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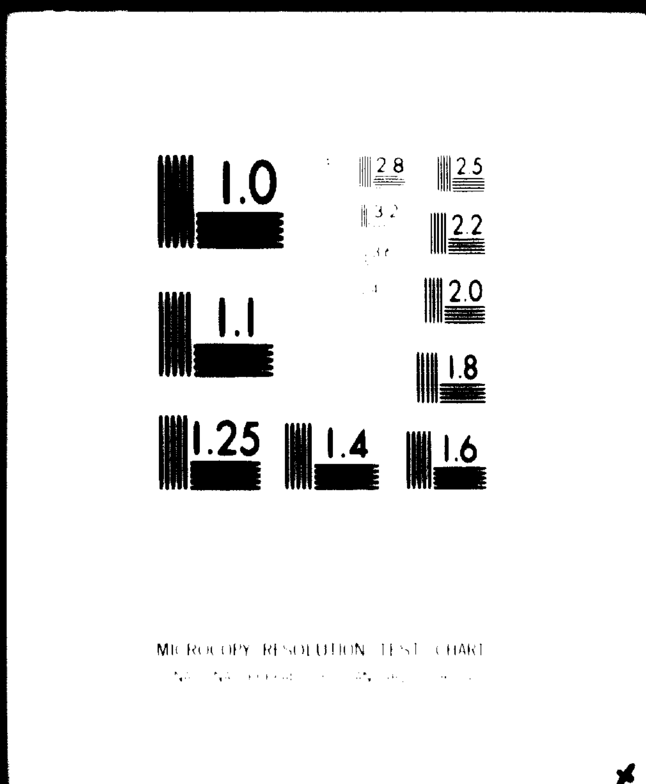
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FINAL REPORT

To

UNITED NATIONS
INDUSTRIAL DEVELOPMENT
ORGANIZATION

UNIDO
CONTRACT
72/17

For

SPAIN ELECTRICAL TESTING AND
EXPERIMENTATION CENTRE
IN MADRID

Prepared by

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Montreal, February 4th, 1974.

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 fifteen (15) English copies of our Final Report for the above project as requested by Article 2.09 (d) of our Contract and following your letter of January 3rd, 1974. This Report, the last in the series of Reports mentioned in the contractual documents, closes our activities in this assignment.

The performance of this study and the production of all related documents were found most gratifying from both standpoints of scope of challenge and of the cordial relations that were maintained with your personnel throughout the fulfillment of this contract. We wish to extend to you and all those who have participated our most sincere thanks and hope that we may be of service to you in undertakings of a similar nature in the near future.

Yours very truly,

Jean-Paul Lalonde, Engineer
LALONDE, GIROUARD, LETENDRE & ASSOCIATES LTD.
Consulting Engineers
in Association with IREQ

JPL/mg

SYNOPSIS

SYNOPSIS

This Final Report summarizes the work performed during the study and contains a résumé of the various reports submitted concerning the Electrical Testing and Experimentation Centre in Madrid, Spain..

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PRELIMINARY SECTION

I - PRELIMINARY SECTION

PURPOSE:

This report summarizes the work that was to be carried out in accordance with the Terms of the Contract Documents. The results of the work carried out appear in numerous volumes which give all the details necessary for the National Consultants to complete the design of the Buildings and the necessary specifications which will allow the Government to call tenders on the various testing equipment needed to operate properly the High Voltage and High Power laboratories. These laboratories are designed for testing and experimenting on electrical equipment and as a help to the Spanish Electrical Industry.

SCOPE:

The reports that were submitted and are summarized in this Final Report are:

1- Final Building Report
2- First Equipment Report
3- Second Equipment Report.

1- Final Building Report

This report covers the requirements of buildings forming part of this testing and research centre. It includes some explanations on the functions of these laboratories and some recommendations as to the selection of criteria and parameters regarding equipment and operation. It is subdivided in four volumes:

Volume 1: Laboratory implementation
2: Civil Engineering - (services - structural)
3: Mechanical and Electrical
4: Terminal Section and Appendices.

In Volume No. 5 we have supplied reproduction of large scale drawings for easy reference, the plans at large scale being cumbersome for discussions and meetings which will necessarily follow this presentation. Large scale drawings were also supplied for better understanding of specific details and for final design by the Local Consultants.

This report was presented to the Government Technical Advisory Commission on September 24, 1973 at a Special Meeting held in Madrid and was well received by this Committee.

2- First Equipment Report

This report includes the specifications of testing equipment for which long delivery is expected and may be considered in a few cases as being on the critical path of the overall schedule. This equipment will require special care and supervision during manufacturing. With this Report were included suggestions on General Conditions for tendering purposes on the international market for the recommended equipment. Attached to the report was a list of suppliers and approximate prices. This report was submitted October 16, 1972. In the recently published Second Equipment Report modifications were made to some of the specifications, issued in the first report, according to recent developments.

3- Second Equipment Report

The Second Equipment Report issued September 1973 in two volumes, one covering HV, the other HP Equipment, covers the specifications of all other testing and laboratory equipment which did not form part of the First Equipment Report. The delivery for this equipment is relatively short in comparison to those of the first report and can be procured partly on the local market and partly on the international market.

We have added a list of recommended suppliers and given an approximate value of the equipment based on 1970 prices: In this report we have submitted a list of instrumentation required for the operation, the name of a few suppliers and an approximate value.

