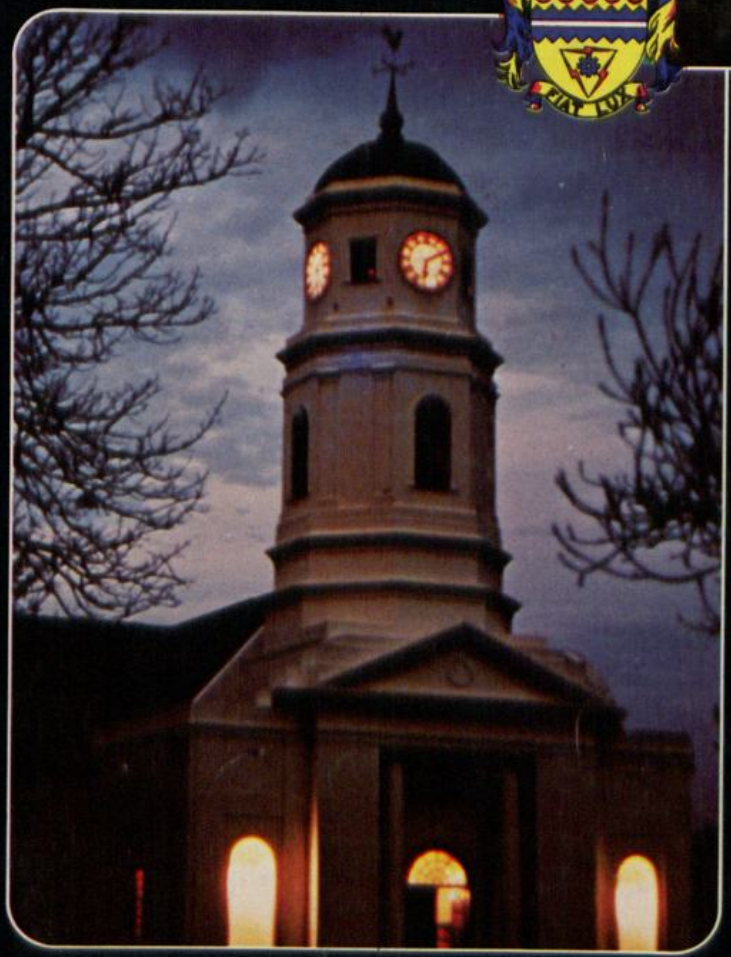
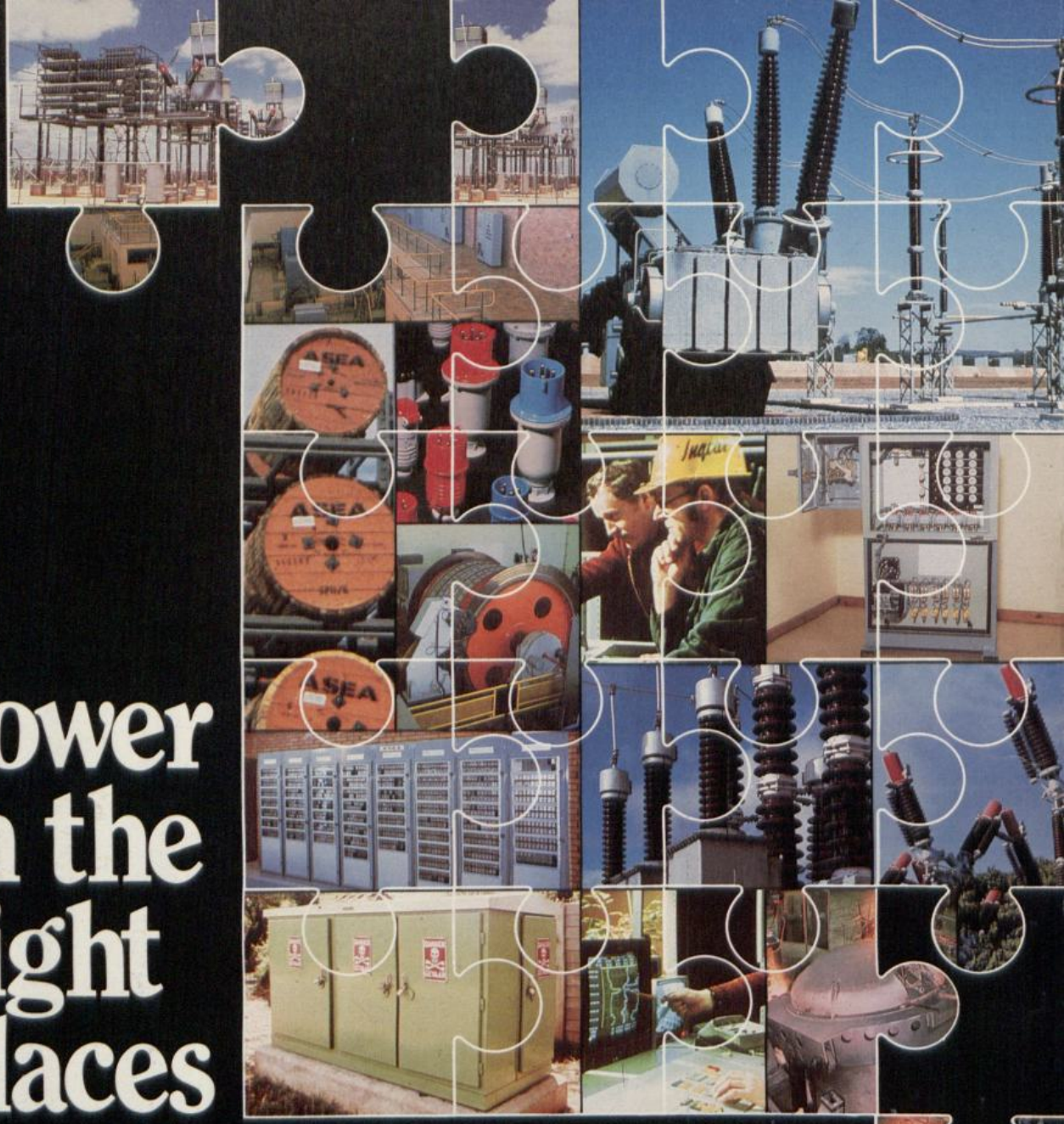
DIE VERENIGING VAN MUNISIPALE ELEKTRISITEITSONDER-NEMINGS VAN SUID-AFRIKA

