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UNIDO/DECHEMA Seminar on Operation, Maintenance, Design and Manufacturing of Chemical Plants and Equipment in Developing Countries

Königstein (Taunus) near Frankfurt/Main
Federal Republic of Germany
25 - 26 June 1970

SUMMARY

ELECTRICAL EQUIPMENT 1/

by

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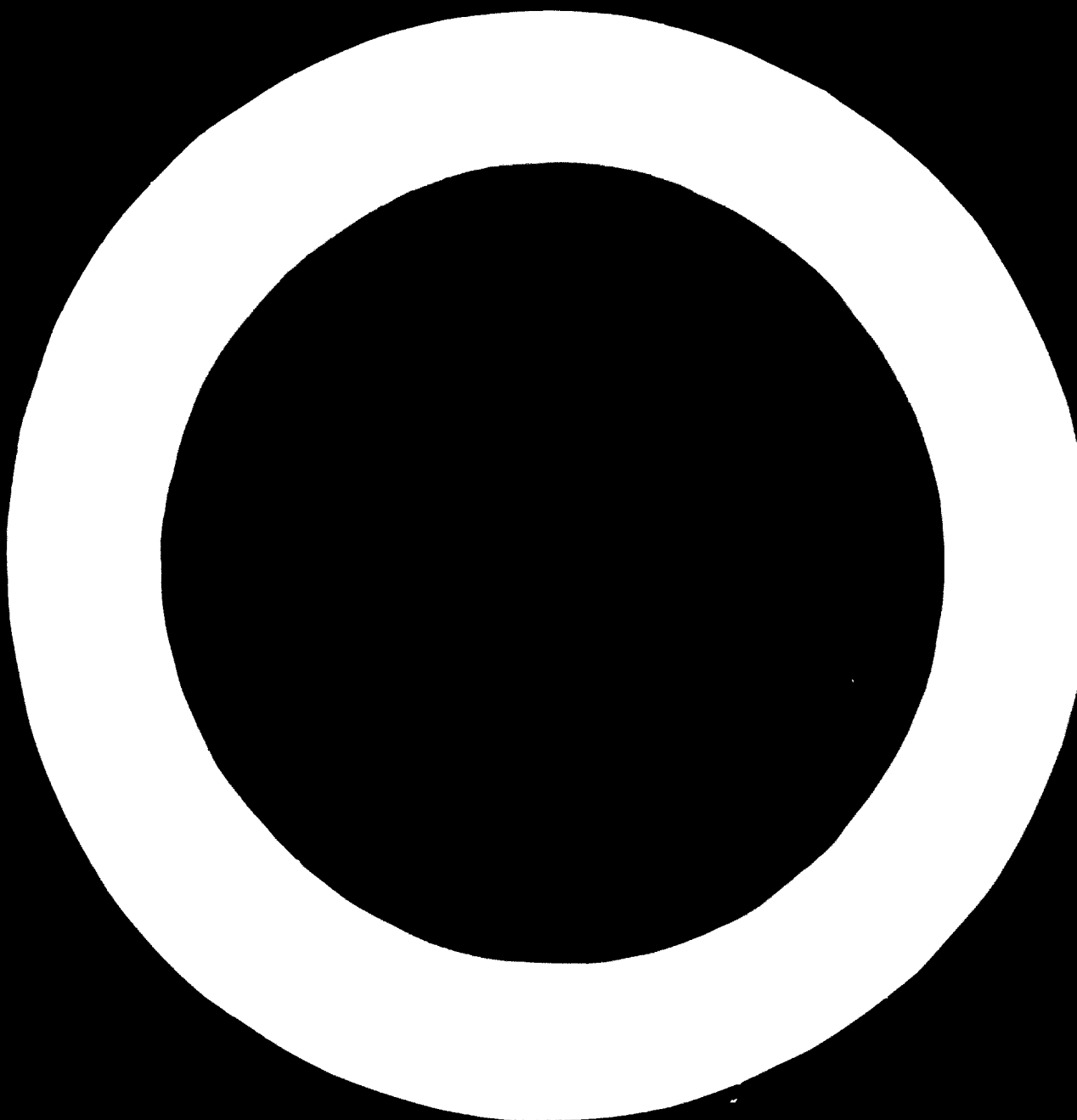