4- <u>Special Report - December 1972.</u>

After the presentation of the Draft Building Report, in September 1972, a meeting was held in Madrid where the two UNIDO Consultants, Prof. Dr. Hans Prinz and Dr. J. Cihelka offered their comments on the draft. Answers to some of the objections raised to our concept are included in a Special Report dated December 1972 which should also form part of the various reports prepared in accordance with contractual documents, as it may shed some light on some of the more difficult aspects of the selection of equipment and laboratory implementation. This is a very important factor for the team that will finally be selected to prepare the final design and will in all probability supervise the construction.

REPORTS SUMMARIZATION

II - REPORTS SUMMARIZATION

As indicated in the preliminary section the purpose of this Report is to summarize the detailed report submitted.

1- Building Report:

1.1 The March of Events

In accordance with the contractual documents the Contractor was to present a Draft Building Report four months after the beginning of his activities. The Contract was signed on the 13th of March 1972 and the work was to begin no later than April 7, 1972. Our draft report was presented in September 1972. As indicated in the Contract, the UNIDO, within a period of one month, was to offer comments on the draft after which the Contractor was to revise and submit the Final Building Report twenty-one days after receipt of such comments.

In November of 1972 a meeting was held in Madrid where our Draft Building Report was discussed with the representatives of the Government and the UNIDO Consultants Dr. H. Prinz and Dr. J. Cihelka. A special Report was submitted in December 1972 in answer to some of the objections raised by the UNIDO Consultants. In January 1973 another meeting was held in Madrid where experts from Siemens in West Berlin and from AEG in Kassel invited by UNIDO were requested to give their opinion on the plan that we had submitted based on the concept of combined buildings for both High Voltage and High Power Laboratories.

We had the opportunity to express more views to the Technical Advisory Commission on the 19th of February 1973 at a meeting held in Madrid. Some comments on this meeting were included in our Fourth Interim Report of April 1973. While in Madrid we had the privilege to meet with the Director of the Junta Rectora, Ilmo Sr. J.L. Diaz Fernandez with whom ideas were exchanged on the concept and implementation of the two laboratories. On the last day of this meeting the Technical Advisory Commission outlined a scheme which would meet with their approval and rallied the concept of combined buildings but in an elongated layout maintaining a distance of over 150 m. between the test areas of High Voltage and High Power.

At the beginning of April 1973 we received from Madrid a sketch indicating the Technical Advisory Commission's views on the building layout while your Project Manager invited us to start revising our Draft Building Report on this proposition, but indicating that this arrangement had not received the approval of the Junta Rectora. We nevertheless prepared, on that recommendation, two schemes which we felt were acceptable to us even if we were of the opinion that they were a little more expensive than our original proposal. These schemes were submitted in May 1973. Scheme No. 2 was accepted as indicated in a letter of June 27, 1973 from your Project Manager. By this same letter your Project Manager requested us to proceed in completing our Final Building Report in accordance with the accepted scheme.

Upon receipt of this letter on July 6, 1973, we immediately started on the revision of the report and preparation of the Final Building Report together with the Second Equipment Report which had been delayed until the approval of a layout. Though it had been manifested in a few instances that a closer collaboration was desired between our group and the Spanish Representatives to avoid redundancy in our work, our main activities were again falling in a period of national holidays when it would have been most difficult to maintain progress locally. On the other hand more than twenty persons were involved in this revision and we still feel that it would not have been practical to transfer such a group on the site when most of the doubtful issues had been previously discussed. It was felt that in further phases remaining debatable issues could be agreed or modified to meet with local requirements. Our Final Building Report and the Second Equipment Report were forwarded to Madrid and Vienna on September 11, 1973.

1.2 The Building Concept

Having been involved most recently with IREQ in the construction of their modern and huge laboratories, where the separate buildings concept was used for reasons that have been given in the Special Report of December 1972, we, immediately at the beginning of our studies, were conscious of certain problems that had been previously discussed here on the functions and operation of separate laboratories. After debating the pros and cons of the separate buildings concept we had come to the conclusion that, if we had recommendations to offer to any organization contemplating the construction of similar laboratories it would be in favor of a combined system of buildings for a more efficient and functional design. After two years of operation and tests in the High Voltage laboratory we were convinced that there was no danger of interference and we could recommend without hesitation the same design in a new building. With this concept we could envisage separating the two laboratories by an area of common services, resulting in a very economical layout with a lesser foundation perimeter and of a minimum exposed wall area. For these reasons we felt that our Draft Building Report should be submitted with this most modern approach. We knew of existing laboratories that had already been implemented on this principle, though their design was not comparable to the one we were offering. Since our presentation was made we have agreed that economy and efficiency may not necessarily always be the dominant selection criteria. Unquantifiable social and/or political benefits may sometimes weigh more in the final decision towards the choice of a more conventional implementation.

1.3 The Final Building Report

The Final Building Report has been divided in five volumes as follows:

Volume 1: Laboratory Implementation
2: Civil Engineering
3: Mechanical and Electrical Engineering
4: Terminal Section and Appendices
5: Drawings.

1.3.1 Laboratory Implementation

In accordance with set forth objectives in Contract Documents, the Laboratories have to be designed so that all tests required by standards can be performed on electrical equipment produced by the Spanish industry for equipment used on distribution and transmission systems and also some research.

In developing new equipment it is very important in testing that secrecy be maintained. Because of their functions, these laboratories have to offer flexibility in the sense that many tests can be performed simultaneously and that a multi-purpose floor area utilization be provided.

