches.

5.8 Conditions for acceptance of the switches

The purchaser shall accept the disconnect switches only after they have passed all the tests successfully.
Any changes or modifications made to a switch having already been tested shall necessitate repetition of all the tests..

6.0 RESPONSABILITY FOR CONDUCTING THE TESTS

The Manufacturer shall have the responsability of conducting all the tests on the reactors, switches and bus bars.

7.0 GROUNDING

All the non-conducting metal parts of the reactors, switches supporting structure shall be connected to the main grounding system of the high power test station.

The Manufacturer shall supply all the connectors linking the metal fittings of each piece of equipment to the main grounding system, which will consist of copper bar measuring at least 0.64 cm. x 5 cm or equivalent.

The buyer will supply the grounding system.

8.0 STRUCTURE

The Manufacturer shall supply the structure required for supporting all the equipment on the floor.

9.0 ACCESSORIES

The Manufacturer shall be supply a complete set of accessories.

10.0 GALVANIZING

All steel parts shall be galvanized in accordance with the Spanish standards.

11.0 ALTERNATIVE

The Manufacturer is invited to suggest as an alternative, any system and/or measure that could save money or facilitate installation or operation.

However, the alternative shall offer at least as many impedance values and as much flexibility.

12.0 TECHNICAL DATA QUESTIONNAIRE TO BE COMPLETED BY THE TENDERER AS PART OF THE TENDER

1) General description of the reactors and switches.

   Description attached..........

2) Preliminary outline drawings indicating the main dimensions of the reactors and switches.

   Description attached..........

3) Information on the weight of the reactors.

   Description attached..........

4) Continuous current at 40°C ambient temperature of.......... for the reactors, of.......... for the switches.

5) Loss in the copper of the reactors at continuous current..........kW.

6) Loss in the copper of the reactors at rated short-circuit current (3 sec.)..........kW.

7) Resonant frequency (electrical) of each reactor.

   List attached..........

8) Variation in the resistance of each reactor as a function of electrical frequency.

   List attached..........

9) Accidental current that each reactor can withstand several times during its lifetime without being destroyed..........kA.

10) Accidental current that each switch can withstand several times during its lifetime without being destroyed (but which could however, necessitate adjustment of the contacts)..........kA.

11) Test equipment available to the Manufacturer for carrying out the dielectric tests.

Description attached..........

12) Test equipment available to the Manufacturer for carrying out the short-circuit tests.

Description attached..........

13) List of accessories.

List attached..........

14) The Manufacturer's experience, and a list of the short-circuit reactors, switches, already built.

List attached..........

15) Maximum temperature a reactor can reach without any deterioration.

.... °C.

16) Cooling time constant of the reactors..........

17) Maximum vertical forces made by the reactors during short-circuit.

List attached..........

16.6 MVA SHORT-CIRCUIT TRANSFORMERS

This specification covers the technical requirements of the Electrical Industry Test and Experimentation Center for the supply of three (3) 16.6 MVA short-circuit transformers for the high current testing section of the High Power Laboratory. The supply includes engineering, manufacturing, testing and shipment of transformers along with auxiliairy equipment specified herein.

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2. **REFERENCE STANDARDS**

The following standard shall apply, except for modifications or additions stated in this specification:

IEC Publication 76 - "Power Transformers".

3. **GENERAL DESCRIPTION**

The transformers described herein will be used to supply a high current testing station drawing energy from the network and occasionally from a rotating machine.

These transformers will operate routinely under short-circuit conditions. They will be used to perform all the short-circuit current tests of various apparatus such as:-

- bus bars
- contacts of switches
- breakers
- fuses

Tests will be three-phase, two-phase or single-phase. They will be carried out on all types of equipment used in electrical distribution systems.

The short-circuit power available for these tests will be 50 MVA at secondary voltages.

In normal operation, the transformers could remain energised between short-circuits. They will also be used for temperature-rise tests on bus bar, contacts, etc.... The cooling system must therefore enable the transformers to have a total continuous power rating of 9 MVA.

4. **ELECTRICAL CHARACTERISTICS**

The transformers shall be single-phase, indoor type, dry type or liquid immersed (non-inflammable). The three transformers shall be identical and inter-changeable. Rated frequency shall be 50 Hz. The schematic diagram shows the required arrangement of primary and secondary windings.

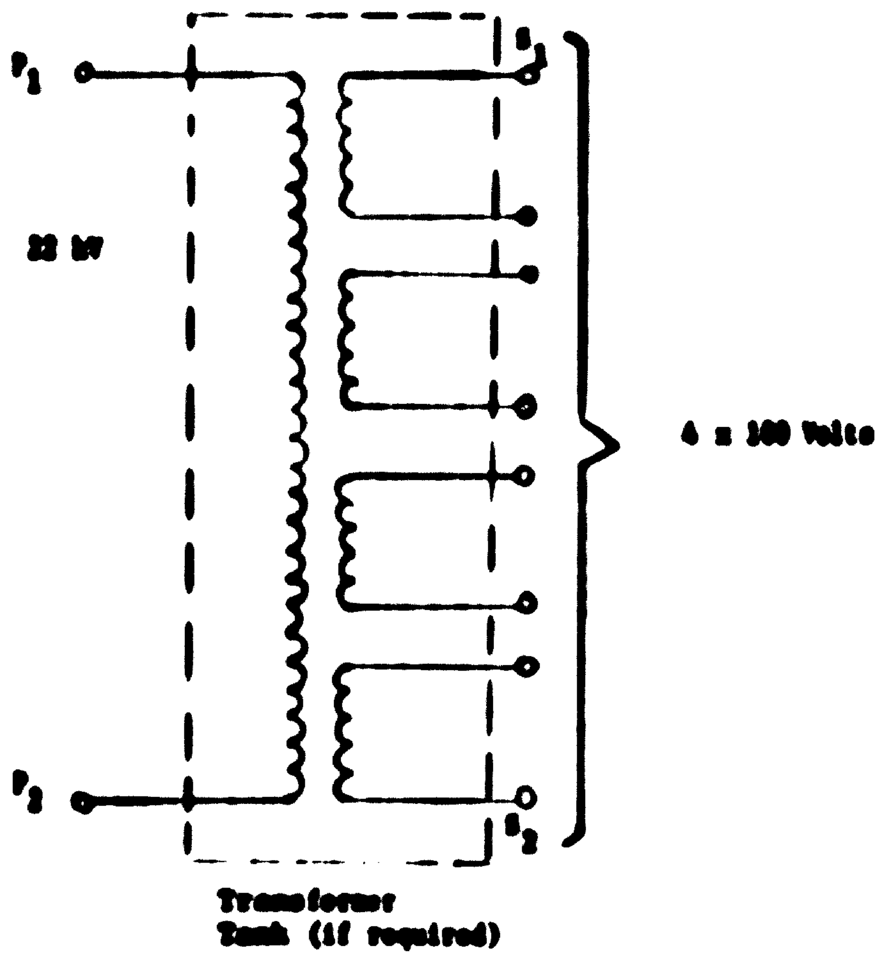


FIGURE 1

TRANSFORMER SCHEMATIC DIAGRAM

TABLE I: Secondary voltages and short-circuit currents (34)
(See also figures 2a and 2b)

Secondary voltage Volts	Secondary current kA	Short-circuit power MVA	Reactance of test object mΩ
692	42	50	4.65
346	84	50	1.16
173	168	50	0.29
400	72.5	50	1.55
200	145	50	0.386
100	290	50	0.097

TABLE II: Secondary voltages and continuous currents (34)
(See also figures 2a and 2b)

Secondary voltage Volts	Secondary current kA	Continuous power MVA
692	7.5	9
346	15	9
173	30	9
400	13	9
200	26	9
100	52	9

4.1 Rated no-load voltage

Primary: 22 kV (two primary bushings fully insulated for connection between two phases of the 22 kV bus system). The primary will be delta connected for the three phase tests.

Secondary: Four (4). 100 Volt windings. This gives for single phase tests all multiples of 100 Volts up to 1,200 Volts and for three phase tests the voltages available will be in star connection 692, 346 and 173 Volts, in delta connections 400, 200 and 100 Volts.

The three (3) transformers shall be capable of being interconnected as shown in figure 2a and 2b, so as to produce the secondary voltages indicated.

The transformers shall be capable of operating at 110% of rated voltage, with the same power rating as specified in articles 4.2 and 4.3.

4.2 Rated short-circuit currents

Primary winding: 765 A

100 Volt secondary windings: 42 kA

Table I shows the secondary currents and power output for each of the connections (3φ)

The transformer must be able to carry the nominal current for 1.0 second every 30 minutes, 4 consecutives times followed by a cooling of period of 12 hours.

The transformer must also be able to carry the nominal current for 0.15 sec. every 15 minutes for a period of 12 hours followed by 12 hours of cooling.

The transformer must be able to withstand these operating cycles repeated indefinitely, without the temperature rise in the copper or any part of the transformer exceeding 70°C.

A few times during its lifetime, the transformer must be able to withstand without damage, an accidental short-circuit current as calculated with a 22 kV network of 250 MVA, the current being limited only by the impedance of a single transformer. This applies for all connections of Table I.

4.3 Rated continuous power

Each transformer shall be capable of a continuous power output of 3 MVA at an ambient temperature of 37°C. The average copper temperature rise shall not exceed 65°C.

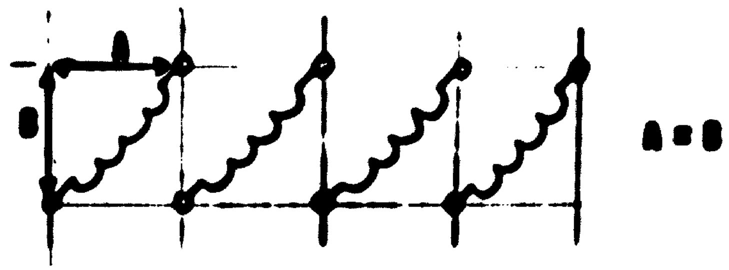
Table II shows the secondary continuous currents and power output for each of the connections (3ϕ).

The total continuous power available three phase (3ϕ) is 9 MVA.

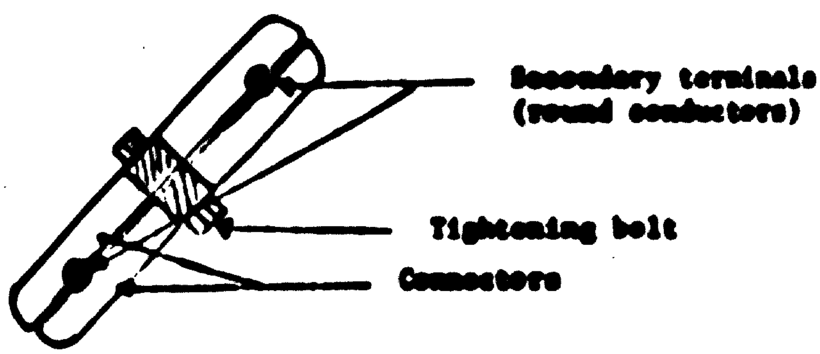
4.4 Connections of the four (4) secondary windings (100 Volts) of each transformer

Interconnection of the four (4) secondary windings shall be done manually with a device which shall facilitate the connections.

The device shall be chosen by the manufacturer and supplied by him. It shall permit fast operation, have a low impedance and be arranged in a geometrical way in order to facilitate the connections. Here is a suggestion:



The secondary terminals shall be round conductors and the connectors could be like this:



4.5 Insulation level

4.5.1 Primary winding

The terminals P_1 and P_2 of the primary winding and the corresponding bushing shall have the following insulation levels:

- Impulse withstand voltage: 125 kV crest
- Power frequency withstand voltage: 50 kV rms.

4.5.2 <u>Secondary winding</u>

With all secondary windings connected in series, the S_1 and S_2 terminals and corresponding bushing shall have the following insulation levels:

- Impulse withstand voltage: 20 kV crest
- Power frequency withstand voltage: 3.5 kV rms.

4.5.3 <u>Induced voltage insulation level</u>

The transformer shall be able to withstand without damage an induced voltage equal to 2.0 times rated voltage.

4.6 <u>Impedance</u>

The rated impedance of each transformer, as seen from the 22 kV side, the secondary windings being short-circuited, shall not be more than 9 ohms.

A tolerance of + 0%, - 10% is accepted on the basis of 9 ohms. The transformer will be rejected if the measured impedance exceeds these limits.

4.7 <u>Time constant</u>

The time constant of a cold transformer shall not be less than 0.0446 sec. i.e., a ratio $\omega L/R = 14$.

The manufacturer shall mention in his tender, the additional cost to provide a time constant equal to 0.0637 sec. i.e. $\omega L/R = 20$.

4.8 Magnetizing current

The manufacturer shall supply with his tender a curve showing the relation between the flux (ϕ) and the magnetizing current (I). The curve will show the relation up to twice the nominal flux. The nominal flux is obtained under a voltage of 22 kV.

4.9 Inherent frequency

The manufacturer shall give in his tender the calculated inherent frequency of the transient recovery voltage when the current is interrupted.

5. DESIGN

5.1 Insulating transformer

The three transformers will eventually be equipped with a current transformer in the tank grounding lead to detect any fault current flowing through the tank. Consequently, all control cables must be insulated from the tank and any power supply required for motors, heating elements, lighting etc... must be fed through an insulating transformer. This insulating transformer shall be supplied by the Manufacturer and mounted on the tank.

5.2 Gas detector relay

Each transformer shall be equipped with an appropriate gas-detector relay if it is liquid immersed.

5.3 <u>Windings rigidity</u>

The clamping arrangement shall be designed so as to prevent permanent deformation of the windings. The Manufacturer shall mention in his tender which measures are taken to insure a permanent blocking of the windings in spite of repetitive short-circuit forces. The manufacturer shall specify in his tender the clamping arrangement and the retightening procedure to be carried out during the life of the transformer if applicable.

5.4 <u>Overvoltage grading device</u>

Devices for distributing the voltage surges between windings shall not contain any non-linear resistances. Linear resistances will be permitted provided the change they cause in the recovery voltage is less than 1%.

If the Manufacturer intends to use grading capacitors, it shall be specified in the tender.

6. <u>TESTS</u>

6.1 <u>Impedance measurement</u>

This measurement is a routine test and it shall be carried out on each transformer.

6.2 <u>Impulse test</u>

This test is a routine test and shall be carried out at the voltage level specified in article 4.5. In addition the first transformer shall be submitted to the chop wave test as describe in IEC Publication 76.

its lifetime without being destroyed (but which could however, necessitate adjustment of the contacts)..........kA.

6.3 Power frequency Test

Induced and applied potential test shall be carried out on all transformers in agreement with insulation levels specified in article 4.5.

6.4 Short-circuit tests

6.4.1 The purpose of these tests is to check the transformer strength under electrodynamic forces. These tests shall be carried out on a completely finished transformer.

6.4.2 The transformer shall be subjected to three (3) tests at accidental short-circuit current as defined in article 4.2. The current asymmetry must be at least 1.8 x $\sqrt{2}$ time the rms value. The duration of the short-circuit will be of 0.1 sec. with a tolerance of ±20%. The purchaser shall have the right to choose, out of the cases given in Table I, the connections for carrying out the tests. The connectionsmay be different for the three cases mentioned above. The facilities of the testing station shall be taken into account for the choice.

Prior to performing the tests specified above, the Manufacturer may, if he wishes to do so, carry out preliminary tests with parameters and connections of his choies.

It is permitted to readjust the clamping of windings between individual preparation tests and between the three tests with accidental current.

6.4.3 After the tests specified in clause 6.4.2, a set of short-circuit tests shall be made at 100% of rated short-circuit current, with maximum asymmetry on a connection selected by the Purchaser. After each test a measurement of the reactance will be made by means of a bridge providing a minimum sensitivity of 0.05% between two successive measurements. A low voltage impulse measurement shall also be carried out between each test to detect variation in winding capacitance caused by local displacement in the winding.

The number of tests will be such as to permit a fair conclusion concerning the stabilization of the windings. The number may be of the order of five (5). If however the stabilization is not reached it will be possible to continue the series of tests, up to a total number of about ten (10) tests. No adjusting, clamping of windings or other changes are allowed during this set of tests.

6.4.4 Oscillographic recording of primary and secondary currents and of the voltage on supply side terminals will be made on each tests.

The transformer will be observed visually and by photographic methods in order to obtain positive proof of the external phenomena during the tests.

6.4.5 Acceptance of the transformer will be based on the fulfilment of the following conditions:

a) no evident sign of damage to the transformer during and after the tests according cl. 6.4.2 and 6.4.3

b) no inflamable gas found in the gas-detecting relay after each test.

c) the reactance measurement according to cl. 6.4.3 will show a fair tendency of winding stabilization.

d) the measurements of the low voltage impulse response according to cl. 6.4.3 will not show excessive changes.

e) a visual checking of the interior of the transformer after the tests shall not show any sign of damage on the bushings, connections, clamping plates and all other parts accessible without dismantling the transformer.

6.4.6 The Manufacturer shall be responsible for carrying out short-circuit tests of the first transformer only. The other units shall be submitted to the same series of tests soon after having been put in service.

6.4.7 The short-circuit on the secondary shall be pre-established.

6.5 Temperature rise

The transformer shall carry the nominal current for 0.15 sec. every 15 minutes until the top oil temperature has stabilized. At that point, the copper temperature shall be measured by the resistance variation method and the temperature rise shall not exceed 70°C. This measurement shall be made immediately after the last passage of current.

This temperature rise test can be avoided if it can be demonstrated by calculation that after 5 sec. of continuous operation at rated current the copper temperature rise does not exceed 70° C.

The rated continuous power shall be demonstrated by a temperature rise test as described in IEC Publication 76 art. 41 using the 200 Volts secondary connections.

6.6 Changes after the tests

Any changes or modifications made on the first transformer following the tests, must also be made on all other units.

If the changes are judged by the Purchaser as major, the transformer is considered as new and all the tests shall be repeated.

6.7 Inherent frequency

The inherent frequency of the winding shall be recorded by any circuit providing a neat interruption at current zero of a sinusoidal current flowing in the secondary windings.

7. **QUESTIONNAIRE**

The Manufacturer is requested to fill in the following questionnaire and attach it to his tender.

1. General description of the transformer and diagram of windings connections.

   Description attached..........

2. Preliminary outlined drawings showing principal dimensions of the transformer and details of the base and final position of bushings.

   Description attached..........

3. Indications concerning the weights of the transformer, the largest shipping weight and description of the transport means.

   Description attached..........