I. Introduction

II. Production

a) Historical development of electro-technical manufacture in developing countries

1. Stage 1: Assemply and completion
   e.g. Switchboard plant

2. Stage 2: Switch-over from assembly and completion to the manufacture of standard material.

3. Stagewise expansion of manufacturing activities - to include more complicated and technically sophisticated electrical products.

   Limitation of manufacturing activities.

   Special constructions of electrical equipment for the chemical industry

   (explosion -proof equipment, rectifiers, etc.)

b) Problems in connection with manufacturing activities

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   raw materials, semi-finished products,
   sub-supplies (quality)
   quality control of incoming and outgoing products

c) Specifications and Standards

1. VDE - BSS - ASA - IEC etc.

   Preparation of norms and specifications with reference to local conditions.

2. Required design alterations resulting from availability of local manufactured standard parts like profiles, sheets, nuts and bolts.

3. Consideration of special conditions in chemical plants (explosionproof equipment etc.)

   Manufacturing problems connected therewith.

III. Project-Planning

a) Size and type of project - Risks involved

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c) Co-operation and co-ordination between local personnel and specialists delegated from industrialised countries

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IV. Service and Maintenance

a) Selection and training of maintenance personnel

b) Spare-parts stocking

c) Operating and maintenance instructions

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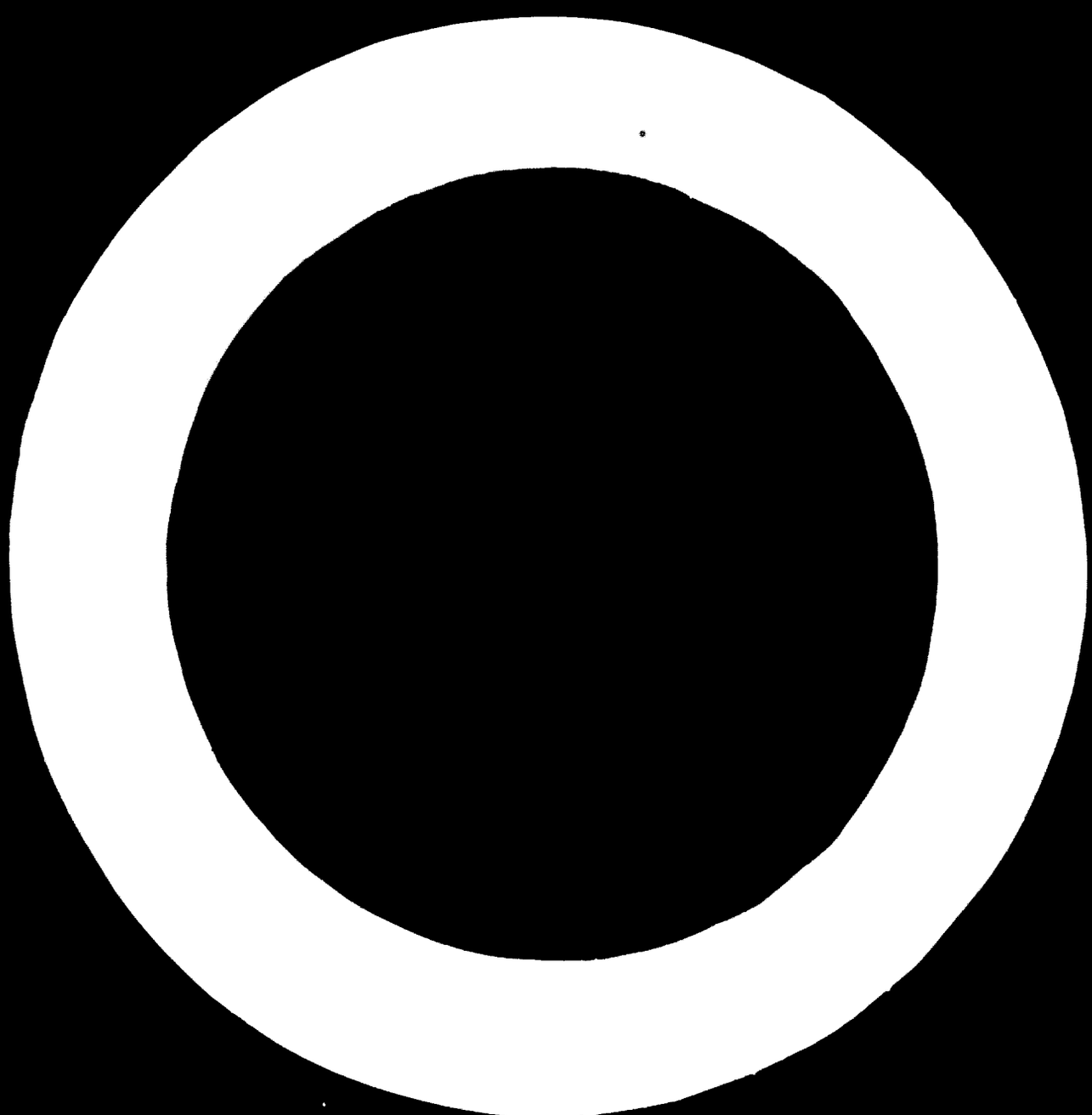