The implementation is based on the two laboratories, High Voltage and High Power, having easy access to areas of common usage such as shops, depots, oil treatment units, compressed air, etc. A corridor is provided to allow transfer of testing equipment or equipment under test from one laboratory to the other when needed.

We have also recommended that power be provided not only from rotating machines but also from the transmission system which offers a double circuit line at 220 kv. at approximately 1 km. from the site. At the meeting of September 24 we were informed that the Government intends to build a special line to that effect but coming from the east rather than the west of the lot.

In this section of the report special attention has been devoted to grounding and some notes have been added on personnel and training.

1.3.2 High Power Laboratory

The most important tests to be performed in the High Power Laboratory are:

- Short-circuit tests
- Load breaking tests with different power factors
- Short-time tests
- Heat run tests

These should be performed mainly on:

- Circuit breakers
- Disconnect switches
- Fuses
- Lightning arresters
- Load break switches
- Transformers; power and instrument
- Reactors, capacitors
- Bus bars, line equipment and cables.

The Laboratory comprises three main buildings:

1. Main machine hall and reactors, bus bars and condensers;
2. the assembly rooms, test cells, mechano-climatic chamber and control rooms;
3. synthetic testing.

These buildings all have access to an outdoor testing area. Within the test yard areas some protection against explosions during tests is foreseen. The interior test cells are explosion proof.

Four assembly rooms are provided where mountings can be made and easily transferred to the test cells or to the outside testing areas. As will be indicated further, all transfer of heavier equipment is based on the usage of air bearings and modular platforms. All tests will be remote controlled with a direct view on each of the test areas. The test cells have their own control room. A mechano-climatic chamber is provided for temperature variations between - 25°C and 65°C with its test area, annex chamber and control room as can be seen in the Second Equipment Report specification HP-15.

The type of tests mentioned previously, which list is not exhaustive, are commented in this section of the report to illustrate the possibilities of the recommended design. Some notes have been added on the test facilities and parameters, with some possible phasing in the procurement of equipment. A basic electrical diagram is included with explanations on the reasons behind this recommendation and reference is made in Appendix 2 for additional possible test circuits.

1.3.3 High Voltage Laboratory

The High Voltage Laboratory will be used for dielectric tests at very high voltages on such items as the following:

- Insulators
- Capacitors
- Bushings
- Instrument transformers
- Circuit breakers
- Disconnect switches
- Lightning arresters
- Power transformers
- Reactors, etc..

On such tests as:

- Lightning impulse
- Switching impulse (wet and dry)
- Power frequency (wet and dry)
- Measurements of partial discharges
- Measurements of radio interference voltages
- Measurements of capacitance and tan δ
- Heat run
- Induced voltage
- Open circuit
- Ratio measurements
- Impedance measurements
- Impulse

The dimensions given are sufficient for testing the equipment having rated voltages up to and including 765 kv RMS. The layout concept is based on the mobility of equipment both for testing or to be tested by the usage of modular platforms mounted on air bearings.

The building includes the main test hall that can be subdivided into smaller test areas by a removable fence, the transformer test area including access by rail, the mounting hall, the corona room, pollution room and control room. An outside test area is also shown on our recommended layout which could be built at a later date. There is sufficient land available that could be reserved on the west side for a future laboratory with a testing capacity up to 1200 kv. as has been requested by the Spanish Technical Advisory Commission.

As we will see later in this report the equipment recommended for the operation of this laboratory is specified in the First and Second Equipment Report, nevertheless some notes have been added on the range of the recommended equipment under this heading. The following have been covered:

1- Impulse Generator 4 MV, 200 kJ

2- Impulse Generator 2 MV, 24 kJ
3- Cascade transformer 1, 2 MV RMS, 1A
4- Voltage divider 3,5 MV impulses, 1, 2 MV RMS 50 Hz
5- Wavefront capacitors 10 of 20,000 pF, 500 kV
6- Discharge-free capacitor 600 kV RMS, 1000 pF
7- Compressed Gas Standard Capacitor 800 kV RMS, 50 pF
8- Wet test apparatus, 1,25-5 mm/min.

A diagram and some information are given on tests on Power Transformers. This information covers:

1) Three phase Coupling Transformer;

2) Single phase Coupling Transformer;

3) Compensation Capacitors;

4) Compensation reactances;

5) Potential Transformers;

6) Current Transformers.

We have added a brief description of the artificial pollution test method to be performed in the pollution chamber. The range of salinities of the salt solution and the withstand criteria are also described.

2- Civil Engineering

Civil Engineering has been considered under two main topics:

1- Site and services

2- Structural

2.1 Site and Site Services

2.1.1 The site

The site finally selected by the Government is known as Alcobendas some six (6) kilometers north of Madrid. The site is well selected for easy access, is undulating and offers a good subsoil for construction purposes. It is also near a double 220 kv line.

The main objective of these laboratories being to help the Spanish Electrical Industry, the provision for an easy access became of paramount importance. It is expected that most of its activities will be highway oriented, that is for equipment to be tested weighing less than 100 tons and for heavier equipment such as large transformers the access will be by rail for loads up to 300 tons. Fortunately in the overall highway planning, a major highway will be built adjacent to the eastern border of thia site with direct connection to Madrid. An existing railway line passes at approximately 4 kilometers west of the site; a spurline can easily be built. The only problem will be in the location south of the site where an existing nursery should be saved. It is important to provide a siding near the laboratories as well as eventually on unloading platform.