4. Curve showing the relation between magnetizing current and flux (Clause 4.8 of the technical specification).

   Drawing attached..........

5. Magnetizing current (primary side).

   At 100% rated voltage.......... Amps.

   At 105% rated voltage.......... Amps.

6. Impedance from primary side for each connection possible on the transformer.

   Description attached..........

   (Clause 4.6 of the technical specification).

7. Time constant of the transformer $\omega L/R =$).

   (Clause 4.7 of the technical specification).

8. Modifications required and increased of dimensions and of weight for increasing the time constant to a value of 0.637 sec. i.e. $\omega L/R = 20$.

   Description attached..........

   (Clause 4.7 of the technical specification).

9. Description of the connections of the four (4) secondary windings (100 Volts) of each transformer and the device which will be used to make these secondary connections.

   Description attached..........

   (Clause 4.4 of technical specification).

10. Description of windings blocking system. Necessity of retighten and procedure to follow in such case.

    Estimation of man/hours necessary for retighten.

    Description attached..........

    (Clause 5.3 of the technical specification).

11. Presence and characteristics of voltage grading device.

    Description attached..........

    (Clause 5.4 of the technical specification).

12. The quantity of askarel required for each transformer will be of .... liters.

    Type and characteristics of the insulation liquid..........

    Manufactured by..........

    Manufacturer's insulation liquid specification name and/or number...... ....

13. Bushing make, type, nominal voltage, nominal continuous current, short-time current (3 sec.).

Description attached..........

14. Test facilities at our disposal to carry out the dielectric tests.

Description attached..........

15. Test facilities at our disposal to carry out short-circuit tests and proposals as to testing procedure.

Description attached..........

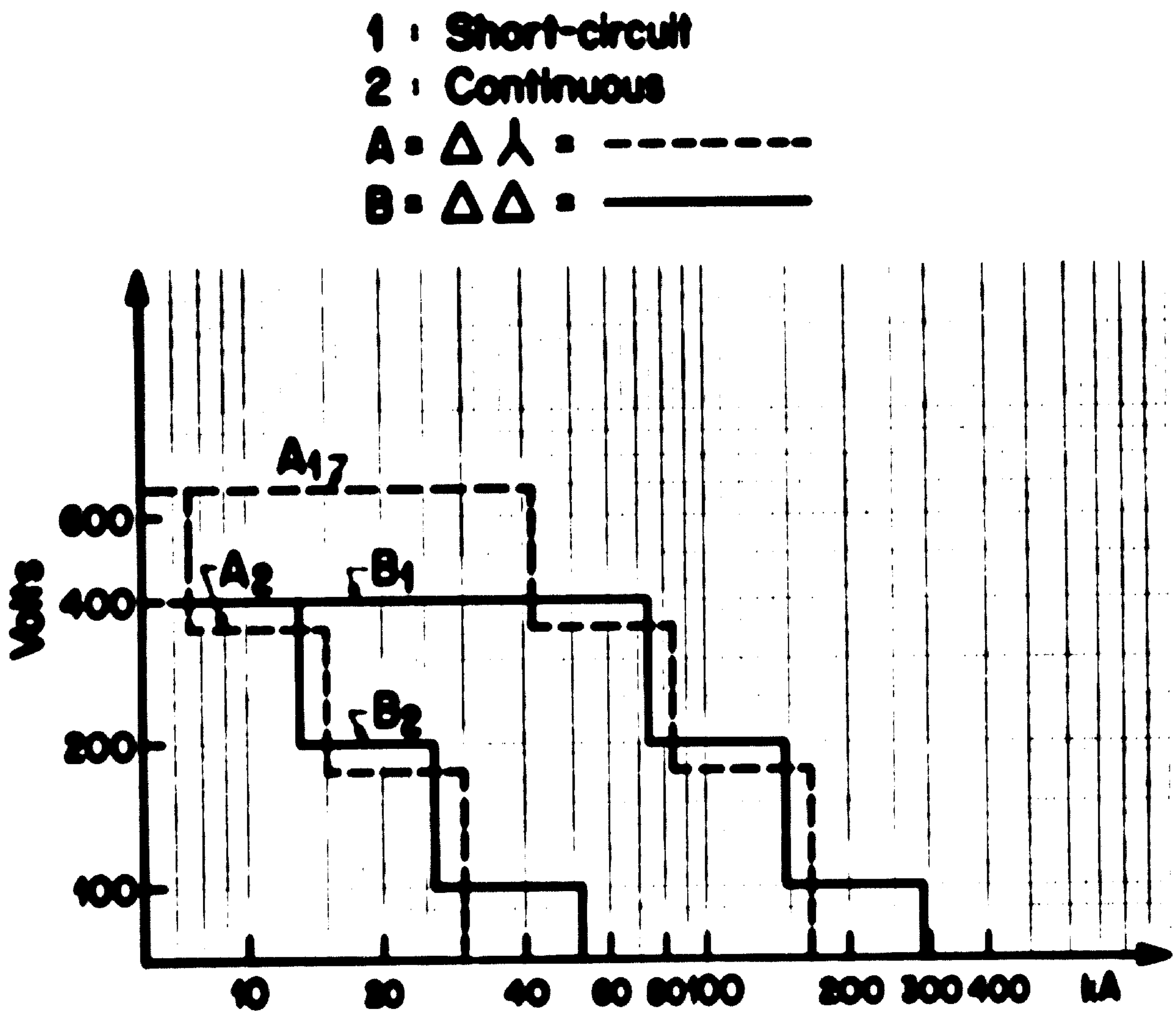
(Clause 6.4 of the technical specification).

16. Estimate of men/hours required to complete the assembly at site.

.... men/hours.

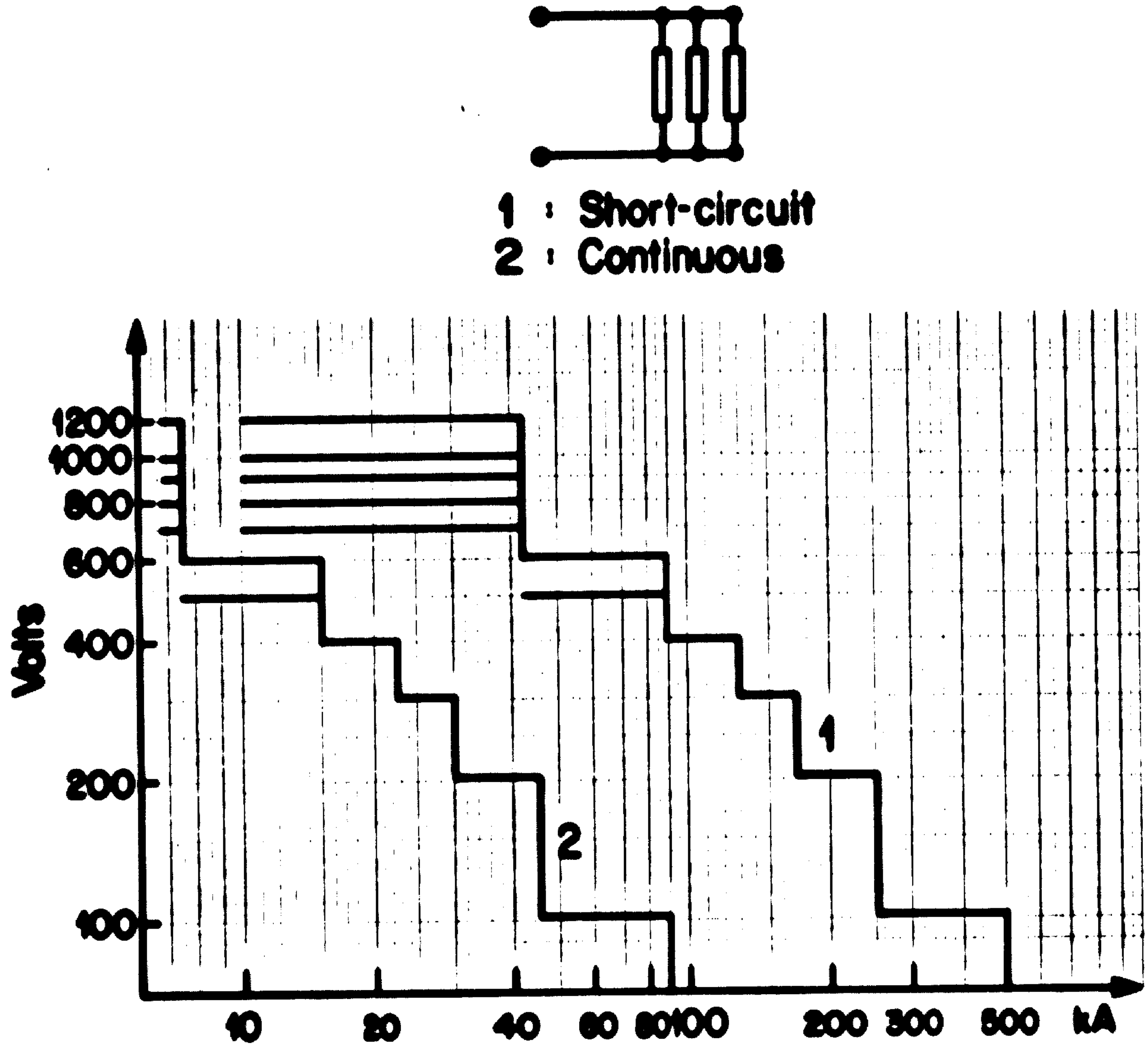
17. Experience and list of short-circuit transformers already built, up to now, by us.

List attached..........



Three-phase voltages and currents

Figure 2a



Single phase voltages and currents

Figure 2b

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27 MW TRANSFORFER RECTIFIER SET

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1. **SCOPE**

This specification covers the requirements of the Electrical Industry Testing and Experimentation Center for the supply of a transformer-rectifier set for making short-circuit and/or heat run tests at direct current in the D.C. test section of the High Power Laboratory.

The supply includes engineering, manufacturing, testing and shipment of the set along with the auxiliary equipment specified herein.

2. REFERENCE STANDARDS

The following standards shall apply, except for modifications or additions thereto made by this specification.

IEC Publication No. 146, 1963: Monocrystalline semiconductor rectifier cells, stacks assemblies and equipments.

3. GENERAL DESCRIPTION

The transformer-rectifier set will be used for supplying direct current for tests, drawing the energy from the network or, occasionally from the main short-circuit generator of the H.P. Section.

It will be used routinely for making short-circuit and heat run tests on apparatus such as:

- bus bars
- contacts and switches in closed position
- D.C. breakers and switches during switching operations
- D.C. fuses
- any other types of apparatus and equipment which might be subject during operation to high D.C. Currents.

The tests will be made at full power and different voltage levels using different D.C. side connections. On the other hand test at limited power may be made using supply voltage regulation.

4. ELECTRICAL CHARACTERISTICS

The schematic diagram hereafter shows, as an example, the general connection of the transformer-reactifier group.

The primary is three-phase, supplied normally from 22 kV bus having a short-circuit rating of 250 MVA, in a back-up circuit breaker a set of current limiting reactors and a synchronous making switch.

The secondary of the rectifier-transformer is formed by 6 separate three-phase windings, each of them supplying one three-phase rectifier bridge. It is left to the choice of the manufacturer, whether all six secondaries will be in one transformer, or whether the set will be split in two or more transformer units.

The six rectifiers shall consist of six three-phase groups of "bridge" connected units. It is suggested to supply three of them by a Y connected winding and the remaining three by Δ connected winding, in order to limit the voltage ondulation.

The rectifiers shall be made of silicon diodes.

The D.C. characteristics of each bridge will be:

D.C. no-load voltage	600 V
Short-circuit current during 0.5 sec.	7.5 kA
Continuous load current	0,750 kA

Combinations of parallel and series connections of the bridges on the D.C. side give the following ratings of the whole transformer-rectifier group, assuming the primary voltage is 22 kV.

TABLE I: D.C. voltages, short-circuit currents and permanent currents

Connection of D.C. bridges	Voltage Volts, D.C.	Short-circuit Current - 0.5 sec. kA	Continuous current kA
6 in series	3600	7.50	0.750
5 in series	3000	7.50	0.750
4 in series	2400	7.50	0.750
3 in series 2 in parallel	1800	15.00	1.5
2 in series 3 in parallel	1200	22.50	2.25
6 in parallel	600	45.00	4.5

4.1 Rated no-load voltage

The primary windings shall be connected in star and have a phase-to-phase rated voltage 22 kV.

The secondary windings of the transformer will be as follows: three of the six three-phase windings shall be in star and the other three in delta. The secondary voltage will be such as to give on the D.C. side a rated voltage equal to 600 V D.C. average value.

The D.C. Voltage shall be 600 V D.C. average value per bridge, permitting to make all voltages shown in Table 1.

In parallel connection of the bridges, interphase transformers will be added where necessary.

The transformer-rectifier group shall be capable of operating at 110% of the rated voltage with the same power rating.

4.2 Rated short-circuit currents

The transformer-rectifier set shall be able to deliver short circuit currents specified in Table 1 during 0.5 second, at every 15 minutes, during one hour (five consecutive shots). After this, the transformer rectifier set shall be permitted to cool down to the ambient temperature.

4.3 Insulation

4.3.1 Primary winding

The terminals of the primary windings and the corresponding bushings shall have the following insulation levels:

- Impulse withstand voltage 125 kV crest
- Power frequency (50 Hz) withstand voltage 50 kV r.m.s.

4.3.2 Secondary windings

- Impulse withstand voltage ~~to earth~~ 25 kV crest
- Power frequency (50) withstand voltage to earth 10 kV r.m.s.

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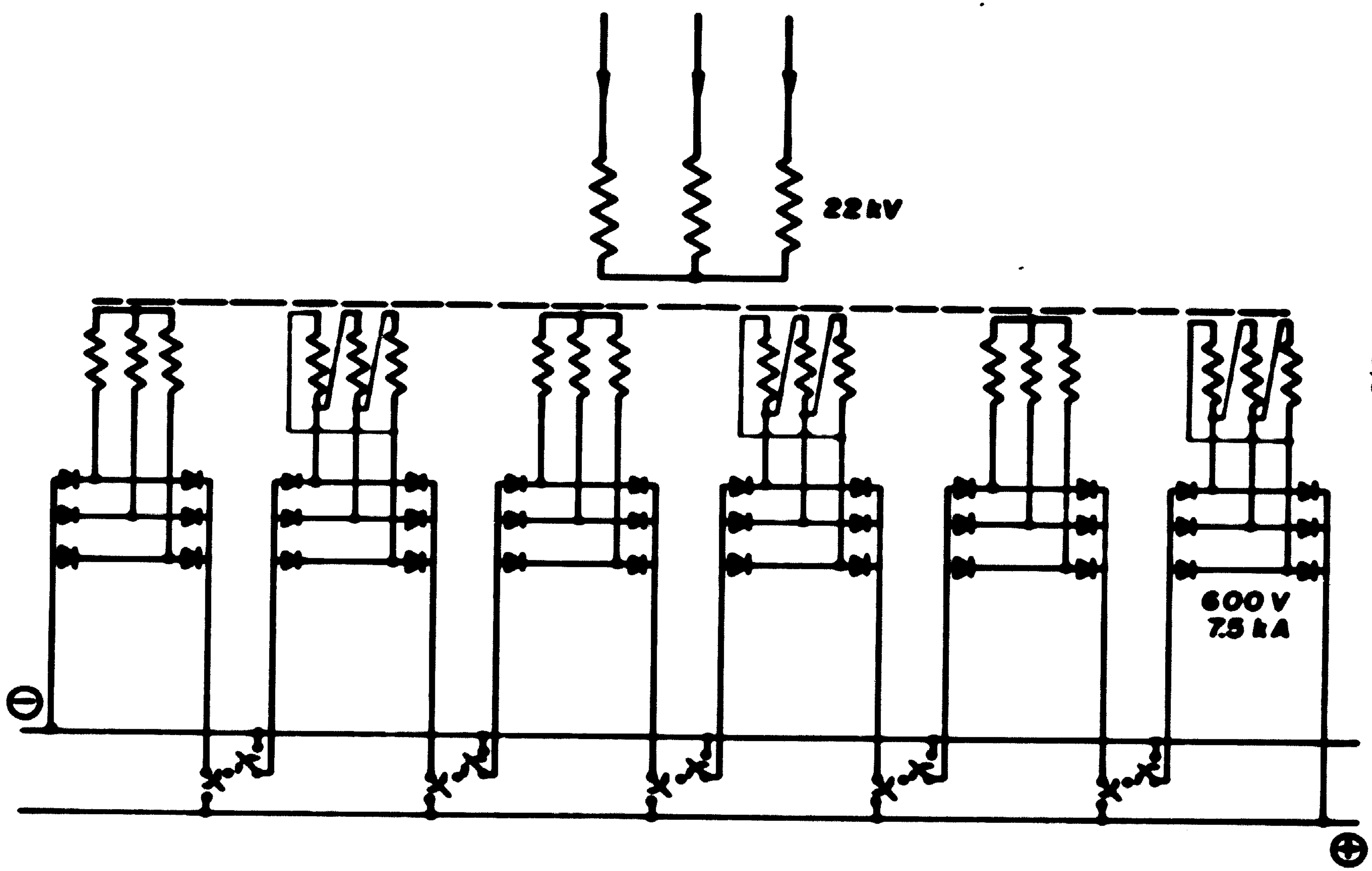

TRANSFORMER – RECTIFIER SET FOR D.C. TEST CIRCUIT

4.3.3 Induced voltage insulation levels

The transformer shall be able to withstand without damage an induced voltage equal to 2.0 times rated voltage.

4.4 Protection against overvoltage

The manufacturer shall propose means to protect the secondary of the transformer and the rectifier against overvoltages produced by instantaneous current chopped by the tested apparatus on the D.C side.

This means shall be such as to permit the development of the over voltage, without any limitation, up to a value of 3.5 times the rated D.C. voltages according to Table 1. Higher overvoltages may be cut off by arresters, lower values shall be managed by such means as voltage grading, adequate insulation levels etc...

Signalization of the overvoltage protection will be provided.

4.5 Protection against overcurrent

Each diode of the rectifier shall be protected by a high-speed fuse. The operation of the fuse shall be signalised on the control panel in the control room. The signaling contacts on the fuses and the wiring up to a terminal board on the rectifier shall be included.

4.6 Impedance

The rated impedance of the transformer, as seen from the 22 kV side, the secondary windings being short-circuited shall be not more than 10 ohms.

A tolerance of + 6%, - 10% is accepted on the basis of 10 ohms. The transformer will be rejected if the measured impedance exceeds these limits.