NEGENDE TEGNIESE VERGADERING 3 – 4 MEI 1982 GEORGE



THE ASSOCIATION OF MUNICIPAL ELECTRICITY UNDER-TAKINGS OF SOUTH AFRICA

NINTH TECHNICAL MEETING 3 – 4 MAY 1982 GEORGE



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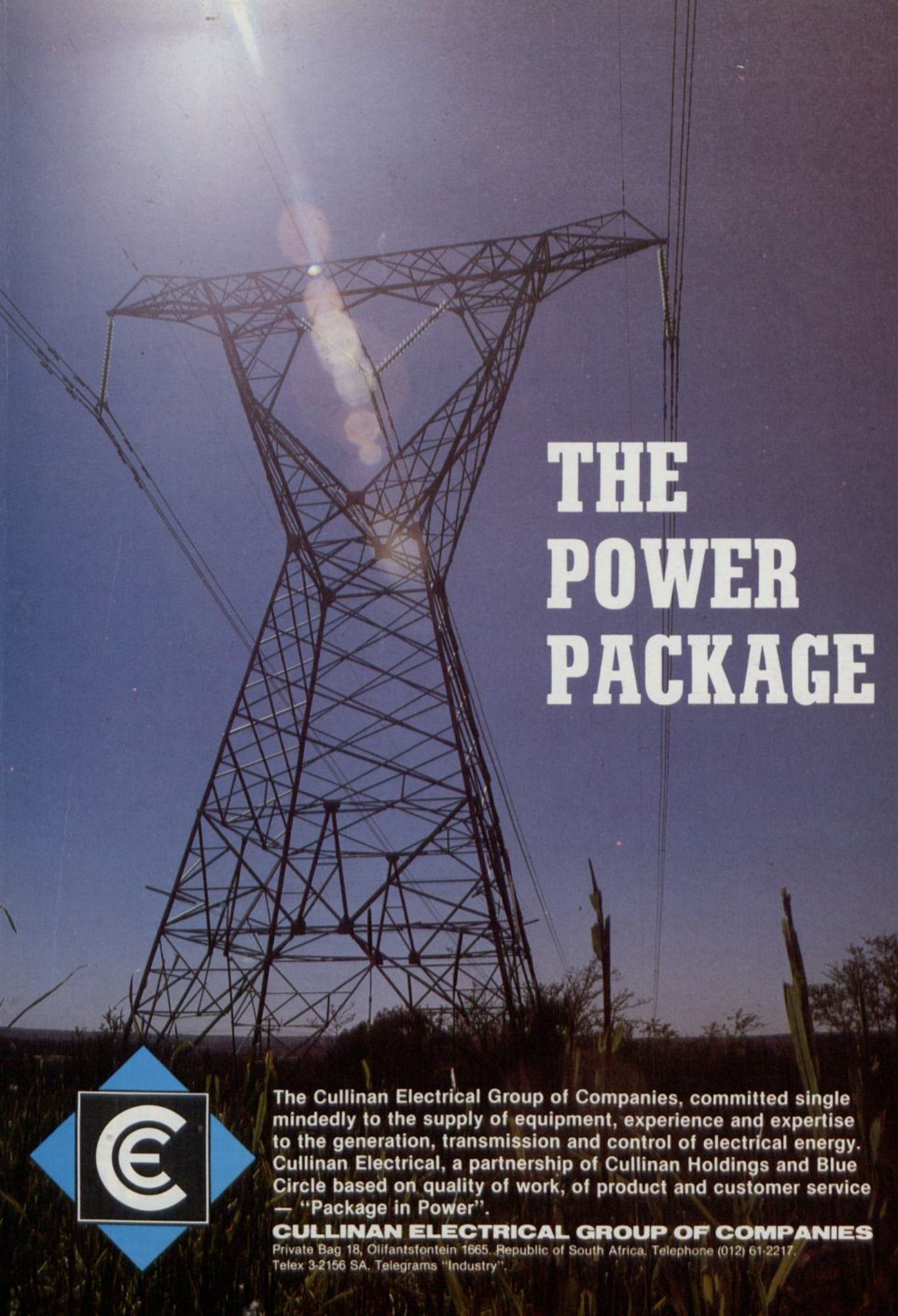