A study has been made of the location of the buildings on the site. Since this site is also to serve as a University Campus, the higher part of the land has been retained for more prestigious buildings and the selection of location for the Laboratories has been in the lower south area on a flatter portion of the land, to reduce excavation and embankments to their minimum, bearing in mind the size of the buildings and the need to have the ground floors kept at a common elevation. The three locations that have been studied are shown on a plan and a few comments are given on each in the Building Report.

2.1.2 Site Services

In accordance with contract documents the site services are to be designed by the National Consultants but we were to be informed of the various national standards so that we could foresee some of the limitations that may be imposed on our recommendations.

The road network that we have shown on our drawings is to be used only as guidance, but it represents also the various areas where access should be provided. The railway location may also be modified to suit local requirements but the access adjacent to the transformer test area in the High Voltage Laboratory must be kept. The location of this particular access caters to other areas as well and we recommended that it should be maintained.

The site services have been considered under the following divisions:

2.1.2.1 Transportation

a) Railroad

b) Roads

c) Handling

i. Horizontal movements

ii. Vertical movements

2.1.2.2 Sanitary services:

a) Drainage

i. Storm

ii. Sanitary

b) Water

2.1.2.3 Protection (Security):

Transportation:

These Laboratories are to provide testing facilities which in accordance with the set forth objectives are to help the Spanish Electrical Industry. This will of necessity generate many movements or trips of equipment to be tested as well as of the testing equipment. We have found that mobility and flexibility are two important qualities of such an installation and are part of the future success of operations in a growing competitive field.

a) Railroad

We have considered that all loads heavier than 100 tons would have to reach the laboratories and return to the customer via the railways. There might well be some limitations but, as a general rule, that statement should be sufficiently accurate. Road bridges are in general of insufficient capacity to accept loads over 100 tons. The heaviest load expected in these laboratories for many years should be around 300 tons.

b) <u>Roads</u>

We have mentioned before that the bulk of the activities expected in these laboratories will be road-based. The plan showing that a highway is projected adjacent to the selected site was therefore most welcomed. The network of roads on the site should be sufficient to allow access to all areas that we have shown. The geometric design, the infrastructure and the surfacing should correspond to the requirements of an industrial area while in agreement with the loadings that have been indicated. Parking is to be provided close to the administration building, some spaces may be added near each laboratory if desired. For security reasons we recommend that the road network serve only the laboratories and if a link with the University Campus is introduced in the final design a well controlled gate should be included.

c) <u>Handling</u>

We recommend that the laboratories be designed on the basis that air bearings will be used throughout (smaller apparatus can be mounted on rubber tired wheels). This is the most modern method for moving loads rapidly and economically on the premises. As indicated in the specifications submitted for various testing equipment, this equipment is to be supplied with its integrated system of air bearings. For moving equipment to be tested we recommend the construction of platforms on a modular basis that can be used as separate units or combined to form larger platforms. This system requires special care for the floor finish that is defined under "Structural" and a compressed air system defined under "Mechanical".

i. Horizontal movements

In this section we acknowledge that even if some horizontal movements are made by the overhead travelling cranes, the majority of these movements will be performed on platforms equipped with air bearings. Some smaller testing equipment will be mounted on standard rubber-tired wheels. We define what the modular platform should be and we give a recommendation on the type of air bearings best adapted to this form of operation. We take this occasion to reiterate what we have already said verbally, we can put at the disposal of the final designers typical plans of the system now in usage at the laboratories of IREQ. We recommend that the outside testing area be designed to accommodate the same handling system.

ii. <u>Vertical movements</u>

In this category two main functions must be considered.

1. Loading and unloading of merchandise received and preparing mountings for testing and experimentation;
2. Supporting parts of equipment or components during test.

The first function is performed by overhead travelling cranes. The second function is performed by overhead travelling cranes also in certain cases, in others by other types of lifting devices that are described in this chapter. For these lifting devices we have supplied certain requirements of capacity and speeds which should be adhered to.

To complete this section we have

recommended the installation of an elevator going to the roof for easy access, as the ceiling of the High Voltage Laboratory is to be used by the operators as a walking platform for mounting purpose, service to lighting system, etc. Depending on local safety codes a staircase to the roof should be provided. We have added a few notes on mobile equipment needed in the laboratories for mounting purposes, easy access to mountings and various other functions. Some are illustrated.

Sanitary Services:

These services are the responsibility of the Government and their agents, nevertheless it was felt that certain conditions should be indicated.

a) Sewers

Our recommendations are based on the assumption that sanitary sewage will receive some form of treatment. Since in testing there is a remote danger of an oil spill from transformers,we recommend that floor drains should be connected to the storm drain and equipped with oil catchers ahead of every connection. Other non-polluting drainage system should also be connected to the storm drain. Because of the earthing system special precautions have to be taken.

b) <u>Water distribution</u>

The water distribution system for potable water and fire protection should form a loop around the whole complex. Here again special precautions have to be taken due to earthing requirements.

<u>Protection</u> (Security)

Because of the potential danger in a testing and experimentation centre of that nature, it is recommended thet the whole area should be fenced in. There should be only one point of entry on the premises controlled by a gate house. This perimeter fence should be signalized for better control and proper danger signs placed well in evidence. Other security matters are left to the National Consultants to implement in accordance with local codes and by-laws.