The subject of my talk is identical with the preceeding three reports, however, with the difference that I refer to the electrical equipment. Since the contents of the various reports have not been compared or coordinated in detail, I beg to be excused if there are repetitions in some points.

The questions connected with this subject are so numerous when one considers the diverse problems of different chemical industries and plants that they cannot be extensively dealt with. The topic of this talk as such cannot be meant as a detailed explanation as to how an electrical plant for a certain chemical industry should be laid out and designed since such electrical plants depend on the individual requirements. I will refer mainly to general manufacturing problems, the question as to how an electrical product is being used should not be dominant. Certain matters of special interest to the chemical industry will however be referred to, i.e., explosion protection, rectifiers for electrolytic plants, etc.

My experiences are restricted to India, apply surely also to Pakistan and to certain extent to the other Asian developing countries. These experiences do not necessarily have to hold true in the case of developing countries in other continents since the industrial progress differs from country to country. Some developing countries have nothing else in common other than perhaps only the name developing countries.

The main objective of this talk is to deal especially with the following points:

1. how to proceed if one is going to start the manufacture of electrical products with the view of gradually increasing the local production activities.
2. which conditions do developing countries have to fulfill if they are to participate in sub-supplies of electrical equipment and later take over the operation, service and maintenance.
3. comments in regard to and questions connected with the manufacture, maintenance, operation, etc. of electrical equipment like switchboards, switchgear and motors in developing countries.

First of all, I would like to refer to the historical development of manufacturing activities in the electro-technical field in these countries.

The local industry, which in some developing countries exists already since a relatively long time, took up usually the production of simple products. I refer to the many examples, where initially factories for the production of normal A.C. motors, distribution and power transformers, cables and wires have been established. Normally, not exactly the latest technique was introduced. However, this was often even not necessary at that time since the local technical standard was not yet as high as needed today. Manufacture was limited to low and high tension equipment up to about 30 kV and the technique of those countries was adopted to which long-standing economical relatipns were existent. A systematic planning of the electrical industry started in many cases only after obtaining independence. Of course, not all developing countries were dependent. Usually, the Governments planned the industrialisation - on account of foreign exchange shortage - in stages, stress being laid according to the individual priorities.

With the proceeding of Siemens in India as an example, I would like to detail the development of the stagewise manufacturing activities. Other companies went ahead on more or less similar lines.

