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HIGH-LEVEL CONSULTANCIES AND TRAINING

DP/SYR/86/009

SYRIAN ARAB REPUBLIC

Technical report: Designing and testing of electrical switch gear apparatus*

Prepared for the Government of the Syrian Arab Republic
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

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United Nations Industrial Development Organization
Vienna

* Mention of company names and commercial products does not imply the endorsement of UNIDO. This document has not been edited.

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A B S T R A C T

The mission has been under-taken under to the Project:

"High level consultancies and training"

DP/SYR/86/009

The aim of this mission was to help the Syrian Government in strenghtening existing facilities used for designing, manufacture and quolity control of electrical low voltage switchgear.

The mission duration was one month.

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Specification 1

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Training to be arranged by the UNDP

Annex

INTRODUCTION AND RECOMMENDATION

A. Introduction

The Government of Syria gives high priorities in the Sixth Five-Year Development Plan to consultancy services and training programme for the power electric switchgear sector, with special attention on the establishment of new production of switchgear low voltage apparatus and testing laboratory.

The national industry in Syria strongly supports the programme of power electric apparatus, establishment of quality control laboratories and training of the postgraduated engineers.

The national Electric Power Company is aware, basing on experiences, of the necessity that the present existing old apparatus, and even to greater extent, those to be developed must be tested to determine their quality and reliability.

The present applied switchgear imported from different countries, different design, makes troubles in maintenance / lack of spare paris /. To unify these apparatus and to reduce import the Government wants to produce home equipment for electric power substation.

No national specialised industry exists. At the existing electrotechnical industry / electrical motor, electronic and cable industries are required facilities / machines and free surfaces/ where establisning of new production lines for the power electric apparatus would be possible. This is due to undercapacity utilization of these factories - some times below 10 % only.

The need of introducting UNIDO project was identified with the aim of assisting the country in elaborating the existing problems and advising the best solution.

B. Recommendation

1. Following the outcome of the preparatory assistance assignment it was proposed to organize a course, which will give theoretical back-ground on designing, testing, manufacturing of electrical switch gear apparatus.

2. Three sections should be established at one of the visited factories supposed to be the manufacturer of the low voltage switch gear apparatus it is: for impregnation of coils, for manufacturing springs and for reeling and annealing of electromagnetical cores.

3. Next visit should be devoted to: training in the area of switchgear, consultations about the central laboratory and elaboration of a concept of a new project which will cover:
   - development of the switch-gear
   - establishment of the quality control laboratories
   - establishment of the central laboratory.

   The duration of this visit should be two months starting from September.

4. Last visit should focuse on training and consultations as above and in elaboration of the proposed project document.

I. OBJECTIVE OF THE ACTIVITY AND DUTIES

A. Objectives

The objective of this mission was to recognize the existing facilities /machines, technology, materials/ and formulate requirements for the switch gear and quality control laboratories destined to verification of the power low voltage distribution system components to be manufactured.

B. Duties

According to the Job Description, the duties were as follows:

1. Finding / trouble shooting / indentification of key problems with regard to the existing design / manufacture / testing facilities in term of applied technologies, productivity, quality control repair and maintenance procedures.
2. Review of technical studies, technical examination assessment of existing facilities and products with the review of improving their performance characteristics, through the modification of existing technologies or introduction of appropriate production facilities.
3. Preparation of work programme for the improvement of the local design / production, quality control of switchgear and other power system components including infrastructural requirements, hardware, manpower, training, training needs and financial consequences for the introduction of production / assembly lines and related testing facilities/.
4. Elaboration of a Technical Report on mission describing the course and results of the respective field assignments including findings conclusions and recommendations for following activities.

II. DESCRIPTION OF ACTIVITY

A. Visits to different centers

Programme of visit and subsequent activities was in general form determined with Mr I. Khankan during the first meeting at General Establishment of Engineering Industries. It was decided that, for the sake of required information it will be highly desirable to visit the main state electrotechnical factories, supposed to manufacture the power electric switchgear. The Industrial Testing and Research Centre adviser for Electrotechnical Industry Electric Power Company, the main user of power switchgear has been appointed partner to the author, able to give information about the required data of electrical apparatus already applied, and these which should be in the power system, also able to determine a substation in the network which can supply testing laboratory.

Electronic factory - SYRONICS.

This factory was designed for manufacture of about 60 thousand of T.V. yearly. Now the existing facilities are not fully utilized, and a great production area, about thousand of m^2 is emply, able to develop production of the low voltage switchgear equipment.

The visited mechanical department is furnished with a set of pressing machine from 50 t to about 200 t and injecting machines from 100 g to about 4 kg.