4.7 Time constant

The time constant of a cold transformer shall not be less than 0.0446 sec. i.e., a ratio $\omega L/R = 14$.

The manufacturer shall mention in his tender, the additional cost to provide a time constant equal to 0.0637 sec. i.e. $\omega L/R = 20$.

4.8 Magnetising current

The manufacturer shall supply with his tender a curve showing the relation between the flux (ϕ) and the magnetising current (I). The curve will show the relation up to twice the nominal flux. The nominal flux is obtained under a voltage of 22 kV.

5. CONSTRUCTION

5.1 Gas detector relay

The transformer shall be equipped with an appropriate gas-detector relay if it is liquid immersed.

5.2 Windings rigidity

The clamping arrangement shall be designed so as to prevent permanent deformation of the windings. The Manufacturer shall mention in his tender which measures are taken to insure a permanent blocking of the windings in spite of repetitive short-circuit forces. The manufacturer shall specify in his tender the clamping arrangement and the retightening procedure to be carried out during the life of the transformer if applicable.

6. TESTS

Besides the standard test, as specified in the IEC Publication No. 146, the following tests shall be made:

6.1 Short-circuit tests

6.1.1 The purpose of these tests is to check the transformer-rectifier set electrodynamic and thermal constraints. These tests shall be carried out on a complete and finished set.

6.1.2. The short-circuit shall be pre-established on the D.C. side.

6.1.3 The transformer-rectifier set shall be subjected to three (3) tests at accidental short-circuit current as defined by the short-circuit capacity of the supply 22 bus (250 MVA) and transformer impedance according to clause 4.6. The duration of the short-circuit shall be of 0.1 sec. with a tolerance of ± 20%. A right shall be reserved to the Purchaser to choose, out of the cases given in Table I, those connections to be used for the tests. The connections shall be the same or be different for the three cases mentioned above.

The Manufacturer is free as to make before the tests mentioned above, a set of preparation tests; the number, parameters and connections being selected by him. It is permitted to readjust the clamping of windings between individual preparation tests and between the three tests with accidental current.

6.1.4 After the tests specified in clause 6.1.3, a set of 5 short circuit tests shall be made at 100% of rated short-circuit current with a duration of 0.5 sec. for each test and with intervals between tests equal to 15 min. The connections to be selected by the Purchaser. After each test, a measurement of the reactance will be made on the transformer by means of a bridge providing a minimum sensitivity of 0.05% between two successive measurements. A low voltage impulse measurement shall also be carried out between each test to detect any variation in the winding capacitance caused by local displacement of the winding.

6.1.5 Oscillographic recording of primary and secondary currents of the transformer, of the D.C. current and of the voltage on the supply side terminals will be made for each tests.

The transformer-rectifier set will be observed visually and by photographic methods in order to obtain positive proof of the external phenomena during the tests.

6. 1.6 Acceptance of the transformer-rectifier set will be based on the fulfilment of the following conditions:

a) no evident sign of damage to the transformer and/or rectifier during and after the tests according cl. 6.1.3 and 6.1.4.

b) no inflammable gas found in the gas-detecting relay of the transformer after each test.

c) the reactance measurement according to cl. 6.1.4 shall show a fair tendency of winding stabilisation.

d) the measurements of the low voltage impulse response according to cl. 6.1.4 shall not show excessive changes.

e) a visual checking of the interior of the transformer after the tests shall not show any sign of damage on the bushings, connections, clamping plates and all other parts accessible without dismantling the transformer.

f) a visual checking of the rectifier shall not show any sign of damage on the diodes, connections and any other parts accessible for inspection without dismantling.

g) the diode fuses shall not be blown.

6.1.7 The Manufacturer shall be responsible for carrying out all tests including short-circuit tests specified hereabove.

7 GROUNDING

All non-conducting metal parts of the transformer-rectifier set shall be connected to the main grounding system of the high power test-station.

The Manufacturer shall supply all the connectors linking the metal fittings of each piece of equipment to the main grounding system, which will consist of a copper bar at least 0,635 cm x 5 cm or equivalent.

The main grounding system shall be supplied by the Purchaser.

8. STRUCTURE AND ACCESSORIES

The Manufacturer shall supply the structure that support all the equipment on the floor, such as metallic cubicles and similar items. The Manufacturer shall also supply a complete set of accessories and tools needed for reliable operation and for maintenance of the transformer-rectifier set.

9. SPARE PARTS

The Manufacturer shall supply with the transformer-rectifier set an adequate number of spare diodes, diode-fuses and other spare parts if necessary.

10. GALVANIZING AND SURFACE PROTECTION

All steel parts shall be galvanised in accordance with the Spanish standards.

All other parts shall be protected against corrosion by adequate means if necessary.

11. ALTERNATIVE

The Manufacturer is invited to suggest, as an alternative, any other system offering better economy, more flexibility or advantages in installation and/or operation covering, however, at least the characteristics shown in the present specification.

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REACTANCES AND RESISTANCES

OUTLINE OF THE REACTANCES AND RESISTANCES FOR HIGH CURRENT AND DIRECT CURRENT SECTION

The reactances will be primarily utilised for adjustment of the short circuit current initial slope. They should be designed in such a way that their Q-factor is not less than 20 at the industrial frequency and at the nominal voltage of 3600 V. A set of six reactances is required and their respective parameters are specified in Table 1. The two last reactances are equipped with taps.

TABLE 1

No.	Inductance	Short circuit current	Taps Number
	mH	kA	
1	24	10	1
2	12	20	1
3	6	42	1
4	3	84	1
5	1.5/0.75	144	2
6	0.4/0.2	144	2

For the dc section a set of resistors is specified. They are designed in such a way to withstand the nominal short circuit current applied to the resistance every 30 minutes or one half of the nominal short circuit current every 15 minutes during an 8-hour shift. The nominal values of the resistances are given in Table 2, their rated voltage is 3600 V.

TABLE 2

No.	Resistance	Short circuit current (0.2s)	Power dissipated 0.2s
	Ω	kA	MW
1	24	0.150	0.6
2	12	0.3	1.1
3	6	0.6	2.15
4	3	1.2	4.3
5	1.5	2.4	8.6
6	0.75	4.8	17.3
7	0.4	9.0	32.4
8	0.2	18.0	65.
9	0.1	36.0	130.
10	0.05	72.0	260.
11	0.025	144.0	520.

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SYNTHETIC TEST CIRCUIT

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5.	Adjustment of parameters	4
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1. GENERAL

The synthetic circuit proposed is based on the principle of current injection, generally known (1.2) and officially recognized (3.).

For the purpose of definitions and terminology used in this report, Fig. 1 shows the basic diagram and shapes of currents and voltages.

As high-current source, the equipment of the test section No. 1 is used, supplying the required current under a voltage equal to about one fifth of the rated voltage of the tested breaker.

As high-voltage source, a special type of oscillating circuit is used. The description of this circuit and its function is the purpose of this report.

2. BASIC FORM OF THE HIGH-VOLTAGE SOURCE

Two branches are specified in the high voltage source as shown in Fig. 1b.

a) The injection branch including the main condensor bank C_p, the main inductance L and the spark gap S, is connected to the terminals of the tested breaker TB, forming together the injection circuit, C_p being charged prior to the test, when the gap S is triggered, the injection current circulates in the injection circuit, superimposed upon the current loop of the high-current source.

b) The T.R.V. control branch, including the T.R.V. condenser bank C_R and a damping resistor R, is in parallel with the tested breaker. The breaker being closed during the current period, this branch is short-circuited. When the breaker opens, the T.R.V. control branch forms an oscillating circuit with the injection branch, and an equalizing current in that circuit creates the transient recovery voltage across the tested breaker.

Fig. 1 shows, however, the synthetic circuit in simplified form only. Actually two additional principles, developed recently have been applied in combination with this project: first the multistage high-voltage circuit and second a two-frequency T.R.V. control circuit. These two principles will be described now.

3. MULTI STAGE H.V. CIRCUIT

Instead of one circuit-element, as shown in Fig. 1b, the H.V. source is made up of several stages (five in our case) each stage having all the elements as shown in Fig. 2 . Interstage isolating switches are arranged to put the stages either all in series or all in parallel or in any other possible series parallel connections. The test connections being pre-selected by means of these switches. The stages are always charged in parallel via charging resistors and isolating switches. They are discharged, by triggering the gaps S of all stages. Only at this moment the preselected connection enters into play.

It might be said that this circuit is in a general way similar to the Marx multiplication circuit, and is a combined current and voltage impulse generator, delivering prior to the moment of interruption the injection current loop and, following interruption the T.R.V. wave. All the numerous advantages of this circuit are enumerated in the patent granted to one member of our scientific staff (4.5).

4. TWO FREQUENCY T.R.V. CONTROL CIRCUIT.

This is another recent innovation proposed by another member of our staff (6.7). This circuit is shown in a simplified form in Fig. 3, and has been proposed mainly to meet the requirements of the IEC Publication 56, concerning the shape of the T.R.V. wave, described by four parameters (8).

According to the basic idea of this circuit, instead of having just one oscillating circuit as shown in Fig. 1b, two circuits are used in series, each one having its injection branch and its T.R.V. branch.

During the injection period, the inherent frequencies of the two injection branches are the same and the charging voltages of the precharged capacitors are proportional to the inductances L_1 and L_2, so that no energy exchange exists between the two injection sections. Due to this condition the T.R.V. branches behave as if they were short-circuited.

After the interruption, the two T.R.V. circuits start to oscillate independently. Two very different T.R.V. control branches are usually used. The high-frequency circuit is usually a low energy content, heavily damped circuit, delivering mainly the high initial rate of rise of the T.R.V. The low frequency circuit has much more energy and is basically without any or with very little additional damping. This circuit delivers mainly the major peak of the T.R.V. shape.

The two frequency T.R.V. control is readily obtainable, using the multi-stage H.V. circuit as described in article 3 and shown on Fig. 2. Usually 3 or 4 stages will be used as low-frequency circuit and 2 or 1 stage as high-frequency circuit.

The stages having a very fine control of the elements the T.R.V. shape specified by I.E.C. and many more shapes according to the specifications of the manufacturer or user of the tested breaker can be obtained with a high degree of accuracy.

As also shown in Fig. 2, two charging generators are used, enabling to pre-charge the stages belonging to high-frequency circuit and low frequency circuit respectively, to slightly different voltages as stipulated by the method.

5. ADJUSTMENT OF PARAMETERS

For testing, broad ranges of test capacities, rated breaker voltages and T.R.V. shapes are desirable. This will be possible to achieve by using three methods in combination:

a) connection of stages(series, parallel or combined.)
b) connection of elements inside the stages
c) interchanging capacitors between C_p and C_R.

Method according to a) will be used as rough adjustment, and all possibilities are evident from Fig. 2. Fine adjustment will be made using different connections inside the stage. Fig. 4, shows the detailed circuit diagram of one stage.

As can be seen, the main capacitor bank is made up from 48 capacitor elements, each rated at 30 kV, 20 μF. All 48 elements are connected permanently in chain and any intermediate point between two elements can be connected to any of the two collector bars, by remotely controlled isolating switches. This system permits to put all elements in series or in parallel and to use groups of any number of series connected elements, which are put in parallel by means of the switches and collector bars. The rated voltage of a stage being 180 kV peak, up to 6 elements at full charging voltage can be used. All multiples of 30 kV, up to 180 kV, give the full capacity of the bank. Only with 5 units, in series are three elements lost. A higher number than 6 elements per stage will be used for lowering the capacitance, in this case the charging voltage must not exceed 180 kV.

The general lay-out and circuit diagram of the T.R.V. control bank is the same as that of the main bank. Only two differences appear: first the elements are 10 μF instead of 20 μF, second, the halves of the stage can be connected in series as shown in Fig. 4. This takes into account the overshooting of the T.R.V. up to twice the stage voltage.

The same principle applies to inductances, having however, 30 coils in a stage. The physical arrangement of the coils in a stage is shown in Fig. 5. The idea is to avoid any mutual inductance between the coils, thus making it possible to use any connection. In fact, the arrangement shown in Fig. 5, gives inherently no coupling between two adjacent coils. The percentage of coupling between any other two coils does not exceed 0.45%, which is fully compatible with the accuracy of adjustment.

12 resistors in series, forming a geometric series of values are used as damping resistors. Each resistor can be short-circuited by a switch. The lowest stage is equipped permanently with heavy damping resistors (high frequency circuit). The stages 3, 4 and 5 are equipped permanently with light damping resistors (low frequency circuit). Stage No. 2 is made in such a way that the two types of

resistors may be interchanged, so that this stage may be associated to low frequency or high-frequency circuit respectively, according to the need.

A third method of adjustment applies to capacitors only. Sections of condenser banks C_p and C_R , indicated by fine lines, may be physically separated from the respective bank and connected to the other bank.

All three methods in combination assure an extremely economical utilization of the capacitors, which are the most expensive elements of this circuit.

6. PHYSICAL LAY-OUT AND DESIGN

The circuit diagram of Fig. 4, corresponds to the physical lay-out, shown in full details in the drawing No. 1016. The drawings Nos. 1013, 1014 and 1015 show respectively a tower of main condensers, a tower of T.R.V. control condensers and a tower of inductances. The complete condenser banks, each of them, are formed by placing four towers side by side. The towers can be moved on air cushions, and when in place, they are electrically connected at the level of each stage.

In other words, both condenser banks are subdivided horizontally in five floors and vertically in four towers. The vertical subdivision and the possibility of moving the towers is made for two main reasons:

1. As mentioned before, a certain amount of exchange of capacitors between main bank and T.R.V. bank improves the overall economy, or in other words, for a given installed number of capacitor units, a higher test capacity is available.

2. As specified in detail in M.P.21, the capacitor banks will be used for several other purposes, besides synthetic testing. For these secondary purposes it is usually necessary to rearrange the banks inside the hall. This is readily done by moving the towers on air cushions.

For instance, when a lumped, three-phase condenser bank is to be made, one phase will be represented by the T.R.V. bank, the other two phases by the main bank split on two identical parts. The three phases which now have the same capacitances are located at suitable distances, and the remaining parts, not used in this case, are moved against the walls.

7. TEST CAPACITIES OF THE SYNTHETIC CIRCUIT

The test capacity of a synthetic circuit is not a fixed constant value. It changes in function of several parameters the two main being:

a) Capacity of the high current source
b) The shape and characteristics of the T.R.V.

The influence of the high-current circuit capacity is usually expressed by what is called "amplification factor". This factor being the ratio between the rated voltage of the tested breaker and the voltage of the high-current source, the lower is the voltage of the high-current source, the higher the amplification factor. This is, however, limited by the distortion of the current loop shape and it is usually assumed that the voltage of the current source (crest value) must be at least 4 times the sum of the arcing voltages of the tested breaker and the auxiliary breaker (see Fig.1). Consequently, depending on the arcing voltages of specific breaker designs, the amplification factor will be between 5 and 8, the average value being equal to 6.

Taking the latter value as an example, the Table hereafter shows in column 1 the test capacities, as limited by the high-current source for one and two generator-transformer sets respectively.

<u>The influence of the shape of T.R.V.</u> is more intricate. It can be accepted, as a very rough general rule, applicable at least for single frequency T.R.V. circuits, that the test power is proportional to the square of the T.R.V. frequency. In general, this is also true for more complicated shapes.

Based upon the T.R.V. shapes and values specified in IEC Publication 56 (See. Ref. 8), column 5 shows the calculated 3Φ equivalent test capacities, for test parameters specified in columns 2, 3 and 4.

Unfortunately, the T.R.V. parameters for rated voltages of 420 kV and more, according to IEC are based on very low T.R.V. frequencies, and result in very low test capacities in some cases.

This has been found incorrect and a revision of the tables of values is under way. It is practically sure that higher rates of rise and shorter times to crest will be accepted for 420 kV and more, implying higher T.R.V. frequencies. This will result in much higher test capacity limits than those shown in columns 5, without any change of the equipment.

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The International Symposium on High Power Testing
July 21-23, 1971, pp. 41-42

3. IEC Document: 17A (Central Office) 94, September 1971
Report on synthetic testing of H.V. alternating current circuit-breakers.
This document has been approved in 1972 and is now being printed.

4. Vladislav Zajic, Guy St-Jean: Multistage synthetic circuit for extra-high-voltage circuit-breaker testing.
IEEE Transactions, PAS-91, No. 3, pp. 782-790

5. Vladislav Zajic:
Patent, U.S.A. No. 3604976, Sept. 14, 1971
Patent, Canada No. 930461, July 17, 1973

6. Guy St. Jean: A method for calculating directly the components of a synthetic circuit for the testing of AC circuit-breakers
IEEE Transactions Paper: T73 340-7, April 25, 1973.

7. Guy St-Jean: Patent specification in preparation

8. I.E.C. Publication No. 56 (third edition 1971/1972)
High-Voltage Alternating-current circuit-breakers.

Table 1. Test capacities of the synthetic circuit

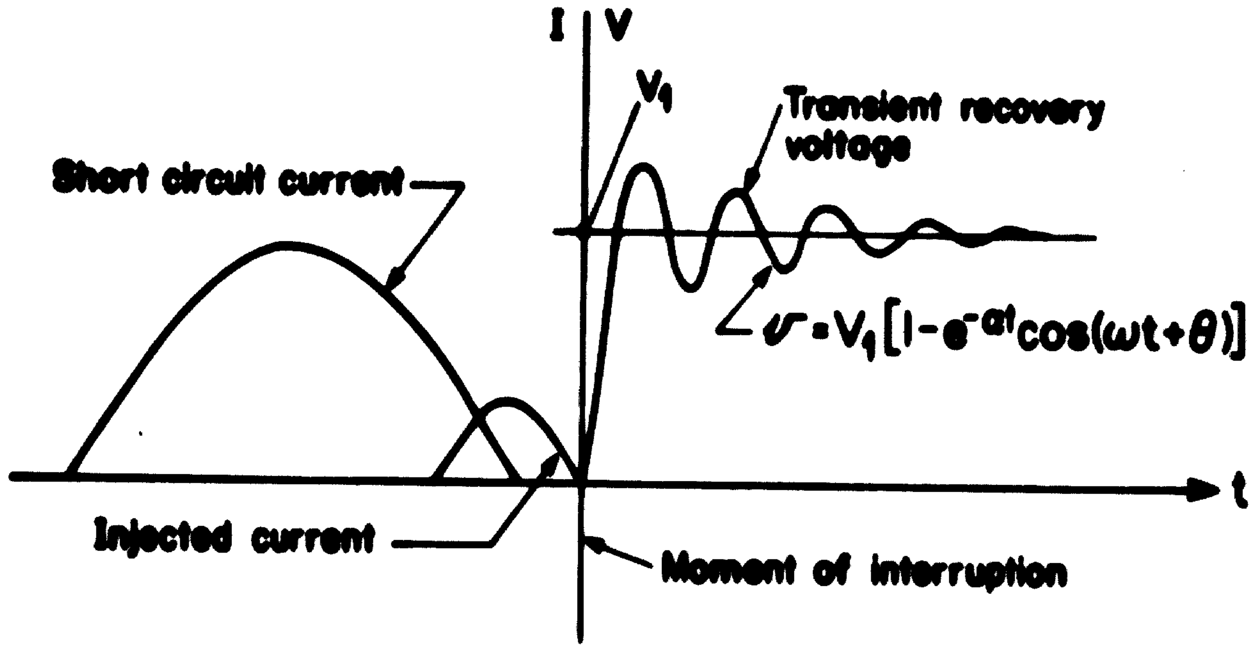
Notes: 1. The capacitinitive energy installed in H.V. Circuit is 3.2 MJ

2. The capacities are evaluated for one and two generator-transformer sets respectively.

3. The amplification factor is assumed to be equal to 6.

4. The T.R.V. shapes and values are according to I.E.C. 56, for first-pole-to-break factor k_T = 1.3. The last 6 lines of the table (4 parameters, 100% breaking capacity) are, however, calculated taking into account a correction due to the 50 Hz wave decrement.