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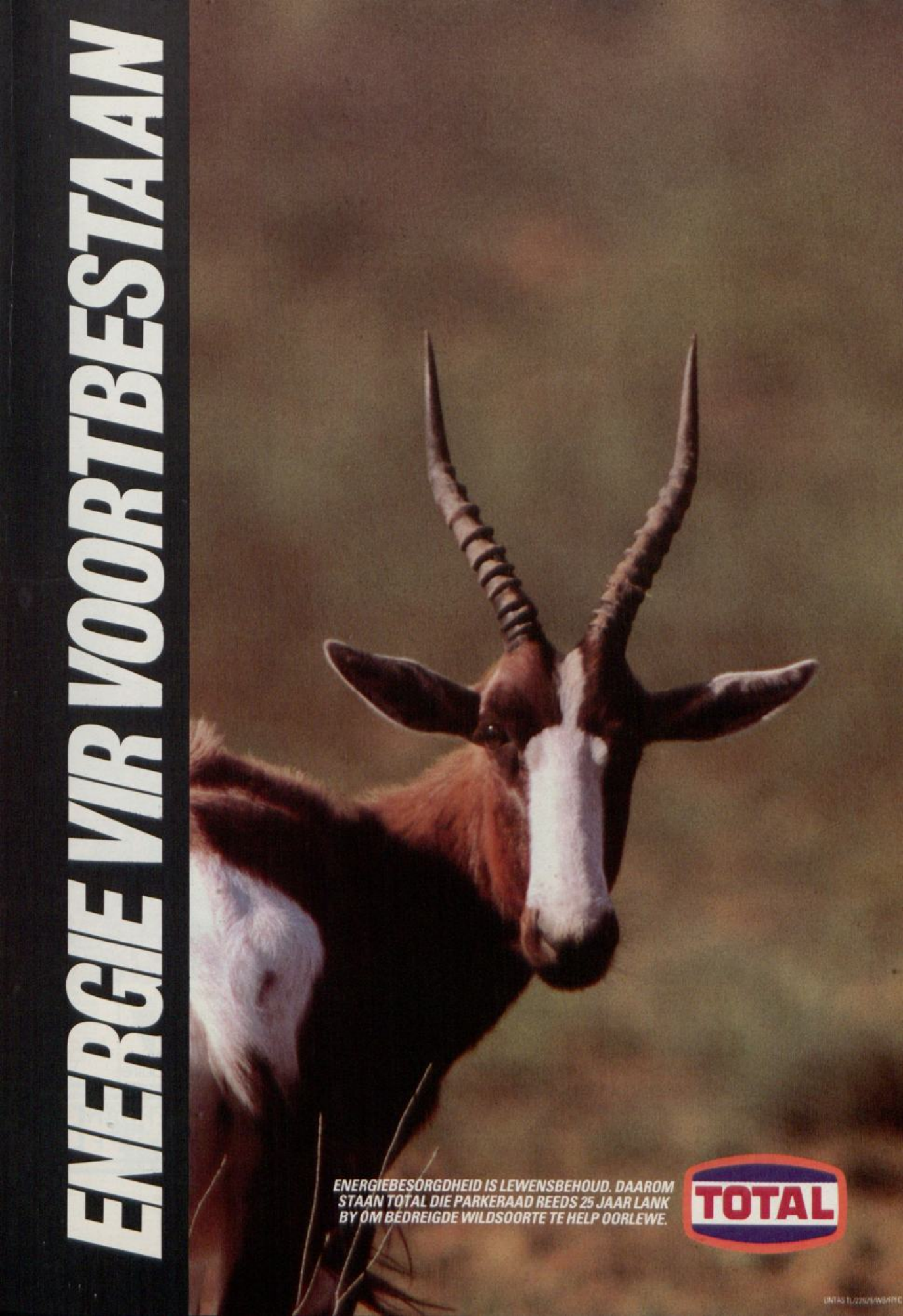
ENERGIE VIR VOORTBESTAAN
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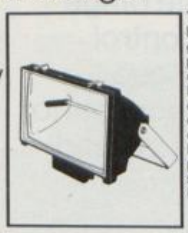