Initially, we started a workshop with a design office for switch-board plants. The equipment that was to be built in were mostly still imported, only limited products of simple nature being locally available. In the beginning construction drawings, layouts and circuit diagrams of simple switch-boards were produced in India. The mechanical part of the switch-board plants (steel and sheet-metal constructions) was manufactured from local material.

Our Indian designers and workers were made acquainted with and trained in this switch-board-plant technique and with the equipment. We manufactured L.T. and H.T. Plants up to 33 kV. The intelligence and the quick grasping power of our Indian staff accounted quite quickly for a considerable number of skilled men with whom technically complicated production could be taken up.

A training centre for apprentices for the professional categories of electricians, mechanics and fitters, tool and die-makers added to the qualified staff of skilled workers.

Parallel to the building-up of the switch-board plant factory, a repair shop was established for transformers, electrical motors, switch-gear and measuring instruments. In

this workshop, we faced continuous problems with regard to spare-part procurement and with regard to the available material for repair purposes (enamelled wire, insulation material, etc.). On the other hand this repairshop offered excellent opportunities for the training of our workers.

At this stage, we switched over from assembly to the manufacture of simple switch-gear and standard material like clamp terminals, fuses, fuse bases, bus-bar holders, isolators and packet switches. For such simple equipment, no import licences - not even for components - were granted. We followed up with the manufacture of normal and special electrical motors in the range of 11 to 350 kW with only minimal imports from W. Germany/Japan (ball bearings). For motors in the range of up to 11 kW and for transformers in the range of up to 33 kV and 1500 MVA as well as for cables and wires, we entered into collaboration agreements with reputed local companies, whose slightly out-dated designs needed only to be modernized. With the increasing skilledness of our staff, more complicated techniques were introduced, however, also with a view to be able to meet the ever-rising and unavoidable demands on quality.

The switch-gear programme was expanded with the inclusion of starting equipment, air contactors, load and circuit breakers of the low and medium voltage range - not any more as only assembly but as part of the manufacturing programme. A most important prerequisite was the establishment of a tool room of highest standard.

The ratio of local manufacture including sub-supplies from other local companies as compared to imports developed as follows:

a) <u>Switch-gear</u>

1st year -	local manufacture	20 - 40 %,	imports	60 - 80 %
2nd year -	"	app. 50 %,	"	app. 50 %
3rd year -	"	app. 75-90%,	"	app.10-25%

b) <u>Motors and transformers</u>

1st year -	local manufacture	85 - 90 %,	imports	10 - 15 %
2nd year -	"	app. 95 %,	"	app. 5 %.

With the exception of motors, for which in most cases only ball bearings and shaft steel remained to be imported, an average of 10 to 15 % needed to be imported for other electrical products like switch-gear, etc. (This is not unusual since we here in Germany also do depend very often on imports, even if for other reasons.) Mostly special material and components of high precision or of

a sophisticated technique or even simpler components on account of a too low production number - for which taking up manufacture on one's own would not be economical, e.g., tulip contacts, arc chambers for medium voltage circuit breakers etc. - remained to be imported.

The question arises whether the manufacturing possibilities for electro-technical goods in developing countries are fundamentally limited. The answer is yes, the reasons being as follows:

I) limitations imposed on research and development; there is a lack of sufficient technical tradition and financial means (Siemens spends about 8 % of the turnover for coping with research and development).

Qualified technical scientists - very often trained in industrialised countries - remain idle on account of a lack of employment possibilities by wey of research and development institutes or are employed in totally nonsuited fields.

II) The expenditures for research and development stand at the present moment in no proper relation to the actual production figures. To quote only one example: a single big German factory produces in one year

twice as many motors as the total Indian market does require. This fact applies even to other products.

III) To achieve the quality as we have it here in Europe is very difficult in most cases. Import permits for sophisticated components, high precision machinery and testing equipment are very difficult, often not at all to be obtained. These are but primary prerequisites for quality production. The qualification itself of the people does not present any great problem. They are intelligent and full of enthusiasm.

I am coming now to a few questions in connection with the equipment.