High-current source capacity limit 3-φ equivalent GVA	High-voltage source capacity limit: Type of T.R.V. I.E.C. 56 -	High-voltage source capacity limit: Test cycle I.E.C. 56 No. & %	High-voltage source capacity limit: Rated Voltage KV	High-voltage source capacity limit: Available Capacity G.V.A.	Ultimate test capacity limit (lower of values from columns) 1 and 5: 1 gen.	Ultimate test capacity limit (lower of values from columns) 1 and 5: 2 gen.
1	2	3	4	5	6	7
1 generator-transformer set P 1.2 x 2 x $\frac{1.5}{1.3}$ x 6 = 16.6 GVA; 2 generator-transformer sets P 2.4 x 2 x $\frac{1.5}{1.3}$ x 6 = 33.2 GVA	T.R.V. specified by 2 parameters	2 (30%)	245	190	16.6	33.2
			300	190	16.6	33.2
			362	190	16.6	33.2
			420	190	16.6	33.2
			525	48	16.6	33.2
		3 (60%)	245	30	16.6	30.0
			300	30	16.6	30.0
			362	30	16.6	30.0
			420	30	16.6	30.0
			525	9	9.0	9.0
		4 (100%)	245	150	16.6	33.2
			300	103	16.6	33.2
			362	70	16.6	33.2
			420	52	16.6	33.2
			525	34	16.6	33.2
			765	15.7	15.7	15.7
	T.R.V. specified by 4 parameters	3 (60%)	245	10.0	10.0	10.0
			300	10.0	10.0	10.0
			362	2.5	2.5	2.5
			420	2.5	2.5	2.5
			525	2.5	2.5	2.5
		4 (100%)	245	26.0	16.6	26.0
			300	8.7	8.7	8.7
			362	10.5	10.5	10.5
			420	7.3	7.3	7.3
			525	10.0	10.0	10.0
			765	5.9	5.9	5.9


I
V
V_1
Transient recovery voltage
Short circuit current
$v = V_1[1-e^{-\alpha t}\cos(\omega t+\theta)]$
t
Injected current
Moment of interruption

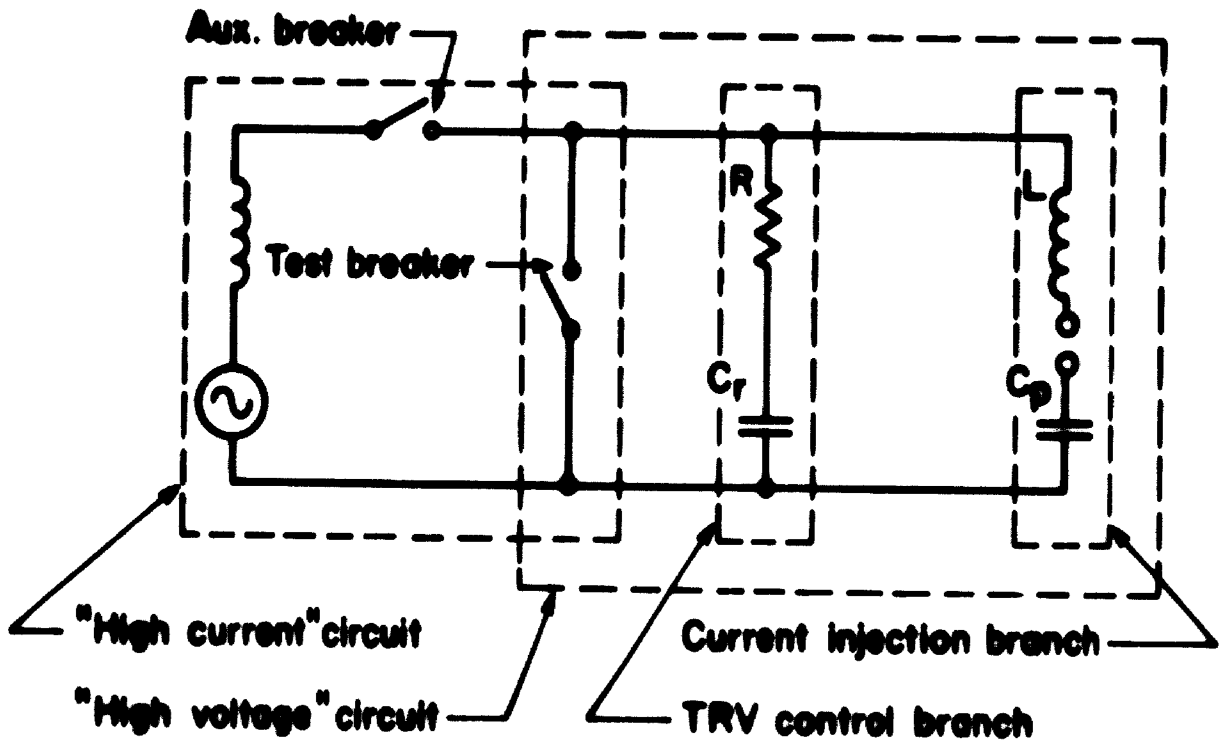

Aux. breaker
R
L
Test breaker
C_r
C_p
"High current" circuit
"High voltage" circuit
Current injection branch
TRV control branch

Figure 1

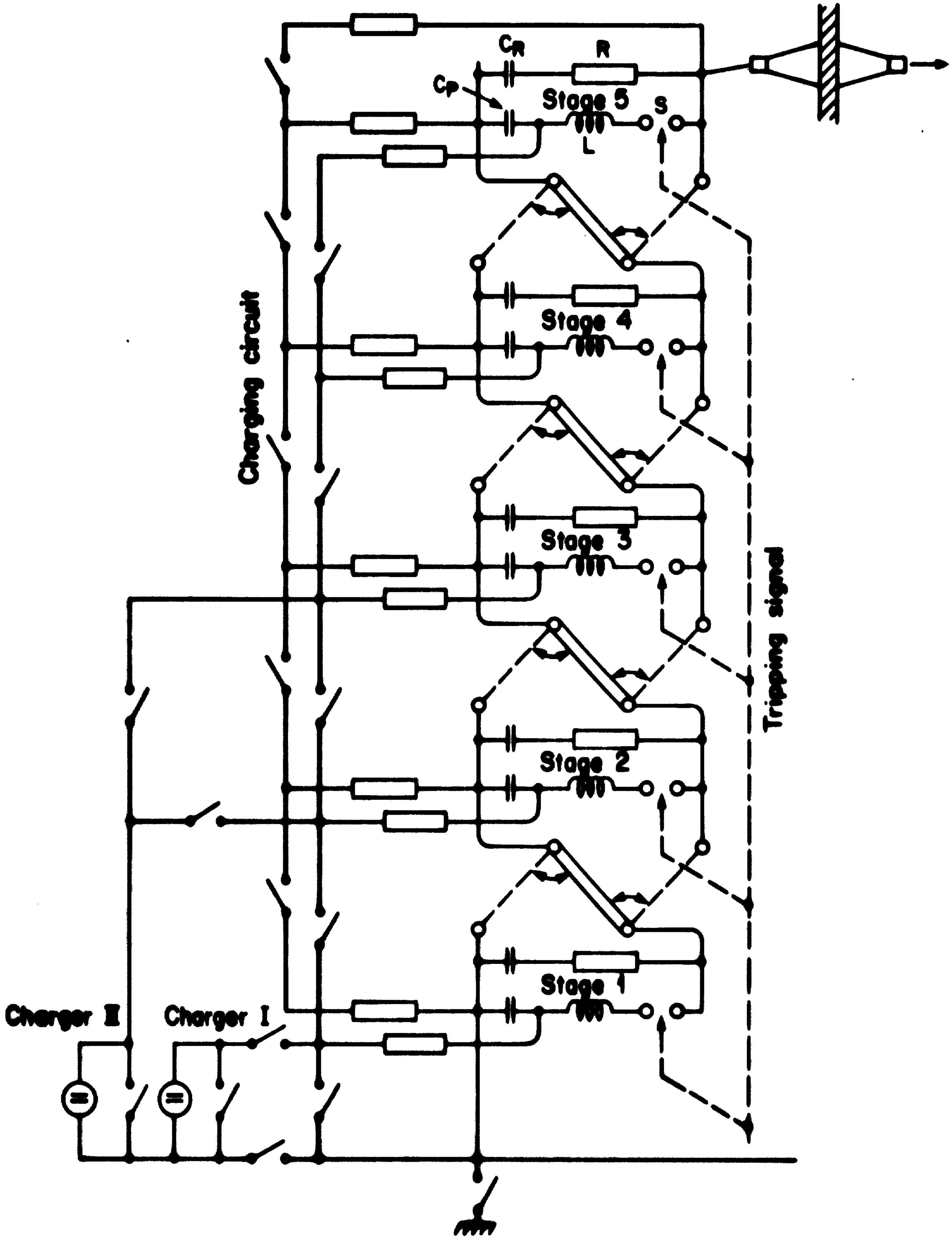
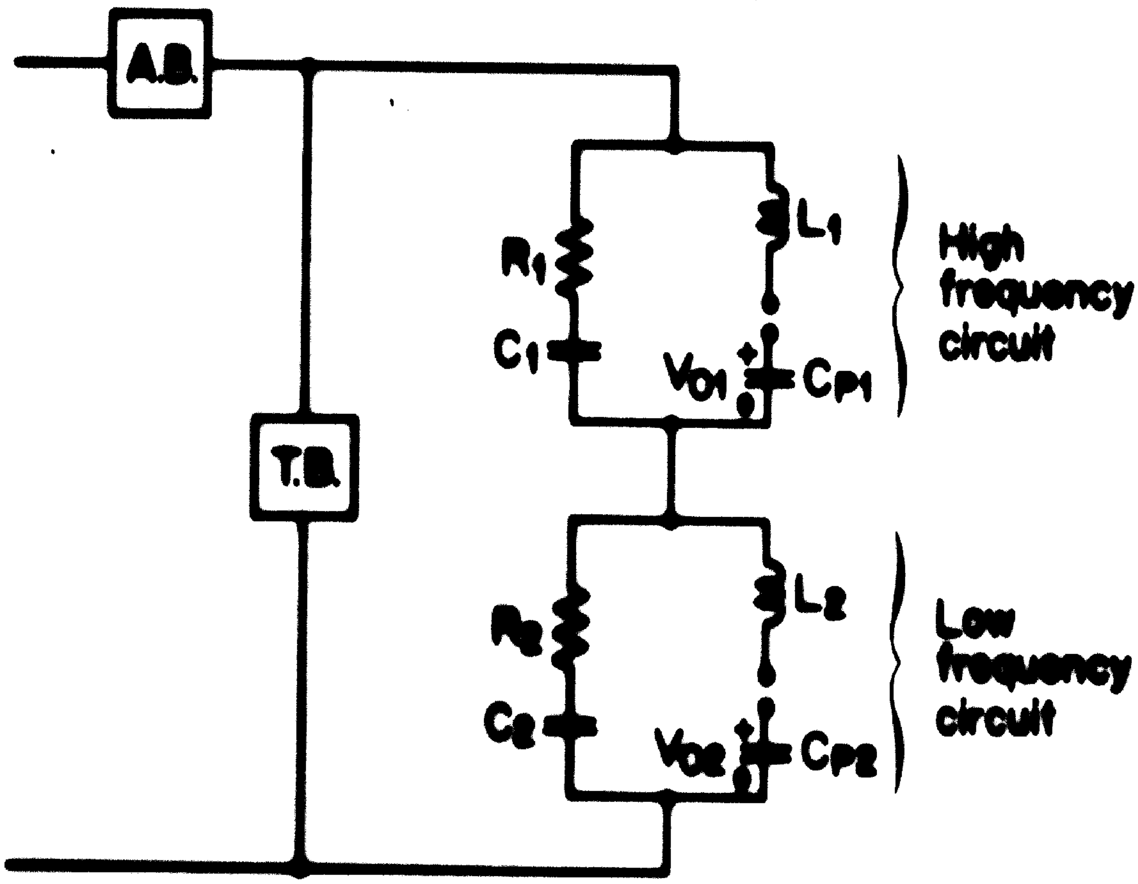

CR
R
CP
Stage 5
S
L
Stage 4
Stage 3
Stage 2
Stage 1
Charging circuit
Tripping signal
Charger II
Charger I

Figure 2



T.B. : Test breaker
A.B. : Auxiliary breaker

Figure 3

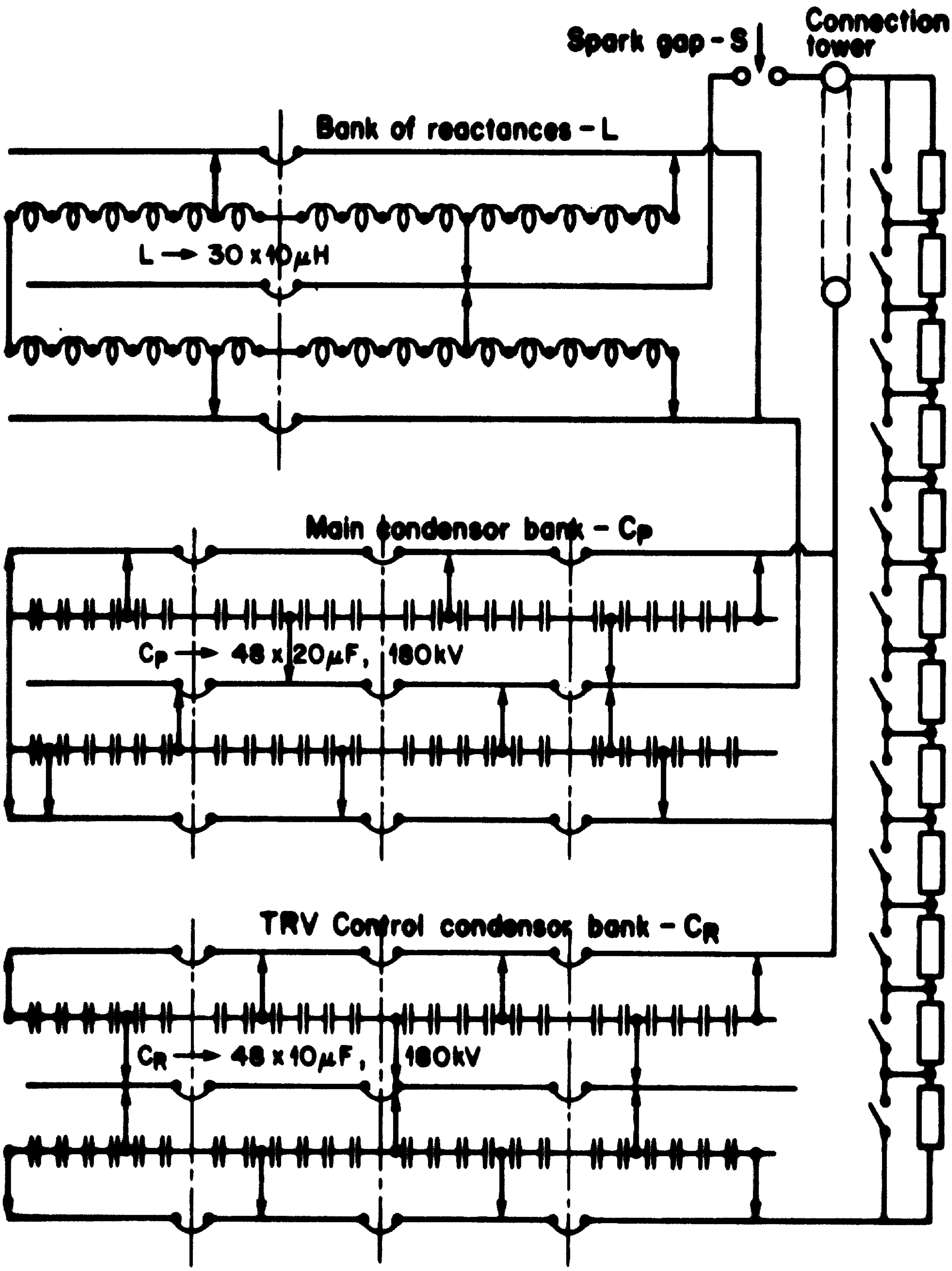


Figure 4 - Circuit diagram of one stage

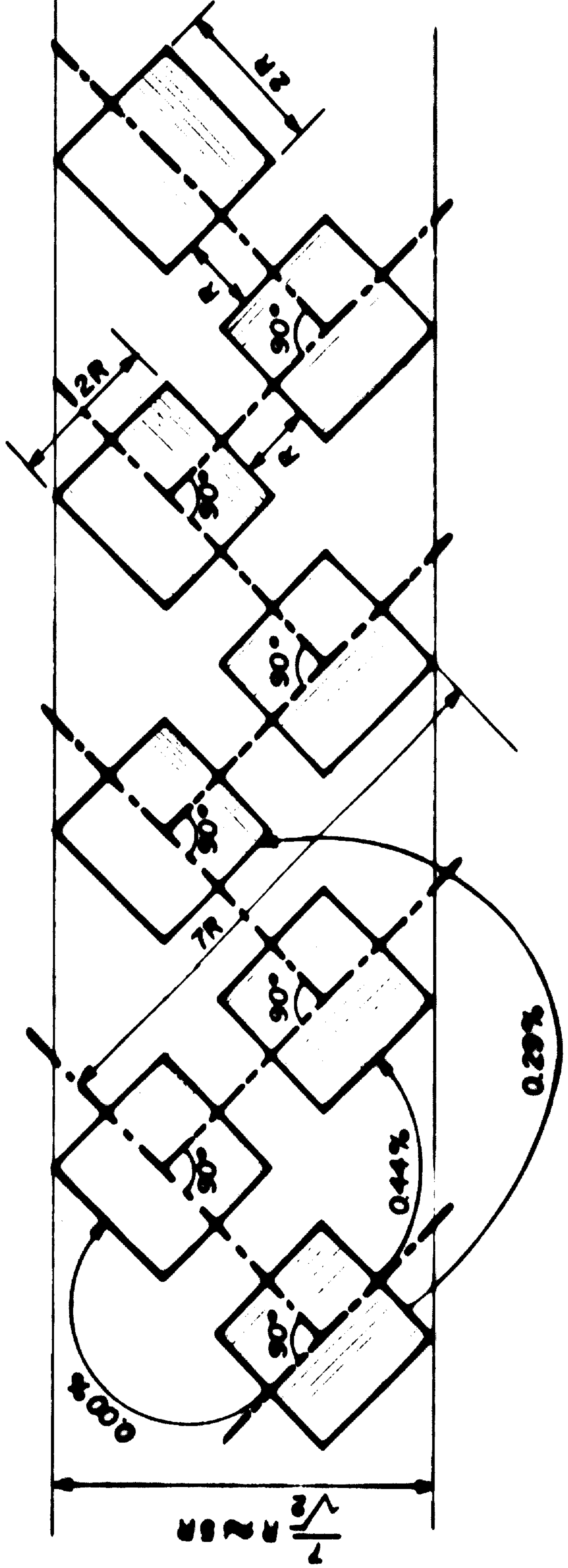

2R
R
2R
R
90°
90°
90°
90°
90°
90°
90°
7R
0.29%
0.44%
0.00%
$\frac{7}{\sqrt{2}} R \approx 5R$

Figure 5

HP 21

30 KV CONDENSERS

SCOPE

The present specification covers the requirements of the Electrical Industry Experimentation Centre for the supply of capacitors used in the synthetic test circuit of the High Power Laboratory.