In separate room there is about ten winding machines of different size, and others of high efficienty for reeling, at the same time, up to ten coils. At the winding section there was also a highly efficient autoclave with epoxy resin, used for impregnation and drying. This specialized autoclave is forseen but only for small coils like those used for generation of high voltage in T.V.

In an other section of mechanical department a set of electric welding machnes were only partly / about 10 % / used, also able to help in manufacturing of electrical switchgear apparatus.

BARBADA Combine

This multiplex combine was forseen to produce a great quantity of houshold devices but the initially assumed manufacturing programme can not be realized. Therefore, at some of the departments a new product, like considered switchgear apparatus, can be produced with possibility to manufacture all of required elements.

The mechanical department is equipped with tens of pressing machines from 60 t to 300 t and more than ten injecting machines from 80 g up to several kg. able to produce plastic elements from some cm^2 to 1,5 m^2 different thickness.

Some of required moulds and tools were also made there, for which milling, drilling, grinding and cutting machines of different size and application were used.

In a separate section, of mechanical department tens of lathes able to work out materials from 10 cm up to 1 m diameter.

This specialized equipment can produce at once mechanical elements, for the considered in the project switchgear, with the only exception that coils for electromagnets should be produced in co - operation with the Electronic or Electric Motor Companies. These two factories are equipped in set of different winding machines.

In this factory, as it was also at the visited SYRONICS factory there is a great free manufacturing area, which can be used for production of low voltage switchgear.

Factory for repair of distribution transformer and low voltage switches.

This factory has the necessary equipment for oil regeneration,

for impregnation and drying of medium voltage distribution transformers after repair, a laboratory to perform high voltage test / impulsegenerator and power frequency voltage test 1,2 μs/ 50 μs - 400 kV and 50 Hz - 200 kV / and no-load tests. A great quantity of low voltage switches are repaired calibrated and tested. This work is made without acces to new spare parts; required elements are taken from switches, which cannot be repaired, or on the expence of some others.

To improve working conditions of this section the author proposed to arrange disassembly and assembly lines at the end of which will be a stand for calibration or testing. This will facilitate working conditions and increase efficiency.

The aim of visit was to apply the no - load laboratory for eventual testing of low voltage circuit-breakers, switches, contactors and other apparatus. According to the received information the maximum available current is of about 2500 A at about 800 V received from the generator. This power source cannot be used for short-circuit tests; the generator was not specially designed. After application of low voltage transformer with the ratio 800 V / 110 V/220 V/400 V tests of low voltage contactors-verification of the rated normal current at 220 V and 400 V, heating tests of contactors, disconnectors, switches and circuit-breakers can be made.

For switching tests a set of reactors and resistors for current regulation also making switch is required and for d.c voltage a rectifire for 400 V, should be added. These additional equipment need some space which in this laboratory is not sufficient. Also Power Energetic Company, owner of this laboratory, is not interested in extention of the existing facilities.

Ceramic Company

For manufacturing fuses a co-operation with the ceramic Company will be important. Enclosures and sockets are tradicionaly made from hard porcelain. The visited factory is well equipped with four tunnel furnaces from which one / six year applied / is only used. Two others, after twenty years of application, were consumed and will be substituted by new ones. With the same machine having necessary tools and required materials this factory is able to produce the required quantity of ceramic elements for the electrotechnic industry.

The hard porcelain can be used for fuse enclosures up to about 100 A, but for higher rated currents a stronger porcelain, like oxide porcelain / Al_2O_3 / should be applied.

Mechanical Workshop

Since about two years the mechanical workshop is equipped with different machines and partly / about 15 % / utilized.

Tens of lathes and some milling machines / vertical and horizontal /, rather not new, but in good condition and some grinding and drilling machines can be used to produce different tools required for production of switchgear.

Technical University

The Electrical Department of the Technical University is one of the largest in Syria, not only from the point of viev of quantity of students but also because of the existing facilities. The High voltage laboratory has 2 MV impulse generator, 1,2 MV power frequency voltage test source and above 1 MV d.c. high voltage generator and set of meters used for measuring partial

discharges, voltage waveshape of lightning and switching over voltages. For climatical tests a set of equipment and facilities are available for students. Artificial / standard / rain, fog, salt fog can be simulated and used for testing of high and low voltage electrical apparatus, insulators relays and rneters.

At the time of visit the programme of establishing a low voltage central laboratory was discussed.

A great support received the idea to organize this laboratory at the Technical University, from many points of view :

- The University serves from very beginning as an advisory Centre for Power Energetic Company and Industry.
- It is easy to get skilled staff-engineers and technicians.
- This laboratory can be used for education also.
- After some short circuit test it is necessary to verify insulation materials applied in tested apparatus, and the required testing equipment is at the University.
- The University is far enough from the city centre that interferences of high magnetical fields on electronic equipment like this used in medical centres is negligible.