The power supply equipment for the chemical industry does not differ fundamentally from such equipment for other industries with the exception of explosion proof equipment.

Of course, many chemical processes require an uninterrupted power supply. But this fact does not call for special equipment - required are only more standard materials such as double bus-bar systems, higher capacity ratings-to reduce wear and tear-or emergency supply sets to meet sudden breakdowns.

To limit the danger of (ignition) explosion hazards, the electrical equipment is installed - wherever possible - beyond the limits of explosion-endangered areas. This applies normally to L.T. and H.T. Switchboard plants, capacitors, measuring equipment and control gear. However, motors, for example, which have to be installed within endangered areas, are normally remote-controlled by push-button-stations. The problems of explosionproof-designs refer therefore mainly to this two categories of equipment, namely motors and remote controlstations.

In this connection mention must also be made of the requirement of special electrical equipment like rectifiers for electrolytic plants for the production of chlorine, aluminium, etc., as well as big synchronous and induction motors employed as drives for compressors in air separation plants (i.e. fertiliser factories).

These two products are two extremes when considered with regard to the problem of manufacture and service in developing countries.

The development of rectifiers has passed quite quickly through various stages:
DC-Generators, rotating converters, mercury arc rectifiers, mechanical rectifiers.

To-day the silicon rectifier dominates the scene because of its superior quality. This semi-conductor technique offers the advantage that there are no rotating elements and parts which are subject to wear and tear.

On account of parallel or series connections of the Silicon-diodes, rectifierplants of any required voltage and very high current rating can be built to-day. The requirement of high current ratings in electrolytic plants up to about 200.000 Amp. calls for high production figures of diodes which have normally a rating of 200 Amp.

Such production figures make a local assembly or part manufacture quite attractrive. A complete production including the silicon tablets would be quite difficult. The production of the required ultra-pure silicon and the manufacture of the silicon tablets is even to-day problematic in industrialised countries.

The local assembly and production of complete rectifier units with a fair number of imported components has been successfully done quite often. The design of such rectifier units has of course to take into consideration the problems in connection with such high current ratings (Eddy currents).

Coming back to the motors used as compressor driven,

the development points clearly to very big units.

10.000 kW are no rarity for a synchronous motor for a compressor drive and induction motors with above 20.000 kW are presently being built. Besides the known advantages, synchronous motors for compressor drives are often selected to improve the power factor of the plant.

The tendency towards the use of ever higher capacities of the individual drive-compressor units results in a low production figure on account of no or very little growth of the process units. Low production figures and production problems of the large machinery does not make the manufacture attractive, except of course if technical experience in comparable fields, like for instance in the manufacture of turbo generators, turbines, etc., is available in a country and the demand justifies the heavy expenditure involved.

The foregoing explanation of the proceeding in principle for building up manufaturing activities organically does not apply only to the above mentioned example of a big undertaking of world renown. Every well managed local industry proceeds in a similar manner, mostly under licence with a collaborator. The only difference is

that it is easier for a big undertaking with world-wide experience, since they have the technical know-how the skilled personnel and sufficient financial means at their disposal.

The manufacturing technique to be employed for the same product is at most times different in a developing country as compared with that in an industrialised country, the reason being normally that much lower manufacturing numbers are involved in developing cpuntries.

The use of highly sophisticated production machinery and equipment would on the one hand entail most complicated tools and dies which possibly cannot be locally manufactured, on the other the capacity of these expensive machinery could by far not be economically utilised.

A few words to licence problems:

Foreign companies starting manufacturing activities in a developing country require normally the sanction of the local Government. This sanction is usually dependant on:

a) the necessity and urgency of the production.

b) submission of detailed information on outlay and continued requirement of capital/foreign exchange as well as detailed information on the overall financial structure.

c) a stage-wise manufacturing plan and explanation as to what extent and over which period the local manufacture can be intensified (i.e. to become independant of or to reduce the requirement of foreign exchange).

d) the amount of royalties

e) a limited employment of foreign technicians.

f) probable export committments.