Four options are specified as follows:

OPTION A: 720 elements rated at 30 kV, 10 μF

OPTION B: 1440 elements rated at 30 kV, 5 μF

Any of the two options may be offered in two sub-options:

SUB-OPTION I : Having a 50 Hz/60 Hz permanent service rating.

SUB-OPTION II : Not having a 50 Hz/60 Hz permanent service rating.

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2. GENERAL DESCRIPTION

The capacitors described hereafter will be used in the High Power Laboratory for the following purposes.

Primary use:

As a component of the H.V. part of a synthetic test circuit as in function of both the main capacitance and the T.R.V. control capacitance as will be explained in detail later on.

Secondary use:

From time to time, it will be possible to use the capacitors for the purposes listed hereafter. It is understood that the ratings of the elements for certain specific applications will be lowered if necessary.

a) As an element of a switching surge generator able to produce front durations of the order of 1 ms and more, at crest voltages up to 1400 kV.

b) As a T.R.V. control capacitance during direct tests, up to 765 kV, requiring very low T.R.V. frequencies.

c) As a lumped condenser bank during H.V. circuit breakers tests when switching capacitive currents of the condenser banks and charging currents of cables, at 50 or 60 Hz.

d) As an element for creating artificial circuits simulating long H.V. lines, unloaded or loaded at the end, for testing circuit breakers when switching such lines.

e) For power factor compensation during heat run tests of big transformers and of shunt reactors, at 50 Hz and 60 Hz.

2.1 Use of condensers for synthetic testing

Figures 1a and 1b, show the voltage and currents during a synthetic test, and the basic circuit diagram used, respectively.

The capacitance C_p being charged prior to the test at a specified voltage, the triggering of the spark-gap produces a pulse of injected current circulating in the circuit made up of the injection branch and the test breaker. This pulse is usually just one half-period of a sine wave. Sometimes, however, when a restrike occurs in the test breaker, the injected current continues to circulate until the whole energy of C_p is dissipated, giving a damped sine wave falling gradually down to zero.

The transient recovery voltage (TRV) pulse will be produced across a "control branch" (fig. 1b) made up of a capacitance Cr and a resistance R in series, by an equalizing current flowing from the injection branch to the control branch, after the interruption of the injected current. This pulse will have the shape determined by

$$v = V_1 \ (1 - e^{-\alpha t} \cos \omega t + \theta)$$

Where V_1 is the peak value of the power frequency recovery voltage:

$$(V_1 = K_T \frac{\sqrt{2}}{\sqrt{3}} \ V_n)$$

where K_T is the first pole-to-break factor and V_n the rated rms (phase-to-phase) voltage of the breaker. The oscillating frequency (ω) will vary from 200 Hz to 75 kHz and the control resistor will often be negligible which means that the voltage across the TRV control capacitors will be nearly twice the charging voltage.

2.2 Secondary Use

2.2.a The stress on the condenser when used as an element of an impulse generator are sufficiently specified by the general form of the switching surge wave produced. This is an aperiodic pulse having front times reaching up to 1 ms and possibly more and tail times of the order of 10 ms or more. The circuit used will be the Marx generator.

2.2.b The stress of the condensers, when used as TRV control capacitance during direct tests is exactly the same as that of the condensers in the T.R.V. control branch of the synthetic circuit, except that the 50 Hz or 60 Hz recovery voltage might be maintained for a longer time, up to 1 second.

2.2.c When the condensers are used in the form of a lumped capacitance for circuit breaker tests their stress will be as follows:

Before the opening of the tested breaker, the bank is stressed by 50 Hz or 60 Hz voltage wave during a time of the order of 1 second.

When the breaker opens, two cases may arise:

The breaker is restrike-free: In this case the bank remains on a voltage equal to the crest value of the test voltage and is gradually discharged through potential transformers or through measuring dividers. Special discharge resistances will be used as well to discharge the bank some 2 or 3 seconds after the test.

Restrikes in the tested breaker may occur: In this case a suitable number of condensers will be used so that the over-all rated voltage of the group is higher that the estimated overvoltages caused by restrikes. After the test, the bank will be discharged in the same way as in the previous case.

In both above mentioned cases a suitable over-voltage protection of the bank will always be used.

2.2.d The application as artificial circuits, for simulating long lines includes several cases. It is impossible to specify a general rule as to how the bank will be stressed in those different cases. Each case will, consequently, be estimated separately and a suitable number of condenser elements will be used in such a way as to stay within the rated characteristics of the condensers.

2.2.e The capacitors will be used occasionally for compensation of reactive power during heat-run tests of big reactors and transformers. During these tests the condensers will be stressed by 50 Hz or 60 Hz voltage quasi-permanently, that means during a few hours. A special rating is specified for this application.

3. GENERAL CHARACTERISTICS

3.1 Standards

In general, the capacitors according to the present specification must comply with the IEC Publication No. 70 (1967) Power Capacitors, except for modifications or additions contained in this specification.

3.2 Ambient temperature

The capacitors according to the present specification shall be installed in a synthetic test hall of the High Power Laboratory. The temperature in this hall may vary from 0 °C to + 40 °C. During delivery, however, temperature between -40°C and + 40°C must be taken into account.

3.3 Electrical connection

The diagram in Fig. 1b, shows the high voltage circuit in simplified form only. In reality the H.V. circuit is made up of five identical stages, each stage having all elements shown in Fig. 1b. A high-voltage change-over switch is provided, which enables to connect all stages either in series or in parallel connections or in all available series-parallel connections.

Each element C_p of a stage is made up of 192 elementary condensers 5 μF (Option B) or 96 elementary condensers 10 μF (Option A). In a similar way, each element Cr is made up of 96 elementary condensers 5 μF (Option B) or 48 elementary condensers 10 μF (Option A). Within C_p 4 elements 5 μF, or 2 elements 10 μF are in parallel permanently, giving 48 20 μF capacitances in a stage. Those 48 elements are electrically connected in a chain (all in series) and two collector bars are provided, with a possibility of connecting any intermediate point between two elements to either one of the two bars by means of compressed air isolators. In such a way series connected groups from one to

48 elements may be made, the groups being in parallel between the two collecting bars. Maximum crest voltage between the bars is 180 kV, so that if a number of condenser units higher than 6 are in series, the units will not be fully charged. For less than 6 units in series, the maximum crest voltage used will be 30 kV times the number of series connected units.

The TRV control capacitance Cr is made in a similar way, with only two differences. First, the units are 10 μF instead of 20 μF (2 x 5 μF, or 1 x 10 μF for option B and A respectively). Second, the collector bars are made in such a way, that two halves of each stage can be connected in series, giving 360 kV as a maximum crest voltage per stage. This takes into account the amplitude factor up to 2 for the T.R.V.

4. RATINGS

Three categories of ratings are being specified with respect to the different applications of the condensers.

a) Ratings with respect to the basic use as energy storage condensers (see paragraphs 2.1 and 2.2a).

b) Ratings with respect to the use at 50 Hz or 60 Hz, during a limited time (see paragraphs 2.2 b; 2.2.c and 2.2 d.)

c) Rating with respect to the use of 50 Hz or 60 Hz during unlimited time (for power factor compensation, see paragraph 2.2.e).

The ratings under a and b apply to all options specified in Section 1.

The rating under c applies to Sub-option I only (that means to options AI and BI, not to options AII and BII.)

4.1 Ratings with respect to the use as energy storage condensers.

4.1.1 Rated charging voltage 30 kV

4.1.2 Rated capacitance

Option A 10 μF

Option B 5 μF

4.1.3 Tolerances on capacitance

a) The measured value of capacitance for each individual element must not vary by more than - 5%; + 10% of the rated value.

b) The cumulative value of the capacitance of a lot of 40 elements must not vary by more than - 0%; + 10% of cumulative rated value.

4.1.4 Rated inversion factor 0.95 at 1 kHz

4.1.5 Rated inherent frequency....... not lower than 100 kHz

4.1.6 Rated operation cycle

a) Normal use.
- maximum charging time: 5 min.
- period at full charge before test: 1 min.
- period at inverse voltage after test: 1 min.
- rest period (after test) 5 min.
- testing rate 1/12 min.

b) exceptional use. (one case out of 50 approx.)
- period at full voltage before test: up to 10 min.
- period at reverse voltage: up to 5 min.
- rest period (after test): to be specified by manufacturer, in function of the charging voltage.

4.1.7 Life expectancy

The life expected will be 10^5 discharges during which the fault occurances must be inferior to 5%.

4.1.8 Internal resistance

When removed from the charging unit each capacitor must be able not to lose more than 10% of its initial voltage in 5 minutes.

4.2 Ratings with respect to the use at 50 Hz or 60 Hz during a limited time.

The manufacturer shall specify the values of R.M.S. voltages, at which the condensers can be used, from time to time, at 50 Hz or 60 Hz, the times of application being:

0.1 second

0.2 second

0.5 second

1.0 second

assuming an interval of rest between the tests of 10 minutes.

4.3 Rating with respect to the use at 50 Hz or 60 Hz during unlimited time (power factor compensation).

(This rating applies on OPTIONS A1 and B1 only).

Rated voltage (R.M.S.) 7 kV

The manufacturer is invited to offer a higher rated voltage, if possible. However, it is assumed that this characteristic will increase the cost of the elements if they are to have the same life expectancy, and an indication of the increase in cost should be given by the manufacturer.

5. GEOMETRY AND DESIGN (See fig. 2.)

The over-all form of the condenser will be that of a rectangular casing with one bushing. The active parts of the condenser will be connected by one terminal to the casing, the other terminal will be brought out through the bushing.

The condensers will be mounted in vertical position, with the bushing on the upper horizontal side. The other terminal will also be placed on the same side.

5.1 Dimensions

For both options A and B, the maximum over-all height including the bushing shall be 135 cm. It is desirable to utilise this height as fully as possible.

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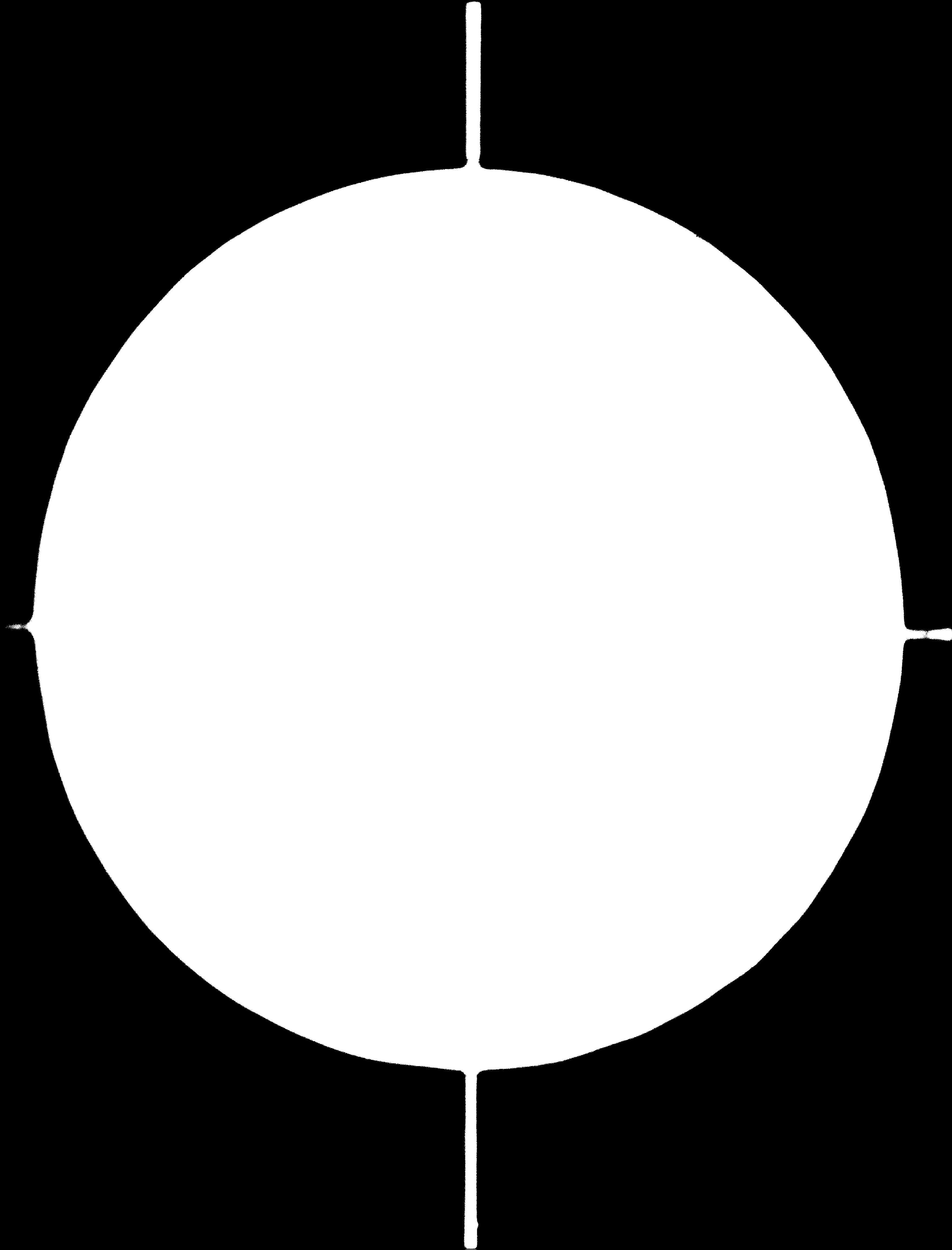

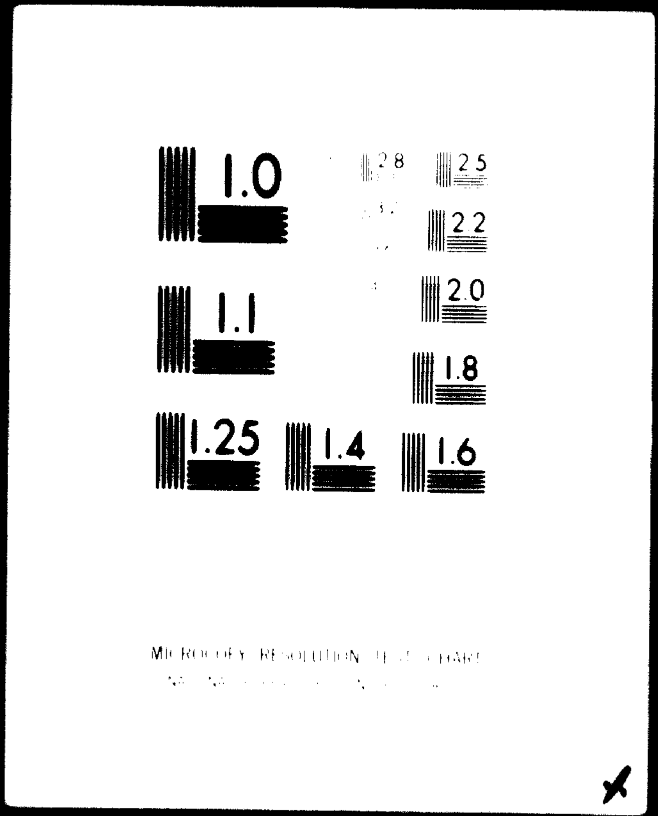

24x
E

The maximum value of one of the horisontal dimensions for both options shall be 20 cm, and it is desirable to make it smaller if possible.

The second horisontal dimension is to be determined by the manufacturer.

The manufacturer shall indicate in his tender all main dimensions and bushing position, suspension brackets etc...

5.2 <u>Suspension brackets</u>

The casings will have suitable brackets or hooks placed on the narrower vertical sides, for suspension of the condenser between two parallel insulating bars.

5.3 <u>Signalling equipment</u>

If available, a signalling device shall be placed on the upper side of the casing. Preferably the equipment shall consist of an electric bellow actuating a small compressed air valve. The over-pressure will open the valve via the bellow, and a compressed air signal will be sent through isolating tubing to ground potential, for signalling purposes.

The equipment containing the bellow and the signalling valve will be a part of the delivery. The tubing however will not be included.