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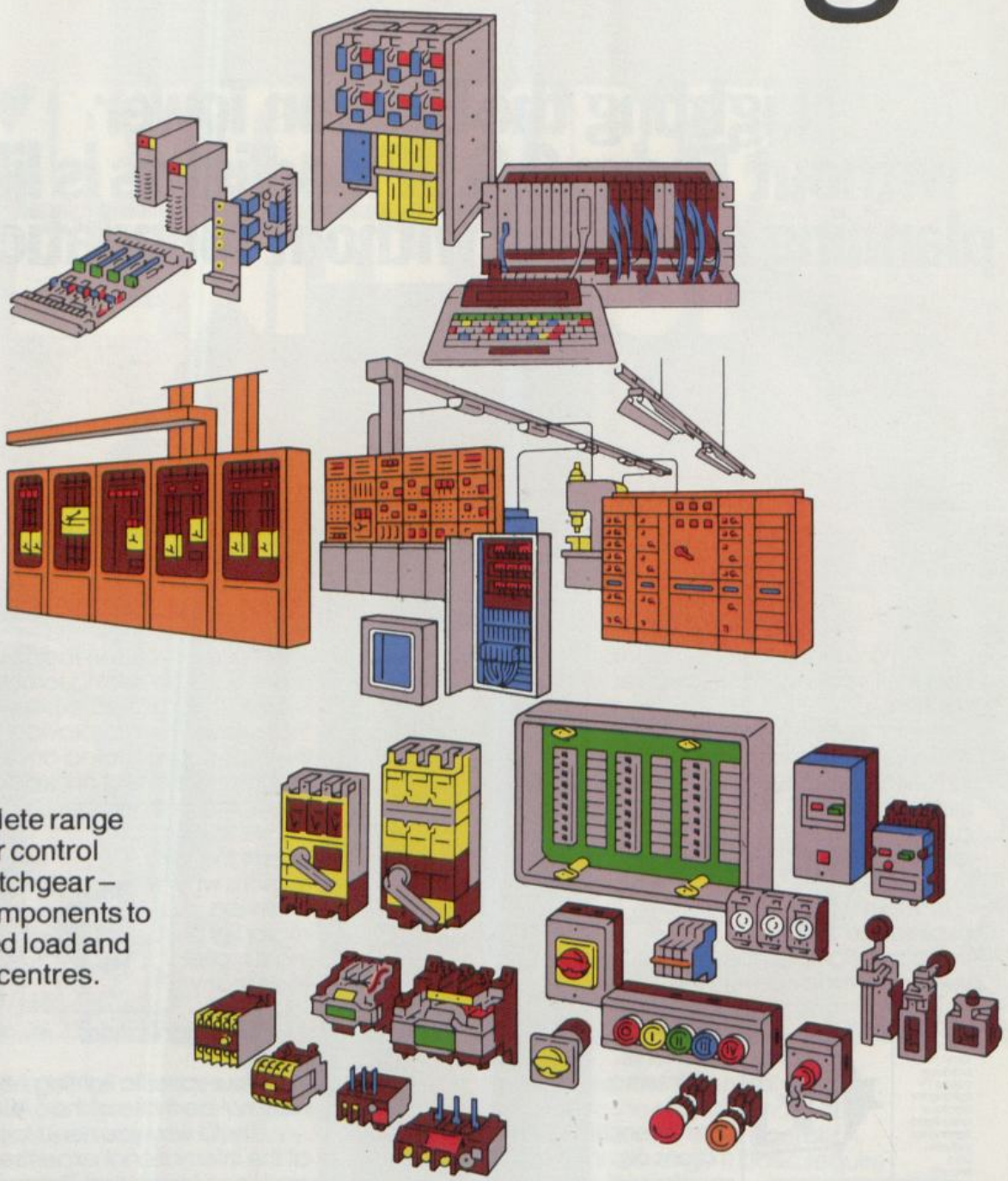