Industrial Testing and Research Centre / ITRC /

The ITRC is an industrial research and service institution having six main departments covering: applied industrial research, testing and analysing different products on request of industry.

From the point of view of the authors mission only Electrical, Industrial Measurements, Chemical and Mechanical departments were the most important.

The Electrical dep. is able to make standard measurements like current, voltage, resistances with electromagnetic meters and some electronic midle olass oscillographs.

In the Industrial measurements dep. a set of different electronic and mechanic balance weights were presented able to measure from miligrams up to 30 kilograms which can be calibrated by a set of standard weights. To determine volume, diameter, length, industrial acustic interferences, and temperature a set of standard equipment of different size and accuracy was also presented.

The Chemical dep. is able to carry-out not only convential measurements but also to realize an own research programme. With the spectograph, a different diagnosties of materials and gas can be made.

At the Mechanical dep. particular three machines used for determination of bending stretching and pressing forces of different materials draw attention. With the available facilities and measuring equipment a qualifying test of some of insulating materials, mechanical tests, shock and vibration tests of light apparatus and different chemical analyses can be made.

Unfortunately the Research Centre is not able to make the required quality control tests of switchgear and, therefore an additional set of testers and other meters listed in specification 3 are required.

Also short-circuit tests can not be made in ITRC and, therefore, a Central Laboratory should be established.

III. DEVELOPMENT PROGRAMME

A. Assesment of needs and methods of development of switchgear apparatus

Enquire made in Industry and Power Energetic Company ascertained the need of unified electrical apparatus with the availability of spare parts. The visited factories can initiate production basing on existing facilities.
The authors activity focused on determining the required switchgear and above all to select these which should be at first produced. Taking into account the needs, possibilities and human potential attention will be concentrated in developing production of apparatus required in great quantity: by industry, and these for domestic installations.
These groups of apparatus listed in specification 1 should be developed in two steps: first for lower rated data / group A - specification 1 / and later up to required rated data / group B /.
The two step programme can be considered as :
- programme minimum - for lower rated data
- programme maximum - up to required rated data.

Depending on financial support one of these programmes can be realized.
Taking into account the required period of realization of this project the possible practical solution of existing problems should be as follow:

1. to develop production of these apparatus listed in specification 1 basing on design made with help of UNIDO technical advisor and drawings received with,

help of UNIDO from specialized manufactures.

2. to develop routine test laboratories, at end of each assembly line, provided with equipment listed in specification 3

3. apparatus listed in specification 2 can be successively produced, after some time, depending on financial support or in parallel to these listed in specification 1.

B. Assesment of needs for quality control laboratories

For development of production of the switchgear listed in specification 1. the routine test laboratory must be arranged and equipped with apparatus listed in specification 3.

In Factories as well as at the University was stressed the necessity of tests of the existing equipment, that from different companies and the new switchgear which will be developed and produced. For this purpose a Central testing station should be arrangedand delivered with about 100 kA at 400 V and about 125 kA at 220 V of short circuit symmetrical current. A direct current circuit requires an interrupting capacity of 50 kA at 250 V.

Taking into account financial difficulties the laboratory should be developed but in two steps :

- first-technical project should be made with the necessary justification of necessity for this laboratory and with economical analysis
- second-project of this laboratory should be introduced into the State plan to get financial support.

The Technical project of this laboratory will be realized with help of author.

C. Equipment / Facilities

To realize this project three groups of facilities must be furnished :

1. the first group refers to the quality control laboratory, which should be equipped with testers and measuring apparatus listed in specification 3
2. the second group refers to the equipment which should be implanted in one of the visited factories:
   - autoclave for impregnation with electroinsulating lackers and epoxy resin / specification 3 / with vacuum pump and vacuum meter
   - furnace for annealing and a stand for reeling electromagnetic cores / specification 3 /
   - a stand for production of specialized springs and furnace / specification 3 /
3. the third group refers to the Central Laboratory - required equipment will be selected after its designing.

D. Training

Training for postgraduted engineers and students of last year should be organized before development of production of the switchgear, but because of the lack of time will be organized parallelly.

The main reason for fraining is that this branch of industrial activity as yetis not developed and also that more attention should be paid to power switchgear its designing and testing.

Programme of the training was disoused at the University / see Annex /.

Manuscript of these lectures will be delivered by the author before lectures and will be distributed among students.