The manufacturer is invited to offer any other system or equipment, if available, to protect the condensers against explosion or able to detect a partial fault at its start.

5.4 Tightness of the casing

The condenser casing, including the buehing and any other elements attached to it, shall be perfectly leak-proof. The dilatation of the active parts and the impregnant shall be taken into account, due to heating caused by normal operation as specified in section 4 of the present specification.

5.5 Protection against corrosion and painting

Adequate protection against corrosion shall be provided on metal casings and all other parts.

The color of the painting will be indicated by the purchaser later on.

6. TESTS

All tests epecified in this section are made under the responsibility and at the expense of the manufacturer.

Three categories of tests are specified:

a) Type teete

b) Tests on eamples of a fabrication lot

c) Routine tests

It is underetood that the tests specified in paragraphs 6.1.3 and 6.2.3 do not apply in case of SUB-OPTION II, specified in the "Article 1".

6.1 Type Tests

Three prototypes shall be subjected to type tests.

The dielectric tests according to subclause 6.1.1 shall be made on each of the three prototypes. As to the discharge tests according to subclause 6.1.2, each prototype shall be submitted to one of the test series specified therein.

The test at 50 Hz or 60 Hz, according to subclause 6.1.3 shall be made on any of the three prototypes, according to the decision of the manufacturer.

6.1.1 Dielectric test

This test shall be made on each prototype.

a) Measurement of capacitance, losses, ionization factor and partial discharges at 5 kV.

b) One dielectric withstand test under 60 kV d.c. for 10 sec.

c) Measurement of capacitance, losses, ionization and partial discharges at 5 kV (1).

6.1.2 Discharge tests

6.1.2.1 On a first prototype

a) Measurement of capacitance, losses and ionization factor at 5 kV.

b) Oscillatory discharges

- 100 tests
- U charge = 45 kV
- discharge frequency = 1 kHz.

---

(1) If there exists a difference between the values measured before and after the tests, it must not be such that it might indicate the possibility of a breakdown in a winding element.

- inversion factor = 0.95
- rate: 1 test per minute

c) Measurement of capacitance, losses and ionisation factor at 5 kV.

6.1.2.2 On a second prototype

a) Measurement of capacitance, losses and ionisation factor at 5 kV.

b) Oscillatory discharges

- 100 tests
- U charge = 45 kV
- frequency = 15 kHz
- inversion factor: 0.90 to 0.95
- rate: 1 test per minute

c) Measurement of capacitance, losses and ionisation factor at 5 kV. (1)

6.1.2.3 On a third prototype

a) Measurement of capacitance, losses and ionization factor at 5 kV.

b) The element will be discharged in short-circuit.

- 1000 tests
- U charge = 45 kV
- frequency $\geq$ 100 kHz
- inversion factor: 0.90 (approx.)
- rate: 1 test per minute

c) Measurement of capacitance, losses and ionisation factor at 5 kV (1).

6.1.3 Tests at 50 Hz or 60 Hz

On one of the prototypes chosen by the manufacturer

- 1 test
- Urms = 8 kV
- duration: 48 hours or up to temperature stabilization

6.2 Tests on samples of a fabrication lot

Assuming the fabrication is made in lots of some 30 to 50 elements at a time, 10% of the elements, taken at random from the lot, shall be submitted to following tests:

6.2.1 Dielectric test

a) Measurement of capacitance, losses, ionisation factor and partial discharges at 5 kV.

b) One dielectric test at 45 kV dc for 1 minute.

c) Immediately after there will be a measurement of capacitance, losses, ionisation factor and partial discharge at 5 kV (1).

6.2.2 Discharge tests

6.2.2.1 Discharge into a short-circuit

a) Measurement of capacitance, losses and ionisation factor at 5 kV.

b) - 10 tests
- U charge = 30 kV
- frequency > 100 kHz
- inversion factor = 0.95 (approx).
- rate: 1 test per minute

c) Measurement of capacitance, losses and ionization factor at 5 kV (1).

6.2.2.2 Endurance tests

a) Measurement of capacitance, losses and ionization factor at 5 kV.

b) - 1000 tests
   - U charge = 30 kV.
   - oscillating frequency = 1000 Hz
   - inversion factor = 0.95
   - rate: 1 discharge per minute

c) Measurement of capacitance, losses and ionization factor at 5 kV, at every 100th test (2).

6.2.3 Tests at 50 Hz or 60 Hz

a) One test at
   - Urms = 8 kV
   - duration = 48 hours or up to temperature stabilization.

b) Measurement of capacitance, losses and ionization factor at 5 kV (1).

---

(2) The successive measurements of the capacitance, tan delta and of the ionization factor after each series of 100 discharges must show a clear tendancy to stabilise, i.e. a variation of those values will be acceptable as long as it decreases as the number of tests increases to the 1000th. If those variations are steady or tend to increase, the element will be rejected unless the manufacturer prefers to continue the tests up until the values stabilise.

6.2.4 Test procedure and the issue of the test

Taking as an example a lot of 40 elements, 4 samples shall be submitted for the test.

The following procedure shall be used:

6.2.4.1 First test series

a) If all 4 tested samples pass the tests, the test is completed and the lot accepted as a whole.

b) If one sample fails, 4 additional samples shall be selected at random from the remaining 36 elements of the lot and submitted for a second test series.

c) If two samples fail, 8 additional samples shall be presented for the second test series

d) If more than two samples fail, the lot is rejected as a whole.

6.2.4.2 Second test series

a) If, in the case specified in 6.2.4.1b hereabove, all 4 additional samples pass the test, the test is completed and the lot is accepted as a whole.

b) If one sample, out of four, fails, 4 additional samples are selected at random from the remaining 32 elements and submitted for a third test series.

c) If two or more samples fail, the lot is rejected as a whole.

d) In the case specified in 6.2.4.1c hereabove, all 8 samples must pass the test. If not, the lot is rejected as a whole.

6.2.4.3 Third test series

a) In the case specified in 6.2.4.2b hereabove, all four samples must pass the test. If not, the lot is rejected as a whole.

6.3 Routine tests

These tests shall be performed on all elements of each lot that have not been submitted to any test yet.

The elements which do not pass the tests according to this section shall be replaced at the expense of the manufacturer.

6.3.1 Electric tests

a) Measurement of capacitance, losses and ionisation factor at 500 V and 5 kV and partial discharges at 5 kV.

b) Dielectric test

- Udc = 45 kV
- duration = 1 minute

c) Measurement of capacitance, losses and ionisation factor at 500 V and 5 kV and partial discharges at 5 kV (1).

6.3.2 Test for leaks

Each capacitor should pass a sweating test. The sweating of the impregnant will be attempted by heating the elements in an oven until the interior temperature has attained a uniform temperature of 65°C. The leaks will be detected by the coloration of the revealing product used.

6.4 <u>Interpretation of test results and conditions of acceptance</u>.

6.4.1 <u>The prototype tests</u> are made in order to check the design and serve as a basis for permission to start the line production of the condensers. This permission will be given when all prototypes have passed the tests in accordance with clause 6.1 successfully.

6.4.2 <u>The tests on samples</u> of a fabrication lot are made to check the fabrication technology and materials.

If the conditions of clause 6.2 are met, the lot is accepted as a whole and will be presented for routine tests. The individual samples, which did not pass the test, if the case occurs, shall be replaced at the manufacturer's expense.

If the conditions of clause 6.2 are not fulfilled the lot is rejected as a whole.

6.4.3 <u>The routine tests</u> on all elements are made as a final quality check.

Elements which do not pass these tests will be replaced at manufacturer's expense.

7. PERTINENT TECHNICAL DATA TO BE FURNISHED AS A PART OF THE TENDER

7.1 General description of capacitors

Description included......

7.2 Drawings and preliminary dimensions

Description included......

7.3 Indications as to the weight of the capacitors

Description included.......

7.4 Description of dielectric of capacitors

Description included........

7.5 Maximum heating of dielectric when capacitors are used as a permanent reactive source .... °C

7.6 Losses of the capacitors

7.7 Natural frequency of capacitors is........... kHz

7.8 Pertinent experience of manufacturer and list of capacitors already produced.

List included.....

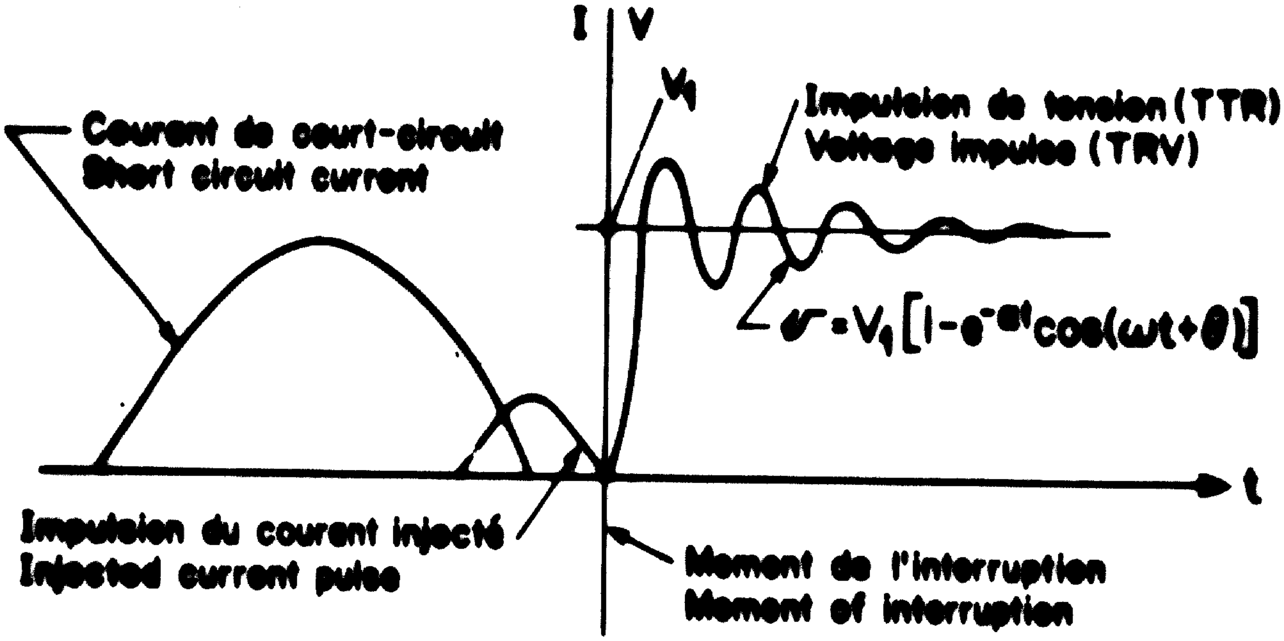

Figure 1a

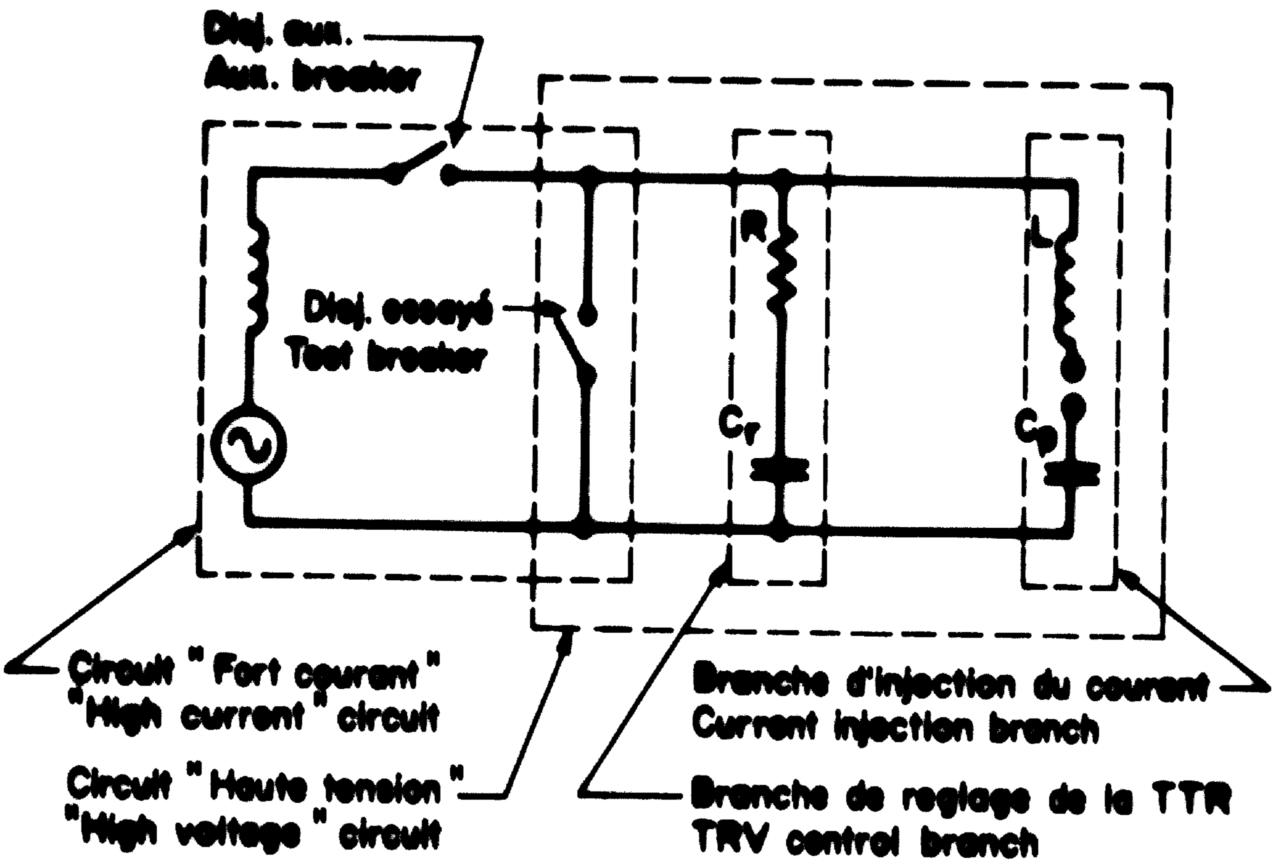

Figure 1b

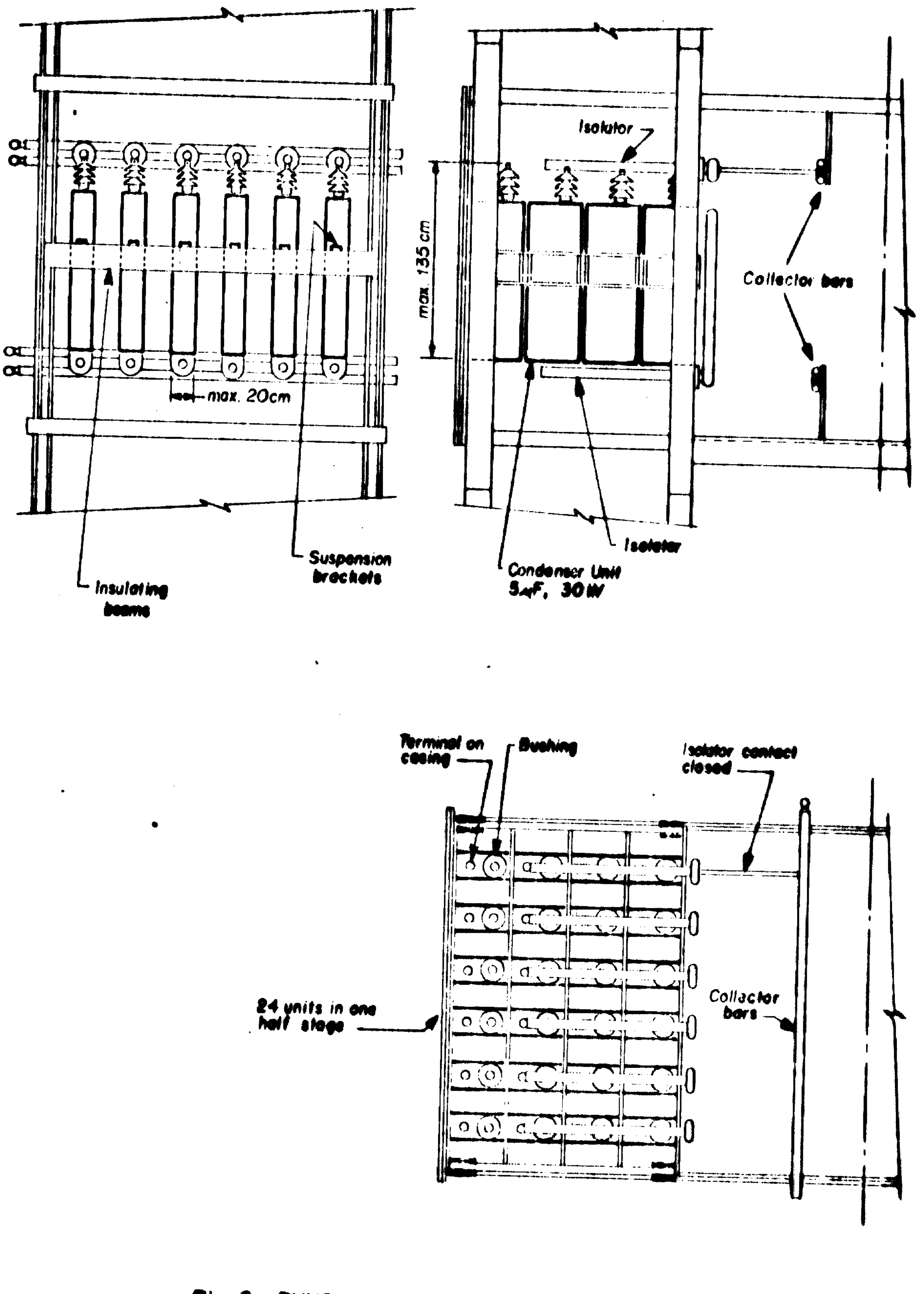

Fig. 2 PHYSICAL LAY-OUT OF CONDENSORS IN A STAGE

HP 22

INDUCTANCES FOR THE SYNTHETIC CIRCUIT

The present specification covers the requirements of the Electrical Industry and Experimentation Centre for the supply of 150 inductances for the synthetic test bay's high voltage source.

TABLE OF CONTENTS

Article	Description	Page
1	Scope	1
2	Quantity	3
3	General Characteristics	3
4	Electrical Characteristics	3
5	Construction	3
6	Tests	4

2. QUANTITY

150 inductance units for the synthetic test circuit.