Further conditions are mostly of secondary importance. Such demands are certainly logical and necessary for developing countries. But they involve a considerable risk for companies without experience in developing countries. The procedure of obtaining sanction to start a manufacture is long-winded. Collaboration agreements between the business partners need likewise to be sanctioned by the Government. Since developing countries rarely can afford a totally liberal economy - although it has been realised that this would enhance chances of a quicker and more successful industrialisation, the foreign exchange capacity does not permit it - these conditions can hardly be altered, as desirable as it may be.

The import requirement of components and material for a running production is again dependant on government sanctions from case to case. Even these formalities are long-drawn-out and the submission of proof of the plants future requirements very difficult. In addition, the time required for order placement, delivery periods and shipping and last but not least customs formalities and

problems have to be taken into consideration. A factual and timely coordination of these formalities and conditions is not exactly easy and borders sometimes upon magical achievement. The very often endangered timely material supplies necessitate abnormally high stocks and as such abnormally high cost. In this context, the local Government could and should introduce improved, i.e. more relaxed stipulations.

Most developing countries dispose already of a certain manufacture of production machinery. These machinery do not correspond in every case with the most modern technical standards. One does not always achieve the required precision and very often they are not suited for use with complicated and sophisticated dies, for which reason also (and not only on account of low production numbers) the original manufacturing technique has to be altered very often. Instead of one work process, two, three, four and more work processes have to be employed. Raw materials like steel, sheet metal and profiles, copper and aluminium sheets and profiles are often not standardised, are possibly supplied in inch or metric dimensions, a uniform quality is not always guaranteed and timely supply doubtful and endangered.

These circumstances necessitate as a rule a more intensive quality control of goods on arrival (incoming inspection),

during the manufacture and in the test fields. The quota of rejections is on this account much higher as is customary here. In our Indian factories, in order to ensure good and stable quality, we had to establish material laboratories to an extent not usual here in our countries. Apart from the quality control and procurement problems, it is to be kept in mind that the original design of the electro-technical products is based on high quality materials which are not always available as far as quality, dimensions and tolerances are concerned. Extremely aggravating is very often the necessity to fall back upon substitute materials, e.g. when copper had to be replaced by aluminium for busbars, conductors, contact parts, etc.

Initially I mentioned that the kind of protection to be observed does influence the manufacture. Some developing countries - especially if they are at the outset of their industrialisation - do not yet have their own standards, rules & regulations. Leaving the east-countries aside, one can classify the techniques - and accordingly the standards, rules & regulations - as English, American and Continental, to simplify the matter.

Consequently, if a chemical plant is erected, the technique - or standards - of the supplier country, or again, if a consulting company is entrusted with the project - the standard of their respective country - will be applied.

Various types of protections for electrical equipment have been developed in various countries and are successfully used. Although not recognised by every country, IEC, entrusted to work out recommendations on an international basis under consideration of rules existent in the respective countries, have selected and published - out of a certainly large palette of existing rules - the following types of protection:

1. Flame-proof enclosures
2. Sand-filled apparatus
3. Increased safety apparatus
4. Oil-filled apparatus
5. Pressurised apparatus
6. Hermetically-sealed apparatus
7. Intrinsically-safe apparatus

Countries which do not have their own standards yet, certainly should follow IEC-Recommendations if these have already been accepted world-wide.

To take up the production of explosion proof equipment presupposes - in my opinion - clearly laid down and binding standards, whichever might be selected out of the available choice.

The numerous protection types, the important question of economics, the lower production figures, the sophisticated techniques will normally make it impossible to manufacture and cover the whole range of explosionproof equipment. A way out is to manufacture equipment of the highest protection type, thus covering the lower degrees of protection, resulting in larger economical production figures, as, for example, practised in India. There, only equipment of the "flame-proof enclosure" protection type is being manufactured. The importance with regard to the safety condition calls - in addition to the routine testing to be undertaken by the manufacturer - for independent, and recognised testing laboratories, where prototypes of the equipment are thoroughly tested and certified for the purpose they have been specified.