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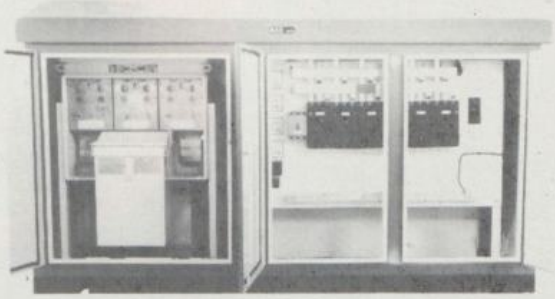

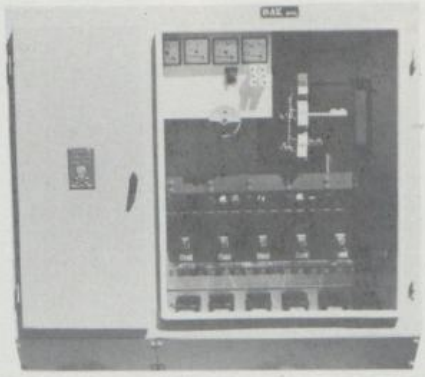

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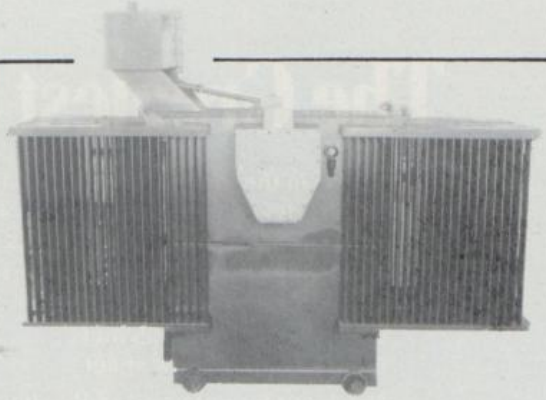