3. GENERAL CHARACTERISTICS

The inductances shall be for indoor installation, with air cores, dry-type and naturally air cooled.

4. ELECTRICAL CHARACTERISTICS

Nominal inductance	10 mH
Tolerance	± 2%
Rated voltage between terminals	30 kV peak
Impulse withstand voltage between terminals	120 kV peak
Peak current at 190 cycles	2.5 kA peak
Quality factor at 60 cycles	20
Natural frequency	≥ 250 kHz

5. CONSTRUCTION

The inductances shall be of the self-supporting type. They will be installed without supports in a structure built of insulated material. Therefore the coils shall be provided with three appropriate devices for installing purposes. The manufacturer chooses the dimensions of the coils in order to achieve the most economic solution.

6. TESTS

6.1 Type tests

These tests shall be carried out on a prototype coil.

6.1.1. Inductance measurement

The inductance shall be measured with a bridge, having a precision of 0.5%.

6.1.2 Short-circuit tests

The short-circuit tests shall be made with a capacitive discharge. The parameters of article 4 would be produced while discharging in the inductance a capacitor C = 70 μF, charged at U_n =30 kV. However, the tests on the prototype unit will be made with U_{ch} = 1.2 U_n, with the intention to increase the current by 20% and the energy and the electromagnetic forces by 40% each.

Test procedure:

10 discharges with 120% of the nominal voltage, i.c. U_{ch} = 36 kV. The resulting initial current will be 3 kA peak. A test shall be made every 10 minutes.
The impedance shall be measured after each test with the voltage-current method.

6.1.3 Dielectric tests between terminals.

The dielectric tests between terminals shall be carried out in accordance with the standards IEC, Publication 60, and the procedure hereafter.

1. Terminal I grounded, terminal II connected to the impulse generator:
   a) 5 tests with the positive wave
   b) 5 tests with the negative wave

2. Terminal II grounded, terminal I connected to the impulse generator:
   a) 5 tests with the positive wave
   b) 5 tests with the negative wave

6.2 Sample tests

10 coils taken out from the complete lot of 150 units shall be submitted to short-circuit tests in accordance with the test procedure of article 6.1.2 but with $U_{ch} = 1.1\ U_n$. Afterwards, the dielectric tests of article 6.3.1 and a final measurement of the inductance in accordance with article 6.3.2 shall be made.

6.3 Routine tests

6.3.1 Dielectric test

Each coil shall be submitted to the following impulse tests with 120 kV peak:

a) 3 tests with the positive wave
b) 3 tests with the negative wave

No disrupture shall be accepted.

6.3.2 Measurement of the inductance with a bridge

The inductance shall be measured on each coil. The measured value shall be marked on the name-plate.

6.4 Acceptance

The acceptance of the inductances is based on the following conditions:

a) The coils shall meet the electrical characteristics of article 4.

b) No sign of damage shall be evident during and after the tests.

c) The measured inductances before and after the tests shall not show any difference.

HP 23

SPARK GAPS

The present document describes the triggered spark gaps for the high voltage source of the synthetic test circuit of the Electrical Industry and Experimentation Centre.

1. GENERAL

The spark gaps in the high voltage source of the synthetic test circuit shall be used to close the circuit. Due consideration for two criteria shall be taken:

a) synchronous closing of the five stages shall be assured.

b) the closing instant shall be well defined and related to the whole test sequence.

The location of the spark gaps is shown in Fig. 2, of H.P.-20 (General description), where the five stages are connected in series. To initiate the injected current, all five spark gaps have to be triggered from earth potential to ensure a simultaneous closing of all five individual circuits.

2. CHARACTERISTICS OF THE SPARK GAPS

All five spark gaps are identical. The trigger mecanism shall assure an operation between the maximum admissible voltage across the gap Ua(zero probability of a breakdown across the gap) and Um = 0.66 Ua. To assure that no breakdown will occur at Ua, the gap spacing has to be adjusted for a 50% probability breakdown voltage U_{50} = 1.4 Ua. This means for the maximum rated (charging) voltage Uch = 180 kV:

Ua = 180 kV, maximum admissible voltage
Um = 120 kV, minimum operating voltage
U_{50} = 252 kV, 50% probability breakdown voltage

For lower operating voltages than 120 kV, the gap spacing has to be changed with respect to the above mentioned rules.

Trigger delay: This is the delay between the trigger order and the actual breakdown of the voltage across the spark gap. This delay may vary for different operating voltages, but shall not vary more than ± 5 μs in tests with the same operating voltage.

3. EXAMPLE OF A SPARK GAP AND TRIGGER DEVICE

The trigger device can be built up from a battery fed circuit in the spark gap and a laser on earth potential. The circuit in the spark gap consists of elements in order to transform 24 V d.c. into 10 kV d.c. A capacitor is charged with this voltage, and its energy can be released on a trigatron by means of an auxiliary spark gap, which is triggered by a laser beam. The auxiliary spark gap is also energized with 10 kV, which corresponds to a gap spacing of 5 mm approximately. The laser is of the CO_2- type, with a tube for each spark gap. The electrical circuit is common for all five tubes, so that there is an absolute simultaneity between the five laser beams. The beams are directed on the auxiliary spark gaps with a mirror system.

The triggering device can also be made by other means, such as with a powerful laser which triggers the main spark gap directly; or a three electrode spark gap, whose central electrode is displaced by means of a coupling capacitor.

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DAMPING RESISTORS

1- The present specification covers the requirements of the Electrical Industry Experimentation Centre for the supply of resistors used for the control of the recovery voltage in the synthetic test circuit of the High Power Laboratory.

There are two options:

Option A - In which each value of resistance is produced by a particular resistor.

Option B - In which each value of resistance is produced by connecting in parallel or in series a fewer number of particular resistors.

SUMMARY

1- Scope

2- General description

3- General caracteristics
   3-1 Ambiant temperature
   3-2 Electrical connections

4- Ratings
   4-1 Rated operation cycle
   4-2 Life expectancy

5- Geometry & Design
   5-1 Dimensions
   5-2 Protective coating

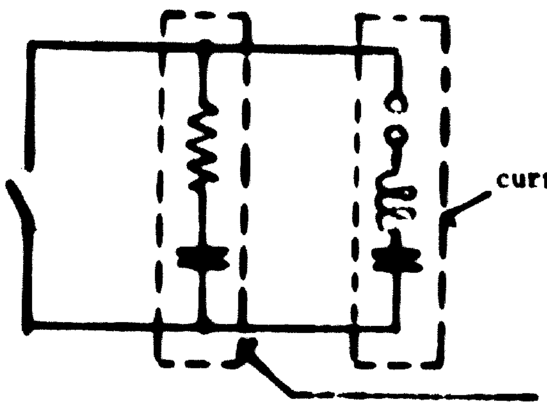
6- Tests
   6-1 Type tests
      6-1.1 Acceptation
   6-2 Routine tests
      6-2.1 Acceptation

7- Pertinent technical data to be furnished as a part of the tender.

3- GENERAL DESCRIPTION:

The resistors described hereafter shall be used in the high voltage circuit in series with the capacitors of the control branch. This branch is the shaping element of the transient recovery voltage (TRV) appearing across the breaker contacts following interruption of the current.

High voltage circuit:



Following the closing of the spark gap (S) the injection branch forces a half-wave of current through the test breaker (T.B.) at the end of which the test-breaker opens and exposes the control branch to an equalizing current coming from the injection branch. The latter produces a voltage wave described by the equation $v = V_1(1-e^{-\alpha\tau}\cos\omega\tau)$, where V_1 is the peak value of the power frequency recovery voltage

$$V_1 = K_T \frac{\sqrt{2}}{\sqrt{3}} V_n$$

where K_T is the first pole to break factor
and U_n is the rated rms (phase to phase) voltage of the breaker.
The oscillating angular frequency (ω) will vary from 500 Hz to 75 kHz and a maximum instantaneous voltage reaching 74% of the charging voltage will appear across the control resistors for the case of critical damping. If the TRV wave shape is overdamped the maximum instantaneous voltage on the resistors may climb to 100% of the charging voltage.

The high voltage circuit will be made up of 5 superimposed stages all having identical characteristics except for the control resistors. Three of these modules will produce mainly a low frequency (LF) TRV and will be called LF circuits while the two others will produce mainly high frequency TRVs and will be called HF circuits. In order to have also the possibility of using 4 low-frequency circuits and one high-frequency circuit, the resistors shall be bought for 4 LF modules (Table I). These circuits will be connected in many series and parallel ways in order to produce the required test voltages and injection currents. Each of those 5 circuits or modules will have a maximum charging voltage of 180 kV.

3- GENERAL CHARACTERISTICS

The resistors according to the present specification will only be used in the control branches of the synthetic circuit and therefore will be subjected only to transient current flow and the corresponding terminal voltages.

3.1- Ambient temperature

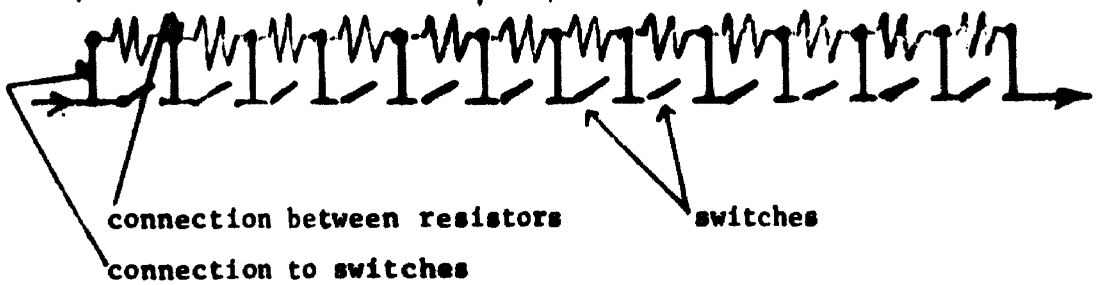
The resistors according to the present specification will be installed in a synthetic test hall of the High Power Laboratory. The temperature in this hall may change between 0°C and +40°C. During delivery, however, temperatures between -40°C and +40°C must be taken into account.

3.2- Electrical connections

As mentioned earlier, the circuit will consist of 5 superimposed stages. The 12 resistor elements of each stage will be connected in series, each element having in parallel a short-circuitting switch. The switches will permit the insertion in the control branch any series combination of the ohmic elements. The ohmic values of both HF and LF elements forming a geometric series with the order of two, the resistances obtainable range from the lowest value up to twice the highest value with the absolute accuracy equal to the lowest value. The following figure shows the resistor set up for both L.F. and H.F. stages.

Series Connection

LF	0.015	0.031	0.062	0.125	0.25	0.50	1.00	2.00	4.00	8.00	16.0	32.0
HF	0.39	0.78	1.56	3.12	6.23	12.5	25.0	50.0	100.	200.	400.	800.



The switches are not a part of the present specification.
The connections for tying the resistors between themselves and to the switches are a part of the specification.

4- RATINGS

These resistors will only be used to pass the exponentially damped sinusoïdal current, circulating trough the TRV control branch and which will be damped out in a period ranging from 1 ms to 100 ms. The number of resistors along with their rated voltage and energy are given in the following table. Also in that table some tentative values of the self inductance are given but they are not rigid caracteristics. However the lowest possible value of self-inductance will be preferable.

4.1- Rated operation cycle:

- Period of current flow: from 1 ms to 100 ms
- Testing rate: 1/12 min.

4.2- Life expectancy:

The life expected will be 10^5 test cycles.

TABLE No: 1

MODULE	RESISTANCE Ω	RATED VOLTAGE kV (dc)	ENERGY kJ	Option A	Option B			Inductance μH
				Number	Basic elements		Connection	
					Value Ω	Number		
High Frequency Circuit	800.0	180	0.5	2			2 series	
	400.0	"	1.0	2	400.0	34	1	40.0
	200.0	"	2.0	2			2 par.	
	100.0	"	4.0	2			4 par.	
	50.0	"	8.0	2			8 par.	
	25.0	90	2.0	2			2 series	
	12.5	"	2.0	2	12.5	18	1	12.5
	6.25	"	4.0	2			2 par.	
	3.12	"	8.0	2			4 par.	
	1.56	"	1.6	2			4 series	
	0.78	"	1.6	2			2 series	
	0.30	"	0.8	2	0.39	14	1	17.0
Low Frequency Circuit	32.0	180	7.5	4			2 series	
	16.0	"	15.0	4	16.0	68	1	16.0
	8.0	"	30.0	4			2 par.	
	4.0	"	60.0	4			4 par.	
	2.0	"	120.0	4			8 par.	
	1.0	90	30.0	4			2 series	
	0.5	"	30.0	4	0.50	36	1	10.0
	0.25	"	60.0	4			2 par.	
	0.125	"	120.0	4			4 par.	
	0.062	"	25.0	4			4 series	
	0.031	"	25.0	4			2 series	
	0.015	"	12.5	4	0.015	28	1	15.0

5- GEOMETRY and DESIGN:

The resistors shall be indoor, non capacitive and non inductive, dry types and cooled by the ambiant air. The elements will be mounted at the end of each other with their axis in the horizontal plane and they must contains some anchorage points in order to be mounted mechanically to an insulating structure.

5.1- Dimensions:

The length of the elements will likely be determined by the insulation level required (6...)
The other two dimensions should be kept as low as possible or made in such a way as to reduce the overall dimensions of the resistors made up of 4 or 8 elements in parallel (Option B)

5.2- Protective coating:

A layer of protective material must cover the resistors in order to protect them from dust and rust unless the design and materials used have been chosen for that purpose.

6- TESTS:

All tests specified in this section are made under the responsability and the expense of the manufacturer.
Two categories of tests are specified.

a) Type tests
b) Routine tests

6.1-Type tests:

This test applies to each different basic resistor in option A and to each different basic resistor in option B, plus the resistor made up from the greatest number of basic resistors in parallel or in series (Ref. Table 1).

Discharge tests:

- At an ambiant temperature of 35°C.

- A capacitor bank charged at 120% rated voltage of the resistor and containing 144% of ths rated energy of the resistor will be discharged into it 200 times.

- Each discharge will be followed by a rest period of 12 minutes.

- At the end of these tests the resistance of the element must be measured at 35°C. and this measured value must not vary by more than 1% with the measured valus before the tests.

6.1.1.-Acceptation

If an element does not pss the type test it will either be rejected or the type test must be passed by two more identical elements while the faulted one is replsced st the manufacturer's expense.

6.2- Routine tests:

Measure of resistance:

The resistance of each element will be measured at 50 Hz or 60 Hz at a temperature of 35°C. The elements having a value of resistance exceeding ±5% the spscified value will be rejected.

Dielectric test:

Each element will be subjected to a voltage impulse test having a rise time of 1.0 µs or 1.5 µs and reaching a peak of 600 kV for the elementa rated st 180 kV and 300 kV for the elements rated at 90 kV.

6.2.1.- Acceptation

All the elements that do not pass the routine test will be replaced at the manufacturer's expense.

7- PERTINENT TECHNICAL DATA TO BE FURNISHED AS A PART OF THE TENDER

7.1- General description of resistors.
Description included.

7.2- Drawings and preliminary dimensions
Description included.

7.3- Indications as to the weitht of the resistors
Description included.

7.4- Maximum heating of element

7.5- Pertinent experience of manufacturer and list of resistors already produced.
List included

7.6- What requirements of this specification are most important in determining:

- the cost of the elements
- their dimensions.

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DISCONNECT SWITCHES FOR THE SYNTHETIC CIRCUIT

The present technical specification covers the requirements of the Electrical Industry and Experimentation Centre for the supply of disconnect switches for the high voltage source of the synthetic test circuit.

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4	Standards	4
5	Electrical Characteristics	4
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9	Tests	9
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11	Supply Limit	11
12	Manufacturing Procedure	12
Fig. 1	General Arrangement	
Fig. 2	Pneumatic diagram	
Fig. 3	Control diagram	

2. GENERAL DESCRIPTION

The High Power Laboratory will be equipped with a synthetic test bay for testing high voltage circuit breakers. The necessary high voltage source will be of the capacitive type, i.e. precharged capacitors will be discharged during the test by means of a spark gap. To be able to simulate different breaking capacities and to cover a large range of transient recovery voltages, the source will consist of unit elements connected so as to meet the required circuit parameters. This tender calls for the disconnect switches, to ba inserted batween the elements.

The high voltage source shall consist of two capacitor banks, an inductance bank, a resistor bank and a connection tower. Each bank shall be divided into five horizontal and identical stages. Fig. 1 shows the arrangement of the disconnect switches in a capacitor bank. The bank is divided into four towers. The layout of the disconnect switches in the inductance and resistor banks shall be similar to the one ahown in Fig. 1.

Considering that the five stages are absolutely identical, there are always five disconnect switches in a vertical plane which are in the same position, open or closed. Therefore, only one control is required to operate five switches. However, the control link effecting the operation has to be of insulated material. All other characteristics are identical for all disconnect switches.

3. QUANTITY

Type I (Capacitors): 960 disconnecting switches

192 controls

Type II (Inductances and Resistors 180 kV):

325 disconnecting switches

65 controls

Type III (Resistors 90 kV):

25 disconnecting switches

5 controls

4. STANDARDS

IEC Publication 60: High Voltage techniques

IEC Publication 129: Alternating current isolators (disconnectors) and earthing switches. A revised edition will be published shortly and will then be applied.

The above mentioned standards shall apply except for modifications or additions contained in this specification.

5. ELECTRICAL CHARACTERISTICS

	Type I	Type II	Type III
Nominal voltage, kV dc and ac peak	180	180	90
Impulse withstand voltage of the isolating distance, kV peak, 1/50	450	600	300

Identical characteristics for all three types:

Nominal frequency: 100 to 5000 Hz

BIL: non-existing (see article 7, Design).

Short-time current: 5 kA peak, ½ cycle

3.5 kA rms, 10 cycles.

Continuous current at 60 cycles: The Manufacturer specifies the current which the disconnect switch can carry on continuous duty.

Impulse withstand voltage of the control link between two stages: 900 kV peak.

The disconnect switches shall not be operated alive.

6. MECHANICAL ENDURANCE

The disconnect switches shall be capable of sustaining 5000 operating cycles (C-O) without maintenance nor damage.

7. DESIGN

The disconnect switches shall be of the sliding type driven by a pneumatic mechanism. They are for indoor installation.

Over-all dimensions: The Manufacturer shall give preference to a construction with the smallest cross section perpendicular to the axis.

There are no isolating supports nor a common base to supply. The cylinder-rod assembly shall be installed in a structure of insulated material, and the jaw shall be fixed on an aluminum bus bar (Fig. 1).