2.2 Structural Engineering

The Building Report, in accordance with the Terms of the Contract documents, was to give a recommended layout of the High Power and High Voltage Laboratories showing estimated overall dimensions, floor plans and elevations, structural requirements in sufficient detail for the architectural plans and structural design to be prepared by others.

Under this heading the recommended layout is submitted together with floor plans and elevations and our concept of the structural requirements. Volume No. III entitled Mechanical and Electrical completes certain details that are requested in the Building Report as forming part of the systems and sub-systems recommended. Some of these systems may have a direct influence on the type of structure.

Some borings have been done and indicate a subsoil of good quality. Nonetheless, these have to be continued on a more extensive basis by the final designers. Because of the heavy floor loading required, special precautions are to be taken in the design of foundations. Some foundation details have been indicated but only for the consideration of the final designers.

As has been mentioned before, the usage of air bearings as a mode of handling requires that the floors should have a very smooth finish and other qualities that are described in this section. Because of electromagnetic protection chiefly in the High Voltage

Laboratory an expanded copper mesh is incorporated in the floor which requires some extra precaution in the design and construction. These recommendations are indicated under this section.

Due to their size and, in other cases, to specific requirements, doors are described in this chapter as well as their functions. In a few instances, it has been possible to illustrate with the aid of photos.

Cladding and partitions are also described for each area. In some cases, they can be varied to suit the availability of materials locally and the construction practice; in other cases, such as the Main Hall of the High Voltage Laboratory, we recommend that no change be made since results obtained here are conclusive enough to validate this choice.

For clarity, all areas have been subdivided in Blocks. For each we have given a short description of their function and the Design Criteria. These are:

Block A - High Voltage Main Hall

Block B - Synthetic Test Hall

Block C - Transformer test area - Mounting Hall
Corona - Pollution - Handling and Unloading area.

Block D - Common area

Block E - High Power Section for reactances, resistances and condensers - Main Machine Hall for rotating machines.

Block F - High Power Section including assembly rooms, test-cells, climatic chamber, control rooms, equipment rooms, etc..

Block G - Main Office Building - High Power test yard. High Voltage outside testing area.

3. <u>Electrical and Mechanical</u>

Volume III of the Building Report includes our recommendations on the various systems and sub-systems in Electrical and Mechanical Engineering as they relate to the various buildings. In some cases it may be necessary to refer to the First and Second Equipment Reports for more details on certain requirements exacted by some of the testing equipment.

In the Building Report this volume has been subdivided in two chapters:

Chapter VII - Electrical

Chapter VIII- Mechanical

8.1 Electrical

Under this heading are covered the various systems:

- Power Sources and Distribution;
- Lighting
- Auxiliaries
- Handling
- Shielding
- Grounding
- Patch Panels, Measuring Cables
- False floors and ceilings

Power Sources and Distribution

Two incoming 220 kV aerial lines will feed a Main 220 kV/22 kV substation supplying power to the Laboratories and to the University Campus. This will be done through two 16 MVA three phase transformers 22 kV secondary, the first with no voltage disturbance (normal), the second with a permissible voltage disturbance (test line).

A main outdoor 22 kv substation will be provided. The normal line is to supply the regulators and the transformers for the power to all the buildings ser-vices, including the University Centre, the secondary testing points and the impulse generator. The test line is to feed the 1 MVA and 300 KVA rotating machines and the 50 MVA short circuit capacity high current-direct current test area. A tie gang load break switch shall be provided between the normal and test line.

From the main substation to the 22 kV substation the connections should be through a system of underground conduits. The distribution system is shown on drawings and described in this chapter. In area such as the Main Hall of the High Voltage Laboratory a high crawling space has been included in the design where cable trsys should be used for power and control cables distribution. As indicated, great care is to be taken for proper shielding and grounding. Recommendations are made for power outlets and receptacles which are to be provided in large numbers for flexibility and efficiency. Some of them, as shown on drawings, have to be connected to the emergency system. Power outlets should also be provided at different voltages as indicated.

Direct current power supply for the operation of circuit breakers and control systems shall come from a group of accumulators. A diesel driven electric generator standby shall provide adequate emergency lighting in case of power failure and shall supply power also to certain pieces of equipment where a sudden interruption of service may cause some inconvenience to the personnel, such as in elevator and in crane cabins.

The electrical requirements of testing points, control cubicles, control desks, s ondary testing points, are described on drawings and in some cases illustrated by a photo. A system of mechanical interlock and key interlock for the protection of the equipment is recommended and described.

Lighting

Lighting is considered as a) indoor, b) outdoor. The illumination levels for each indoor area is shown on drawing No. 212 and attention is drawn that such level is not for initial but for maintained efficiency. The type of source is indicated in relation to the function of an area. Some explanations are given where variable intensity is needed whether this is achieved through step-by-step or continuous dimming. For certain specific areas an interlocking system is desired and described. Some notes are included on the class of lighting fixtures and accessories, on special mountings, on emergency lighting and on exit lights.

The outdoor lighting relates mainly to roads and parking areas as well as to the outside testing yards. In that category could also be included some special area lighting effects which may be desired to enhance this landmark.

Auxiliary Systems

This includes telephone facilities, interphones, clocks, chronometers, watchman tour, security in the test areas, fire alarm.

Handling

Because of the importance of the handling system, including cranes, monorails, jibs and fixed points some notes covering the method of operation through fixed stations, pendant push button, radio control or cabin operated have been added. Again great emphasis has to be brought on the grounding of all this equipment.