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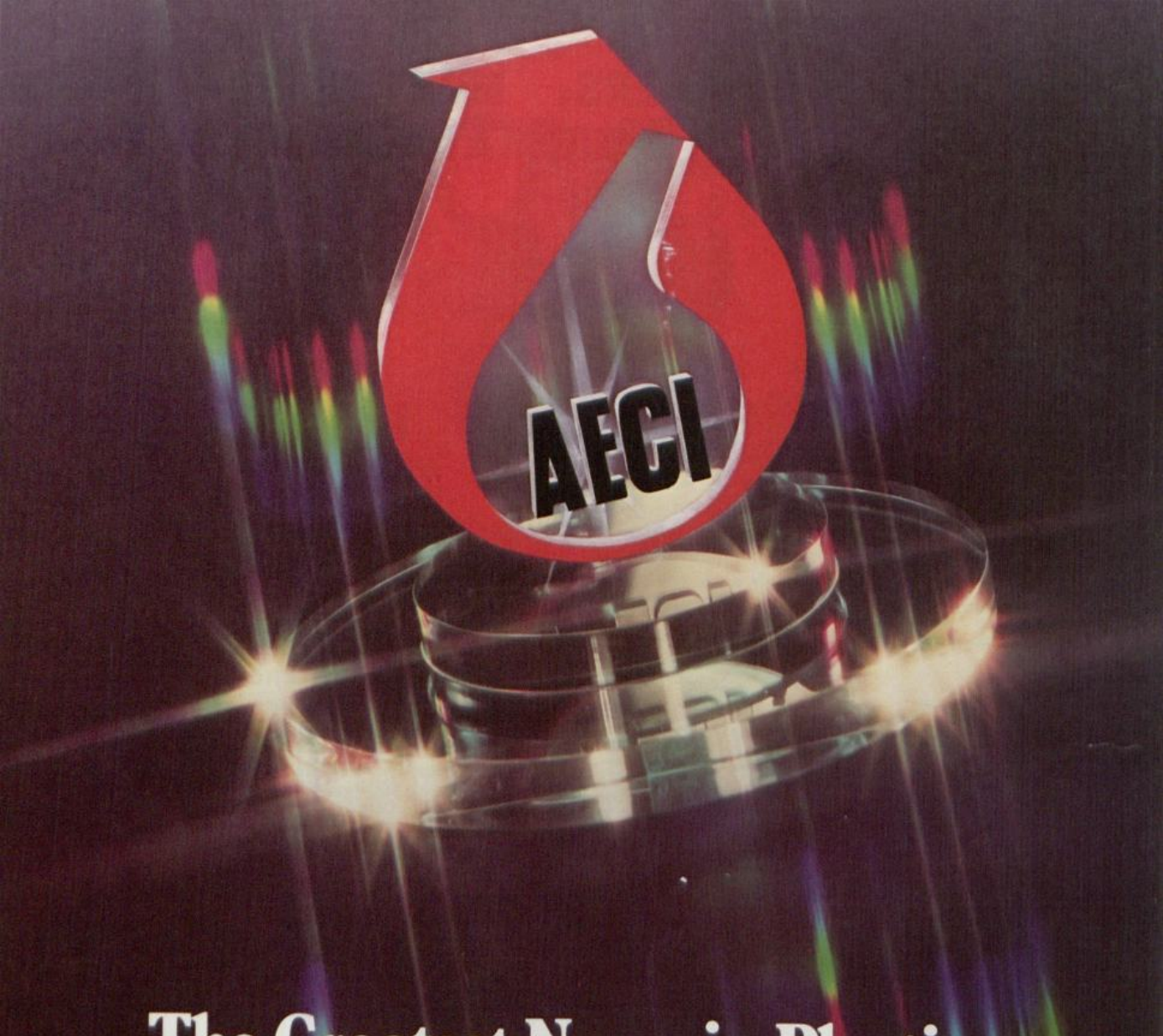

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PROCEEDINGS
9TH TECHNICAL MEETING
3 – 4 MAY 1982
GEORGE

VERRIGTINGE
9e TEGNIESE VERGADERING
3 – 4 MEI 1982
GEORGE

The Rev. J.G. Moolman opened the proceedings with scripture reading and prayer
Ds. J.G. Moolman het die verrigtinge met skriflesing en gebed geopen

TABLE OF ATTENDANCE/TABEL VAN BYWONING

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Guests	19	Gaste
Engineers	109	Ingenieurs
Councillors	18	Raadslede
Affiliates	132	Geaffilieerdes
Lady Visitors	106	Damesbesoekers
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Die Vereniging van Munisipale Elektrisiteitsondernemings van Suid-Afrika

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OFFICIAL OPENING / AMPTELIKE OPENING

Mr. D.H. Fraser: President

Agbare Burgemeester, Raadslid Heunis en Mev. Kellerman, erelede, gaste dames en here, dit is vir my 'n besondere voorreg om u almal hartlik welkom te heet by hierdie 9de Tegniese Vergadering van die Vereniging van Munisipale Elektrisiteitsondernemings van Suid-Afrika.

Dit is baie duidelik dat die Kaap 'n spesiale bekoring inhou vir die VMEO, aangesien ons weer almal so gou na die 7de Tegniese Vergadering wat in 1978 in Somerset-Wes gehou is, hierheen teruggekeer het. Dit is nie moeilik om die rede hiervoor te vind nie want die Here het hierdie deel van ons pragtige land ryklik geseën met die mooiste natuurskoon, asook opregte en vriendelike mense.