E. Mode of Project implementation

The final distribution of tasks and further activities for implementation of this project was agreed with Syrian counterpart General Establishment of Engineering Industries and the idea was the following:

A. Development of production of the switchgear cover be organized in frame of a new project. Concept of this project / frame-work / will be elaborated at the time of next visit and should contain:

- Manufacturing of the required moulds, tools and auxiliary equipment -
- Establishment of assembly lines with the required specialized tools
- Establishment of a section for manufacturing springs specific. 3 /
- Establishment of a section for impregnation -
- Establishment of a stand for reeling and annealing of electromagnetic cores -
- Delivering required raw materials, semifacture available on market or imported -
- Design of apparatus not covered by drawings received from specialized manufactures will be made by experts under the project.

  For designing forms and tools, a second technical advisor / mechanical engineer - specialist in designing tools and moulds / should be appointed.

B. As far as quality control laboratory is concerned - Testers, measuring equipment listed in specification 3 will be delivered.

C. Training will be organized and realized by the author- programme for training was discused.

D. Technical projeot of the oentral laboratory will be made and ils futher realization will depend on financial resources available.

F. Draft Project Document

As a result of the mission, a Draft Project Document has been elaborated.

This Draft Project Document was discused in a final meeting held in General Establishments of Engineering Industries in presence of the General Director of GEEI Mr. M. Mounaged and Mr. I. Khankan.

Amendments were introduced reflecting this discusion.

This Project is supposed to start after aproval by : Ministry of Industry, Ministry of Planing and Higher Authorities and will aproximately cost :

Government about 10 Mil. of SP and UNDP of about 1 Mil of US dollars.

The duration of the project should be of about three years.

Specification 1.

Description	Rated current /A/	Rated current /A/	Remarks
	Group A	Group B	
Plugs	10		
Sockets	10		
Lamp switches	10		
Micro switches	up 10		
Fuses	up 40	600	
Panel switch /type plug in /	40	100	with thermal, magnetical triping
Contactors	40	600	
No - fuse breakers	40	2000	with thermal, magnetical triping
Current transformer	100	1000	class 0,5; 1; 3 load 15 VA
Disconnector	100	600	

Specification 2.

The apparatus which should be produced depending on financial support, which is out of the scope of this project.

Description	Rated current /A/	Rated voltage /V/ dc/ac	AC[x] SCC /kA/	DC SCC /kA/	Current sensitivity /mA/	Remarks
Circuit-breakers	2000	250/380	60	40		thermal, mag triping
Earth leakage circuit-breaker	15-50	240	3	-	10-30	thermal, mag triping
Packed switches	5-20	220	-	-		

Note: x - Rated symmetrical short circuit breaking current.

Specification 3

Equipment

A. Required for the quality control laboratory

- Testers for calibration: contactors, panel-switches, no fuse breakers.
- Bridge compensator for error measurements of current transformers up to 1000 A with low voltage regulator and load boxes.
- High voltage testes 1 A, 1-3 kV.
- Tester for bimetals and magnetic trips with current supply.
- Oscillograph.

B. Required for production :

- Autoclaves/two / with vacuum pump and vacuum motor - about 0,7 m^3.
- Furnace with controlled temperature for manufacturing springs 1500 ^oC 0,3 m^3.
- Furnace with controlled temperature for annealing electromagnetic cores - about 0,7 m^3 and 1000 ^oC.
- Strainers for selection of sand granules from 0,12 mm to 0,5 mm diameter.

Some of the most difficult tools - used for manufacturing enclosures for contactors and no fuse breakers/for one size only.

Note: This specification will be completed by the author- basing on catalogues.

Training

1. Study tour to specialized factories manfacturing switchgear 4 m/m

2. Fellowship - training

2.1. Engineering of switchgear apparatus low voltage and medium voltage 4 m/m

2.2. Engineering of moulds and tools 4 m/m

2.3. Testing laboratories 3 m/m

Institution proposed to grant study tours and fellowship - trainings - European testing stations and factories.

Annex

Programme of training - for postgraduate engineers and the last year students.

1. Designing of switching apparatus.
   Electrical arc extinction methods
   Electrodyramical forces
   Contacts - solution and calculation
   Arc theory and post - arc current recovery withstand.
   Gasodynamics
   Electromagnets - solution and calculation
   Magnetical and thermal triping devices
   Testing methods

2. Fuses - designing
   Methods of arc extinction
   Methods of adjustment of the required characteristies
   $t = f / I /$ and $I_o = f / I /$
   Designing selection and requirements

3. Current transformers
   Designing, calculation of errors for different loads and electromagnetic cores
   Solutions - electrodynamical forces

4. Lightning arresters
   Theory - solutions, Designing of spark gaps.
   Final characteristic. Applications.