Shielding

A Faraday cage is to be provided to obtain an electromagnetic wave attenuation of 60 dB minimum for frequencies of 0.1 to 10 MHz in the High Voltage test areas, the Corona rooms and Control rooms as designated. The metallic walls and ceiling form part of this shielding and every panel is to be welded to the adjoining one at every metre. The floor is to have an expanded copper grid also welded together, to all accessories in the floor area and to the walls to assure complete continuity. Special precautions have to be taken by embedding copper bars in the floor or by joining the rail of all doors to the grid. In control rooms a copper bar around all windows shall be connected to the grid and the windows shall have vertical wires spaced at 15 mm connected to the perimeter copper bar. The Control rooms in the High Power section requiring still a higher attenuation hava to be built with special pane hich are described in this section.

Grounding

Details of grounding are shown on drawings Nos. 208 and 209. In this chapter notas are given on tha main peripheral grounding cable, the grounding of bus bar and pedastals, of cable trays, of crane railways and motorized doors. Notes will also be found on the grounding of measuring cable conduits, of the steel columns forming part of the structure, of primary testing points, of patch panels, of metallic bases, of electrical equipment, of equipment forming part of the mechanical division and of special grounding outlets and boxes for the chain link fence in the floor slab of the High Voltage Laboratory.

All incoming supply systems such as water, gas, drains, etc., shall be isolated from the earthing system by a non conductive length of conduit.

Patch Panels, Measuring Cables and Boxes

The patch panels for measuring cables are illustratad on drawing No. 201. Some notes on the coaxial cables, connectors and boxes for measurement are included under this heading.

3.2 Mechanical

This chapter treats of the mechanical systems that have a special bearing on the building concept and on the specialized services which form part of this Testing and Experimentation Centre. Standard services such as sanitary, roof drainage, pipe sizing, ducting etc., are not covered in the report.

Under this heading the systems that are described are the following, they are preceded by some generalities on grounding, thermal insulation, noise and vibrations, meteorological data:

- Transformer Oil Handling;
- Low pressure compressed air;
- High pressure compressed air;
- Water treatment;
- Plumbing;
- Heating;
- Ventilation and air conditioning;
- Acoustical

3.2.1 Generalities

These cover some notes on the mechanical drawings, the codes, the grounding of the mechanical equipment of which a word has already been said in the electrical chapter. Thermal insulation relates to pi ig which should be insulated for cold and hot surfaces. This is common practice and was introduced only as a reminder. A few notes are given on noise and vibrations, and a list of permissible noise level given for various areas. Equipment that generates vibration should be installed on proper inertia bases, vibration isolators, with flexible connectors, etc. The meteorological data that we have included is only a summary which served as a guide to our designers when considering systems best adapted to the local climate.

3.2.2 Transformer Oil Handling System

This system is intended to fill with suitable treated oil and to drain after test all equipment to be tested which is to travel without its oil. The capital part of the system is a mobile treatment unit described fully in the Second Equipment Report under HV 28. The system comprises the following sub-systems:

- Oil storage tanks
- Pumps
- Distribution headers
- Piping network
- Oil treatment unit

Oil Storage Tanks

Three storage tanks are required: a) usable oil, b) contaminated oil, c) unusable oil. We have recommended an underground system of storage close to road and railway for easy servicing. Each tank to be equipped with proper manhole, level indicators, filling and vent pipes and cathodic protection.

Pumps:

The pumping system is required for filling the equipment, transferring oil from one storage tank to another and for draining equipment or tanks. Two feed pumps are recommended and a mobile draining pump.

Distribution Headers:

The suction, discharge and return headers with proper valves allow easy selection of pipes to be interconnected to perform the required function. The suction header, discharge header and return header are specified with major accessories.

Piping Network:

A brief description is given of necessary piping from tank to headers, from headers to pumps, from headers to local supply outlets and return inlets, and flexible hoses with quick connect couplings to service equipment.

Mobile Oil Treatment Unit:

As mentioned previously this equipment is detailed under HV 28 of the Second Equipment Report. This unit will decontaminate the oil by removing water vapor, dirt particles, air, gases, etc.

3.2.3 Low Pressure Compressed Air:

This system will supply the necessary air at low pressure for compressed air tools and for the handling systems using air bearings. The pressure should be 7 kg/cm^2. This system includes compressors and controls, air receiver, aftercooler. Two or three compressors should be installed. They should be two-stage, piston type, sufficient to meet the maximum air requirement of 0,285 m^3/sec. (at atmospheric pressure). The air receiver should be of sufficient capacity to absorb pulsations and prevent cycling. A water or air cooled aftercooler is recommended to cool the air and reduce its moisture content. A piping system is included to distribute the air to all areas where needed to air outlets as shown on drawings. From the air outlet to equipment, flexible hoses mounted on reels are recommended; these are illustrated on photos in appendix.

3.2.4 <u>High Pressure Compressed Air:</u>

This system intended to activate pneumatically operated electrical apparatus operates at either 55 kg/cm^2 or 250 kg/cm^2. It consists of three compressors each supplying 0,023 m^3/sec. of air through separate piping systems to four spherical pressure vessels in the case of 250 kg/cm^2 each having a capacity of 0,8 m^3 and four cylindrical pressure vessels for the storage of air at 55 kg/cm^2, each having a capacity of 1,2 m^3. Special care is recommended because of ambient temperature. Outlets for both systems will be needed whenever such pneumatically operated electrical apparatus will be used or tested.