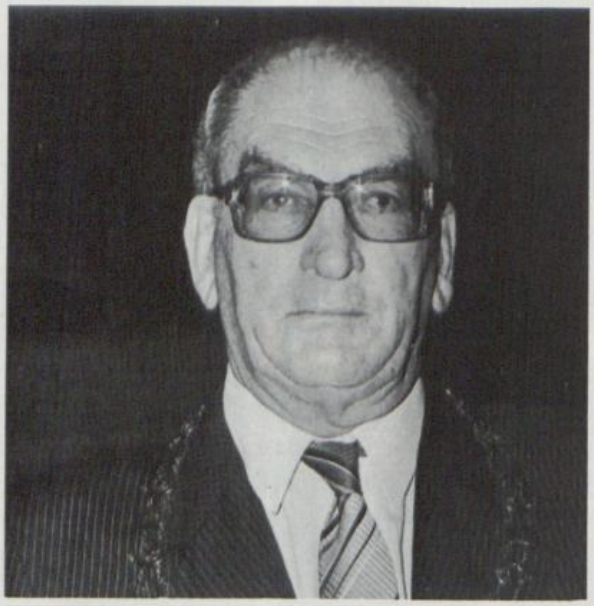
We are both honoured and delighted to be here in George, Mr. Mayor and, on behalf of all the delegates and visitors, may I thank you for your Council's kind invitation. I would also like to express our appreciation to the acting Mayoral Chaplain, Rev. Moolman, for his opening prayers and scripture reading.

The programme for this Technical Meeting promises to be enjoyable and rewarding from the aspects of technical interest and social content. Thanks to the hospitality of the Mayoress and the efforts of the organisers, the ladies appear to have been particularly well catered for and are, I am sure looking forward to their outings while their menfolk are hard at work.

It is now my very great pleasure to call on His Worship the Mayor, Councillor C.W. Heunis, to officially open this 9th Technical Meeting of the AMEU.

Mr Denis Fraser – President of the AMEU

VERWELKOMINGSTOESPRAAK DEUR SY AGBARE DIE BURGEMEESTER, RAADSLID C.W. HEUNIS



Sy Agbare die Burgemeester rld. C.W. Heunis.

Mnr. die President, Burgemeesters van ander dorpe, eregaste en afgevaardigdes dit is vir my 'n besondere voorreg om u vanmôre hier by u eerste kongres te George in die mooiste dorp in Suid-Afrika welkom te heet. Nie alleen bevind u u tans in die pragtige Tuinroete nie, maar u bevind u in die vriendelikste streek in die land, en dit is my wens en my vertroue dat u die skoonheid van ons omgewing, en die vriendelikheid van ons mense, sal aanvaar en met u as 'n mooi herinnering sal terugneem huistoe.

George is not only scenic and friendly. It is also the centre of a region which has had a phenomenal development during the last decade. It is because of this that George has been declared one of the growth points in the Republic. This region, is one of the few outside metropolitan areas which show a growth in population and economical output.

It stands to reason that this exceptional growth, and the expected growth in the very near future, will make a heavy demand, not only on the financial resources of the Municipality, but also on expertise and technical knowledge in many fields. Of these, electricity is one of the most important.

Op die oomblik bevind George hom in 'n unieke posisie dat die dorp krag aankoop van EVKOM, maar ook tot 'n mate krag uit eie bronne voorsien. Die Munisipaliteit beskik nog oor 'n kragsentrale wat hoofsaaklik op stoomvoorsiening berus. Hierdie kragsentrale is in staat om ongeveer 25% van die dorp se totale behoeftes te bevredig en is in tye van nood 'n welkome bystand.

Vanweë die feit dat Suid-Kaap deur EVKOM voorsien word vanaf 'n aftap-punt te Beaufort-Wes, met 'n hoogspanningslyn oor die Swartberge, is hierdie streek besonder kwesbaar, en gebeur dit soms dat onderbrekings, veral tydens swaar sneeuvalle, voorkom. In sulke omstandighede is die plaaslike kragsentrale dan in staat om die ergste nood te verlig en ten minste die vernaamste nywerhede aan die loop te hou. In die kragsentrale vind ons 'n heel unieke situasie, deurdat die oorwig van stoom opgewek word deur steenkoolverbranding, maar daar is ook twee ketels wat stoom opwek deur houtverbranding wat vanaf die Staatsaagmeule verkry word in ruil vir stoom wat aan die Staatsaagmeule gelewer word vir die droogproses van hout. Die kragsentrale voorsien dus nie net in die elektrisiteitsbehoeftes van die gemeenskap nie, maar verskaf terselfdertyd ook stoom wat 'n besondere diens is, wat normaalweg nie deur 'n Munisipaliteit gelewer word nie.

'n Gedeelte van die krag word ook voorsien deur twee diesel-eenhede met 'n kapasiteit van 500 kVa elk wat hoofsaaklik ge-installeer is as 'n noodhulp of bystand.