The successful production of explosion proof equipment is very much a question of skilledness of labour and precision machinery and should not exactly be taken up

at the start or beginning of manufacturing activities. Experience with the manufacture of normal equipment should precede such an attempt.

What can be said about design modifications:

a) Some desings simply cannot be modified. These are those, where even a slight change would endanger the electrical or mechanical function. I would like to mention for example circuit breakers with high rupturing capacities - high current rating - and generally all equipment which serve the protection of a considerable and important part of a plant, the break-down of which would entail heavy damages or even endanger the personal security of human beings.

b) Some desings have to be changed if local manufacture is absolutely imperative. Fundamentally, imports are not permitted any more where a way out is offered by means of design modification or if substitute products and materials are available on the local market which are technically acceptable. This applies even where production machinery for the manufacture of parts and components of the original design is not suitable.

On principle, no modification should be permitted which

would endanger the safty of peration, technical reliability and quality. The compulsion to modify the original design arises quite often - as already mentioned - on account of different measuring systems, meaning metric and inch systems in cases of sheets, profiles, screws, bolts, nuts, springs, etc., of various materials. This compulsion arises however even on account of single components which - in view of the huge production numbers in Europe - are very often standardised works-internally, but cannot be manufactured in developing countries economically enough due to the low manufacturing numbers.

Concluding, I am now coming to the question of maintenance and service.

Considering the many variations of electrical equipment for chemical plants (transformers, low-tension and high-tension switch-board plants, large induction and synchronous motors, for compressors and pumps, speed changing drives, rectifiers for electrolytic plants, etc.,) it is comprehensible that the question of service, maintenance and safety of operation can only be generally dealt with.

In addition, the different standards, rules and regulations, safety stipulations, different conceptions regarding types of protection have to be taken into account. VDE Regulations are not acknowledged everywhere, IEC Recommendations

are not generally binding.

Normally, service, maintenance and repair work could be executed by every qualified electro-technical workshop, e.g. renewal of contact-parts in switch and control bourds, changing of carbon brushes and brush holders, turning of sliprings and commutators, changing of clamp terminals, bearings and packings etc. Important parts should be replaced only by original parts. Special rules on the part of the authorities do not normally exist in this regard. In case of explosion proof equipment, inspection of the authorities is at most times necessary before the same can be put into operation again.

The extent of the plant-owned maintenance of electrical equipment depends on two factors:

a) the size and the technical sophistication of the plant
b) the availability of a reliable workshop at site, the machinery and equipment as well as personnel of which guarantee a trouble-free service.

To be kept in mind is also the requirement very often for a non-interrupted operation or the necessity of only a very short interruption.