3.2.5 Water Treatment System for Rain Tests

Water with a controlled resistivity is required for testing under simulated rain conditions. This system includes:

- deionizer and charcoal filter
- storage tanks
- pump
- piping, controls and outlets

The deionizer (demineralizer) is of the two-bed type with separate cation and anion exchangers. The quantity of water used in a test may be as high as 40,000 litres in 60 minutes. The charcoal filter will remove chemical impurities. Storage tank or tanks are needed and because of corrosion they should be of fiberglass. A pump of 11,5 litres per second capacity forms part of the system. The artificial rain apparatus must have its own system of pumps and regulators. The pump must be of special construction because of corrosion. A system of controls, piping, mixing valve is described so that the proper ratio may be obtained in the mixing of dionized water and salt solution. All piping and fittings should be non-mettalic such as polyvinyl chloride.

3.2.6 Plumbing

As stated before we have not included in this report any note on standard plumbing practice such as sanitary, roof drains, etc. We have provided information on special items of plumbing which are specific to these Laboratories. Such items cover floor drains where an oil spill is possible, the manner in which floor drain grates should be installed to meet the operation of handling platforms mounted on air bearings, the special connections for drainage of electrical floor outlets, location of drains in test cells, the usage of oil interceptor for the floor drainage system. The drainage of the pollution room deserves special attention due to the high concentration of salt, the runoff might have to be treated separately before entering the public sewer.

Cold and hot water should have outlets, besides rest rooms, wherever it is convenient for drinking fountain, for cleaning purposes, etc. at least at every service module which are described under this heading. Dark rooms require special plumbing fixtures.

Fire protection is through standard water distribution piping, hydrants and other outlets with also an automatic CO_2 system and portable chemical units.

3.2.7 Heating System

Under this heading we are offering our views on the design criteria governing the heating system in the buildings and on the selection of heating equipment. We have included also the conditions and areas to be heated and the location of equipment. Since these are electrical laboratories, we have based our approach on electrical heating, it may become necessary for the local Consultants to make a special study to ascertain whether or not this source of energy is the most economical especially in view of the total land development.

The design criteria are the following:

- Minimum outdoor Dry Bulb temperature: -7° C.
- Indoor Dry Bulb temperature maintained at ± 1°C of the mentioned values for the different areas
- Indoor humidity maintained at within ± 5% of the mentioned values for the different areas.
- Wind velocity: 24 km/hr.
- Transmittance of walls and roof 0,045 cal./(hr. - cm^2 - °C).

Humidifiers should operate fram electric steam boilers for better efficiency.

Temperature range and humidity are given for each area from Blocks A to G incl. with recommendations on the type of equipment.

3.2.8 <u>Ventilating and Air Conditioning</u>

To provide the temperature and humidity convenient to the functions of these laboratories it will be necessary in some areas to ventilate and/or to air condition. This section covers the related design criteria, the equipment and the areas where we recommend the usage of such system.

The design criteria should be the following:

- Minimum outdoor temperature: $-7^{o}C$.
- Maximum outdoor temperatures: $35^{o}C$ dry bulb, $23^{o}C$ wet bulb.
- Indoor Dry Bulb temperature maintained to within $\pm 1^{o}C$ of the mentioned values for the different areas.
- Indoor humidity maintained to within ±5% of the mentioned values for the different areas.
- Design wind velocity: 24 km/hr.
- Transmittance of walls and roof: 0.045 cal/ $(hr.-cm^{2} -^{o}C)$.

Notes are given on grilles and diffusers, filters, intakes, air exhausts and screens. Areas requiring air conditioning or ventilation are submitted for Blocks A to G incl. giving the range, the requirements and the system recommended.

3.2.9 Acoustical Recommendations

This applies chiefly to the Main Hall of the High Voltage Laboratory where acoustical problems may be met during tests.

The reverberation time in the hall must be limited to the following values:

- Low frequencies: 2,25 seconds
- Medium frequencies: 1,50 seconds
- High frequencies: 1,0C seconds

A description of the inner wall construction and ceiling is given which meets the recommended values.

The common wall between block A and Block C should be of the double masonry type so that a maximum of 50 dbA in block C is obtained. Doors have to be treated accordingly.

VOLUME IV

Volume IV of the Building Report contains the Terminal Section and the various appendices.

Terminal Section

The Terminal Section recapitulates briefly some of the main principles on which our recommended implementation is based, and in the last paragraph we repeat that a programme of training is essential for the future operators of these laboratories.

Appendices

Appendix 1:

Contains our recommendations for field borings and the results of the test carried out in December 1972 by Sondax, S.A.

Appendix 2:

Gives a review of the possible test circuit diagrams that can be achieved in the recommended layout and equipment of the High Power Laboratory.

There is also an analysis of possible connections of the generator-transformer group. The conclusions of this analysis are:

1- A short-circuit generator in simple star connection will be used.

2- No change over switch of the winding is required.

3- The withstand current of the bus bar system between the generator and transformer will be 86 kA RMS and 260 kA peak.

4- One or two test cells for testing at generator voltage will be employed for the future but will not be equipped at the beginning.

<u>Appendix 3</u>:

Gives a short analysis of the short-circuit generator to be used as the power source for the High Power Laboratory.

<u>Appendix 4</u>:

Gives the photographic reproductions referred to in the text.

<u>VOLUME V</u>

Gives a reproduction of the large scale drawings for easy reference. Large scale drawings have also been supplied for better understanding of details. Though large scale prints have been supplied in limited numbers, additional copies can easily be forwarded.