The Manufacturer shall provide the necessary threaded holes for the installation in the two flanges. The jaw shall be equipped with a device for the purpose of making the alignment rod-jaw.

The front flange shall be provided with an additional threaded hole for the electrical connection.

The Manufacturer shall clearly indicate in his tender and on his drawings the material he shall use for the conducting parts of each type of disconnect switch.

All materials and parts necessary for the fulfilment of the present work, shall be new, of high commercial quality and in accordance with good practice pertinent to the manufacture of disconnect switches.

In the design of disconnect switches, the manufacturer shall prevent all possible electrolytic corrosion on the disconnect switches and at the connecting points.

The atmospheric corrosion of the metallic parts shall be prevented by an appropriate finish (e.g. painting).

Also, no patching, plugging, skimming or other such means of overcoming defects, discrepancies or errors shall be allowed without obtaining written permission of tho Purchaser.

The purchaser prefers a contact arrangement protected from the environment i.e. enclosed in the cylinder or in a cage.

The Manufacturer shall try to minimise the wear and tear of the contacts and the rod due to the friction between them. This could be done by limiting the friction to the last instant of the closing operation. If the friction takes place all over the rod, the number of contacts shall be increased in order to reduce the individual contact force.

The disconnect switch shall not remain under permanent pressure (see article 8.3), so that insignificant air leakage shall be acceptable.

8. CONTROL

8.1 General

One control will operate five disconnect switches. Such a set will be arranged in a vertical plane (Fig. 1). Each of the five disconnect switches will be at a different potential. Therefore, no conductive link is allowed between two disconnect switches or between the control and a disconnect switch.

8.2 Compressed Air

The compressed air shall be dry, without oil, and available at the pressure required by the Manufacturer (max. 200 psi.).

8.3 Characteristics of control and signalling (Fig. 3).

The opening and closing operations are similar in their characteristics. The remote control shall be effected by an impulse not longer than 0.5 second, and the local control by a push-button. The final position of a group of five disconnect switches shall be indicated locally by means of an end switch. A second one, isolated from the control circuit, shall be used for remote signalling. After all disconnect switches of the same control cabinet have completed their operation, the laboratory control will shut off the air supply by operating the master valve. An alternate push-button shall assure a manual operation of this valve.

8.4 Duration of the operation

The duration of the operation of a group of five disconnect switches shall not exceed 30 seconds.

8.5 Design

A certain number of controls shall be put in one control cubicle, as tabulated hereafter.

Cubicle type	A	B	C	D
Number	8	2	1	1
Number of individual controls in each cubicle	24	30	5	5
Admissible length of one cabinet - feet	6	6	3	3
Type of disconnect switch controlled, as in article 3	I	II	III	II

The Manufacturer defines the cabinet width.

The cubicles shall be provided with accessories in accordance with Fig. 2 and 3. The maximum height shall be two feet. The push-buttons as well as the signalling lights shall be installed on the top panel.

9. TESTS

9.1 General

The type tests of article 9.2 have to be carried out on one control-disconnect switch prototype only.

The sample tests of article 9.3 shall be carried out on 50 disconnect switches immediately after their manufacture. These tests shall detect any flaws prior to installation.

The disconnect switches to be tested shall be chosen pro rata to the manufactured ones, i.e. out of each 28 manufactured, one has to be tested.

The routine tests of article 9.4 are performed at the same time as the acceptance tests.

9.2 Type tests

9.2.1 Mechanical tests

One disconnect switch shall be submitted to 5000 operating cycles, which shall be done without maintenance. Having made the specified maintenance after this test series, the series shall be continued until the destruction of the disconnect switch.

9.2.2 Dielectric tests

The impulse withstand voltage of the isolating distance shall be tested in accordance with standard IEC, Publication 60. The test shall be made with both polarities.

If it is doubtful that the control link between the four disconnect switches will withstand the voltage as specified in article 5, the Purchaser reserves the right to check it by means of dielectric tests.

9.2.3 Short time current tests

The prototype disconnect switch shall be submitted to 20 short time current tests, each one consisting of 3.5 kA rms/5 kA peak, 60 Hz, and a duration of 10 cycles. After these tests, the tests will be continued while gradually rising the current until the destruction of the disconnect switch.

9.2.4 Heat run test

This test shall be done in accordance with standard IEC, Publication 129, and the current guaranteed by the Manufacturer.

9.3 Sample tests

9.3.1 Mechanical tests

50 operations C-O shall be done on each chosen disconnect switch. The mechanical characteristics must be the same as those determined during the prototype tests.

9.3.2 Heat run test

The resistance of the main path shall be measured in accordance with article 62 of standard IEC, Publication 129.

9.4 Routine tests

The routine tests shall be done on all disconnect switches after their installation. These tests shall be in accordance with standard IEC, Publication 129, article 69, except article 69a (dielectric tests).

9.5 Acceptance

The acceptance of the disconnect switches is based on the following conditions:

a) The disconnect switches meet the electrical characteristics of article 5.

b) No sign of damage shall be evident during and after the tests.

10. PAINTING

The Purchaser shall specify the color if the disconnect switches are painted.

11. SUPPLY LIMITATION

The present document calls for the manufacture, delivery and tests of the disconnect switches with their control equipment. This includes all valves, fittings, signalling contacts, air hoses. Each cylinder-rod shall be delivered assembled.

The total hose length is unknown as yet. However, a complete loop for a control of five disconnect switches needs about 40 meters. The Tenderer shall give his unit price while considering the total length.

12. MANUFACTURING PROCEDURE

The line production of the disconnect switches shall only be started after the acceptance of the prototype by the purchaser. He reserves the right to refuse any disconnect switches manufactured after one which failed sample tests.

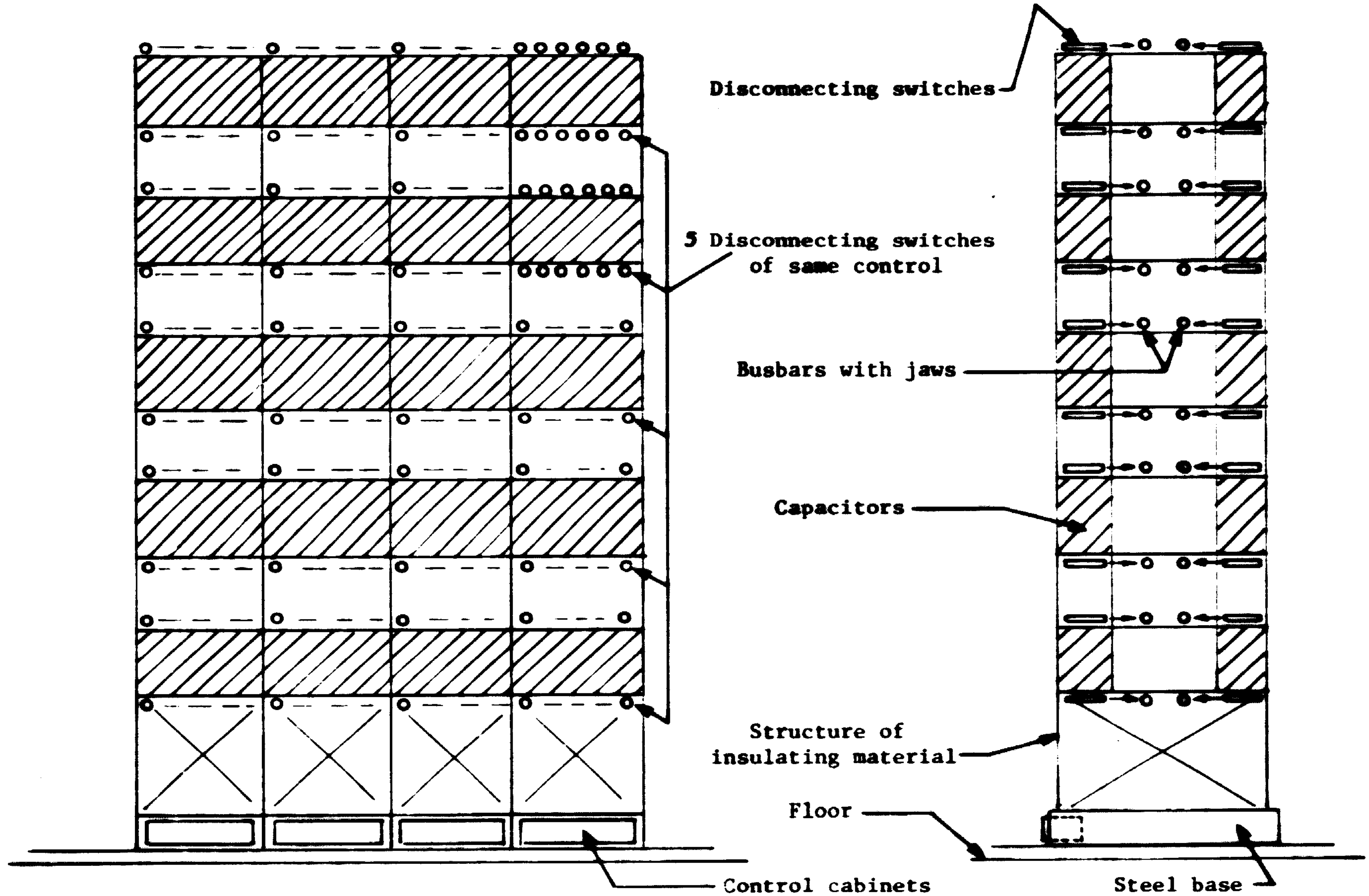


FIG. 1: General arrangement of the disconnecting switches in a capacitor bank

EVM Electric mastervalve
M Gauge
EVO Electric opening valve
EVF Electric closing valve

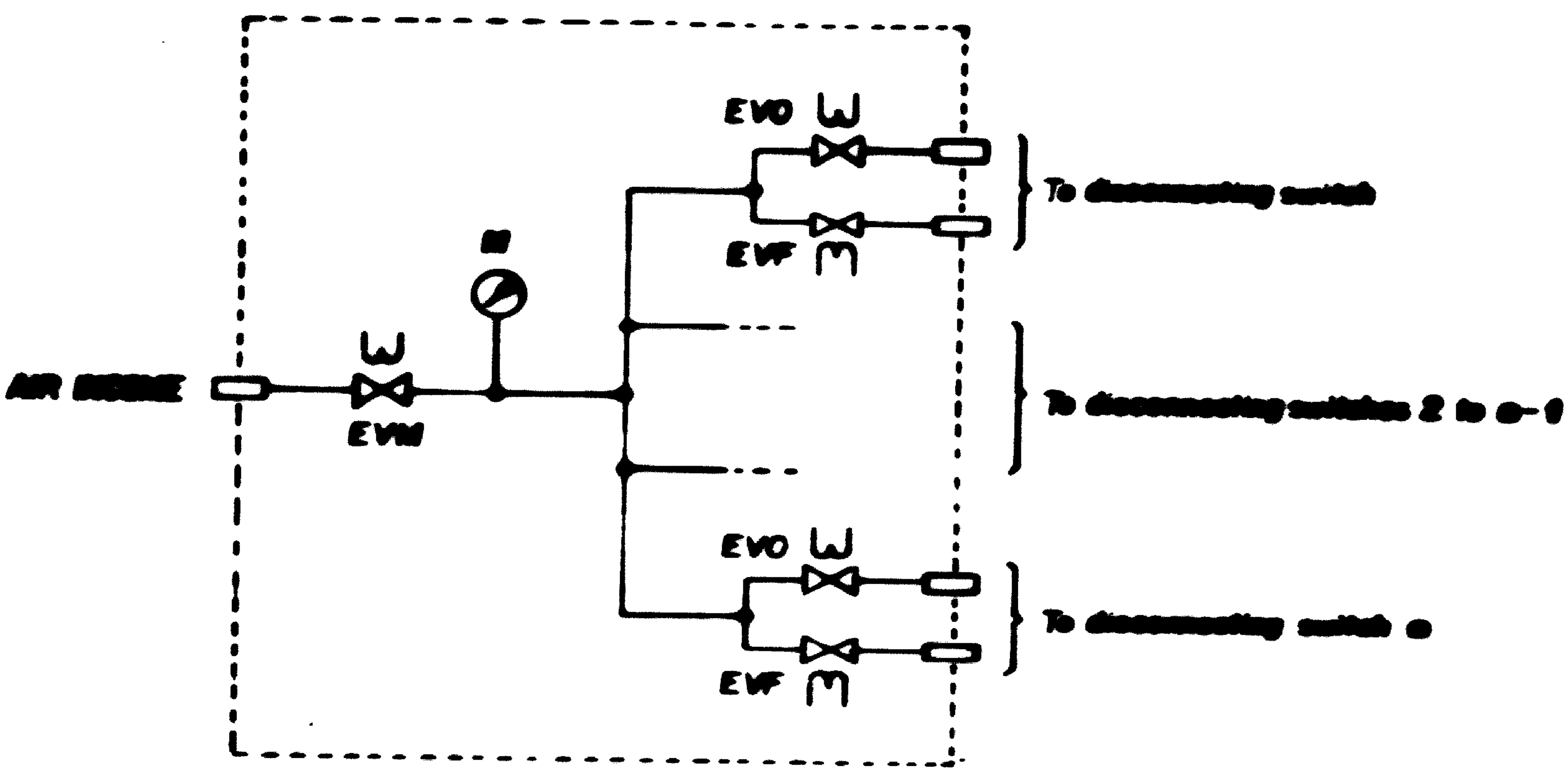
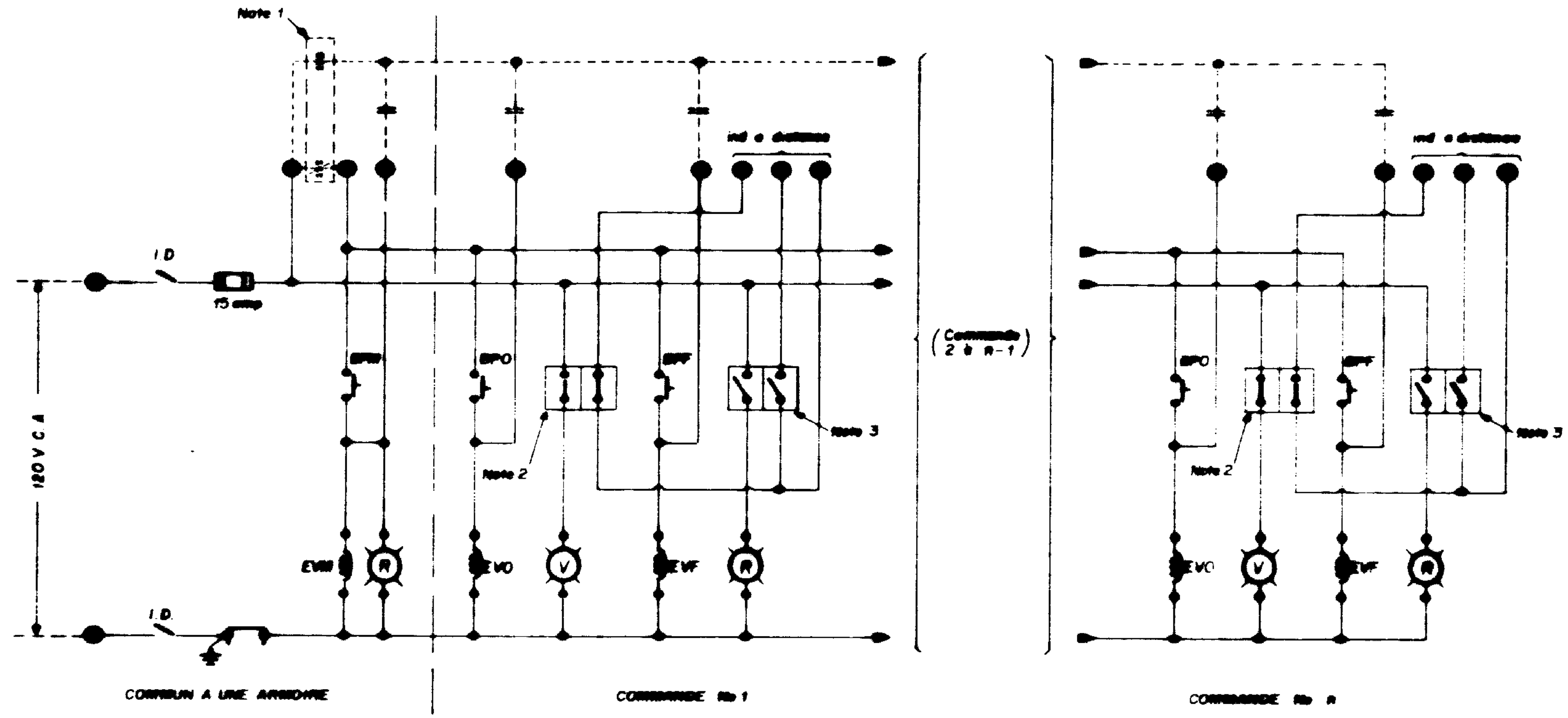


Fig. 2 PNEUMATIC DIAGRAM OF A CONTROL CABINET



- AIR ENLEVÉ
- I.D. OUVERT
- SECTIONNEUR OUVERT

Notes

1 - Sélection de la commande locale ou a distance
2 - Contact de fin de course fermé si les sectionneurs sont ouverts
3 - Contact de fin de course fermé si les sectionneurs sont fermés

LÉGENDE:

- ⊕ Identifie les barres dans l'armoire de commande
- Lignes pointillées sont les connections du client
- n = 24 Commande pour le groupe A
  n = 18 ——— " ——— B
  n = 7 ——— " ——— C
  n = 5 ——— " ——— D
- Chaque commande comprend 4 sectionneurs
- EVM = Electrovalve maitre (normalement fermé)
- EVO = ——— de manoeuvre d'ouverture
- EVF = ——— de manoeuvre de fermeture
- BPM = Bouton-poussoir a action alterné
- BPO et BPF = Bouton-poussoir a action momentané
- I D - interrupteur bipolaire a couteaux

DIRECTION SCIENTIFIQUE: GRANDE PUISSANCE	Institut de Recherche de l'Hydro-Québec IREQ
DESSINÉ: S. Gauthier	
PROJETÉ: M. Dupont, J. Blais	SOURCE HAUTE TENSION ESSAIS SYNTHÉTIQUES SECTIONNEUR DE COMMUTATION Fig. 3 Schéma de commande
APPROUVÉ: P. Rutz	
DATE: 4/7/73	5.0.0.6-0.3.0.0.1 C

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