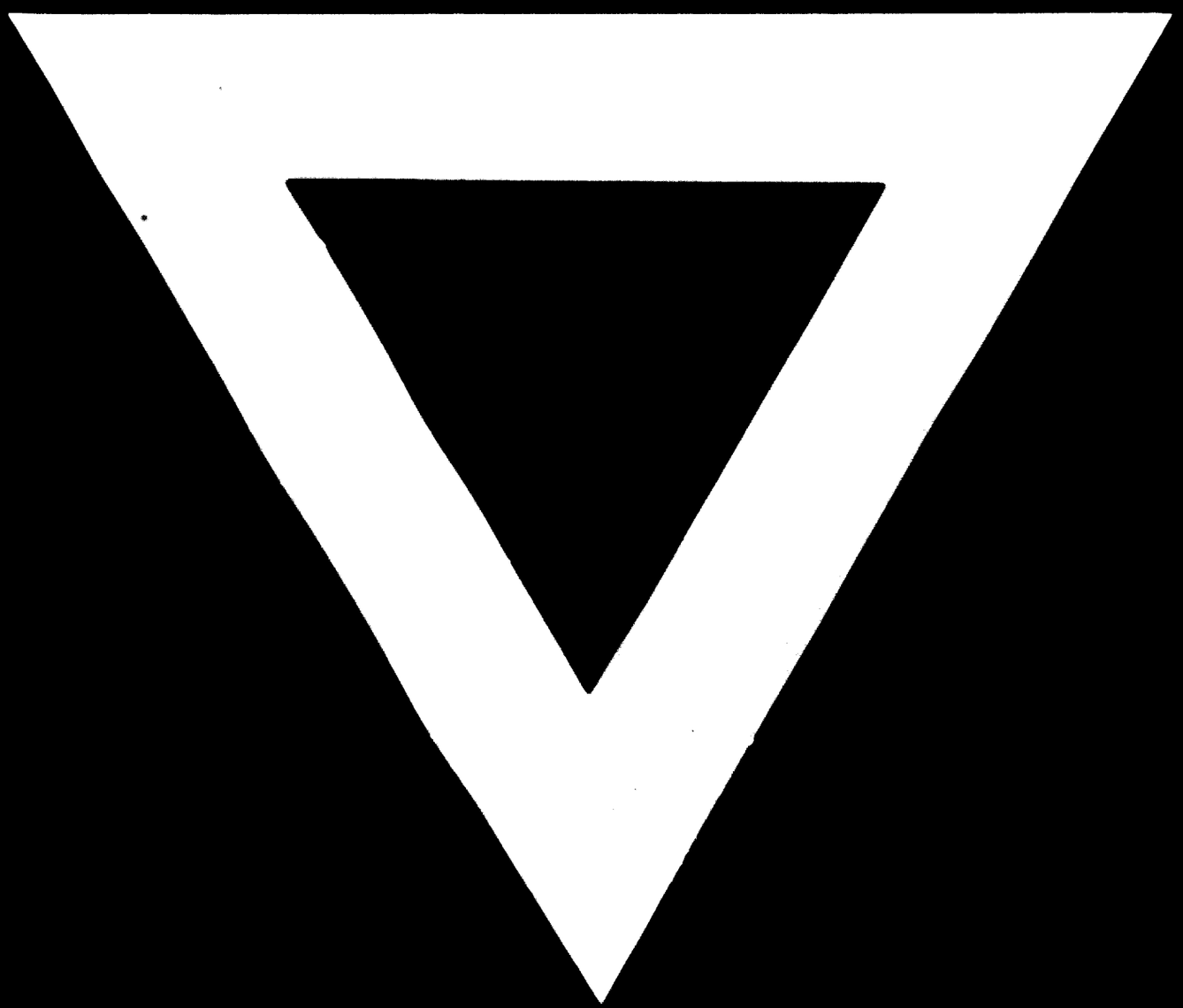
If there is a possibility of concluding a service contract with the supplier firm, this should be done by all means (i.e. for HT breakers, regulator and control equipment, measuring instruments, etc.)

The qualified personnel of the plant-owned maintenance department should be made acquainted already during the building and erection-phase with all details. They should take active part during this phase, at which time the most likely sources of possible breakdowns should be pointed out to them.

Mention must be made that after erection and assembly, the reponsibility for the whole plant and the operation of the same goes over to the owner of the plant, which fact must not be overlooked.

Of course there are certain rules and regulations to be observed in nearly every country for the operation, for design modifications and for repair work of electro-technical plants. Over and above this, it is in one's own interest to train the maintenance personnel periodically and to instruct them to carry out the service stipulations of the supplier firm at the prescribed intervals, to check and supervise the equipment and to maintain records. The

supplier firm should at the same time make proposals regarding the complete furnishings for the maintenance shop, i. e. regarding the required machinery and testing equipment, according to local needs and furnish complete spare-parts lists of parts most prone to break-downs and wear and tear, since in most cases procurement at short notice at the time of the break-down is simply not possible. Apart from parts subject to wear and tear, certain especially important equipment and parts of the plant (like special motors, relays, etc.) should be available on ready stock to prevent long interruptions in the production.



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