2. INTERIM REPORTS

Four Interim Reports have been submitted at the following dates:

June 7, 1972
August 7, 1972
January 8, 1973
April 9, 1973

The purpose of these reports was to provide information to UNIDO on the work progress and future work programme. They were intended to be issued at every second month. However, from August 1972 to January 1973 no Interim Reports were issued as the complete team was involved in the supply of three important Reports:

Draft Building Report on September 29,
First Equipment Report on October 16,
Special Report on December 14.

Still no Interim Reports were issued from January to Arpil 1973 because, except for a meeting in Madrid, very little work was performed pending further comments.

3. <u>Equipment Reports</u>

As requested by the terms of the Contract we have supplied Equipment Specifications as follows:

a) First Equipment Report on October 16, 1972 for such "items of equipment which involve special building requirements or which must be specially manufactured and will therefore have a long delivery time".

In this report were supplied a Tender Form Specimen and the General Conditions applicable to all contracts.

b) Second Equipment Report in September 1973 covering all other equipment of shorter delivery that could be obtained on the international or local markets.

We include hereafter a list of the Equipment Specifications included in both reports without further comments since the Summary Equipment Report covers the specified equipment.

This Summary Equipment Report includes:

a) A short description of the equipment,

b) The date it was provided to the UNIDO and the Government,

c) Our recommended list of suppliers and/or manufacturers.

d) A price list of the equipment.

EQUIPMENT REPORTS

FIRST EQUIPMENT REPORT

GENERAL CONDITIONS:

TENDER FORM SPECIMEN
GENERAL CONDITIONS APPLICABLE
TO ALL CONTRACTS

TECHNICAL SPECIFICATIONS:

HIGH VOLTAGE LABORATORY

4 MV 200 kJ impulse generator.............. HV 1
2 MV 25 kJ impulse generator.............. HV 2
Voltage Divider........................... HV 3*
600kV free capacitor...................... HV 4
500kV front capacitors.................... HV 5
800kV compressed gas capacitor............ HV 6
Vertical sphere gaps...................... HV 7
Cascade transformer....................... HV 8
40 MVAR capacitor bank.................... HV 9
78 MVA 100kV test transformer............. HV 10*
3 MVAR 3 phase 200 Hz reactor bank........ HV 11*
Impulse oscilloscopes..................... HV 12
1.33 MVA transformer 50 and 200 Hz........ HV 13

* HV3, HV10 and HV11 have been replaced by HV14, HV15 and HV16 respectively in the Second Equipment Report.

FIRST EQUIPMENT REPORT

TECHNICAL SPECIFICATIONS:

HIGH POWER LABORATORY

2000 MVA short-circuit generator............. HP 1
Three-phase back-up circuit-breakers......... HP 2
14 kV reactor coils and shunt disconnect..... HP 3
3-700 MVA short-circuit transformers......... HP 4
3-166 MVA short-circuit transformers......... HP 5
25 kV reactor coils and shunt disconnect..... HP 6
Make switches................................ HP 7

LIST OF SUPPLIERS AND APPROXIMATE COSTS

APPENDIX

Parameters for choice of short-circuit transformers

SECOND EQUIPMENT REPORT

TECHNICAL SPECIFICATIONS

I- 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 350kVA single phase voltage regulators...... HV 21
Two high voltage construction kits.............. HV 22
1.33 MVA, 200 Hz rotating machines.............. HV 23
350kVA, 50 Hz, 60Hz, rotating machines.......... HV 24
350kVA, 275kV, 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 purpose 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.

II- 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
Mechano-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.

TERMINAL SECTION

IX- TERMINAL SECTION

As stated in the previous Sections, the Final Building Report is to be used as a general guidance for the Architectural Contractor in the design of the required facilities for the High Voltage and High Power Laboratories forming part of the Electrical Testing and Experimentation Centre in Madrid.

We have exposed all the main aspects and, in many cases, a lengthy description of:

1- The principles of site location

2- The motives of laboratory implementation

3- Characteristics for the design of the structural, electrical and mechanical layouts.

4- Equipment Reports.

Throughout our study we have taken into consideration that the Laboratory facilities are to be developed in stages to meet the actual needs with possible expansions for future conditions.

The laboratories have been designed to meet with the conditions set forth in the contractual documents related to reports prepared previously by two Consultants to UNIDO.

We have gone beyond certain of their recommendations and modified others to meet the requirements of industrial testing and to enlarge the possibilities in experimentation.

Once the volume of the various halls are determined on the basis of their functions it becomes mainly a question of selecting materials to remain economical while meeting set forth parameters. These buildings are considered as more of the industrial type than institutional.

The Equipment is a most important part of such laboratories and this is why much time has been spent in the preparation of specifications for this equipment.

The concept is based on total mobility of the testing equipment in the High Voltage Section enabling a high degree of flexibility without increasing the investment. The same principle has been applied to the High Power Laboratory by offering three independent sections. Mobility is equally important on equipment to be tested.

Some features of the Centre have not been treated in this Report as they can be designed readily by local specialists according to the Spanish practice. Those are: the Office Building, water and sewerage networks, road and railway designs, etc. all in accordance with Contract documents.

The laboratories as recommended in the Building Report will meet the objectives and help the Spanish manufacturers in making acceptance tests on their products according to international standards.

Correspondance has been exchanged between the Spanish Government and our group for the purpose of setting up a programme for the training of technicians to operate the various sections of the Laboratory.

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