Mnr. die President, die stadsrade van Suid-Kaap sien met groot verwagting uit na die daarstelling van 'n tweede kraglyn na Suid-Kaapland, óf die voltooiing van 'n **kringtoevoer,** iets waaroor ek nie in staat is om my oor die tegniese voor- en nadele van die twee alternatiewe uit te spreek nie, maar wat vir u as ingenieurs moontlik 'n belangstelling en 'n interessante onderwerp van bespreking kan wees vir die kongres. Wát ook al die oplossing vir die probleem is, sien ons daarna uit dat hierdie streek, veral in die lig van die ontwikkeling wat in die nabye toekoms verwag word, geheel en al beveilig sal word teen onderbrekings. U weet dat dit al gebeur het dat die hele streek sonder krag was. Die koste van onderbrekings in 'n nywerheidskompleks is onberekenbaar. Daar is natuurlik ook nog die probleem dat EVKOM se voorsieningskapasiteit tans beperk is en met tye nie in staat is om aan al die behoeftes van hierdie

streek te voorsien nie. As 'n mens daaraan dink dat hierdie streek, en veral George, maar op die drumpel staan van geweldige ontwikkelinge, dan word hierdie probleem baie ernstig. Elektrisiteit is die aangewese energiebron vir die streek. Daar word gehoop dat EVKOM binne die afsienbare toekoms in staat sal wees om sy voorsieningskapasiteit dermate uit te brei dat hy in staat sal wees om aan die hele land se behoeftes te voorsien. As in ag geneem word dat George oor die afgelope aantal jare met betrekking tot sy werklike voorsiening van elektrisiteit 'n stabiele groeikoers van 16% plus gehandhaaf het, dan kry 'n mens 'n idee van die enorme belangrikheid van elektrisiteit aan 'n groeiende gemeenskap. Op hierdie basis van groei beteken dit in effek dat die kragvoorsiening elke 4 jaar verdubbel. Dit stel nie net hoë eise aan die plaaslike owerheid wat die hoë koste van 'n verspreidingstelsel moet dra nie, maar dit stel ook hoë eise aan EVKOM wat basies die voorsieningsowerheid is. Dit is dus vir my duidelik dat die tydvak waarin ons ons bevind, veral aan tegnici, hoë eise stel, en dat hierdie eise in die toekoms al feller sal word. Basies lê die beskikbaarheid van ingenieurs, en in besonder ook elektrotegniese ingenieurs, aan die wortel van ontwikkeling in enige land, want die ekonomie kan net groei in die mate waarin die tegnologie in staat is om die nodige infrastruktuur daar te stel. Om hierdie rede beskou ek dit dan as 'n besondere geleentheid om u hier op George te verwelkom waar u as verantwoordelike lede van u professie bymekaarkom om gedagtes te wissel en mekaar se kennis aan te vul, wat ek glo tot voordeel van ons land as geheel is.

I hope and trust that this conference and your deliberations, Mr. President, will be both fruitful and interesting. May you renew old friendships and make new ones. Make yourselves at home in George and enjoy your stay.

Mr. D.H. Fraser: President

My innige dank teenoor u, agbare Burgemeester, Raadslid Heunis, vir die hartlike wyse waarop u ons in u geskiedkundige en pragtige dorp verwelkom het, asook vir die vriendelike wyse waarop u ons verrigtinge geopen het.

George neem in gewildheid toe as 'n kongressentrum en kan nou, vanweë die feit dat daar 'n gereelde S.A. Lugdiens hier ingestel en daar voortreflike akkommodasie naby die sentrum is, op gelyke voet met ander tradisionele sentra meeding. Ek is seker my raadslid sal met my saamstem dat Durban in sy spoor sal moet trap.

Mr. Mayor it is obvious that no effort has been spared to ensure that all our needs during this conference have been catered for and I would like to congratulate your Town Clerk, Mr. Carel du Plessis, to Town Electrical Engineer, Mr. Mostert, and all others who have been involved in the preparations on their achievements. May I, at the outset, express my appreciation to them for making the President's job so easy. It is with regret that we have to record the death of certain members and other persons who have been closely involved in the activities of the AMEU.

Bert Kipling – Honorary Member, Clarence Kinsman – Hon. Member; Charlie de Kock, Past Cllr. Representative and Mr. Charles Adams – former Electrical Engineer of Somerset West. Our deepest sympathy is extended to their families and I ask you all to stand for a few moments in remembrance of them.

We are honoured to have a number of Honorary Members and Past Presidents attending this meeting and I would ask them to stand to receive our special greetings and welcome. There are possibly one or two newly appointed Town Electrical Engineers who are attending a national gathering of our Association for the first time. Will they please stand so that we may recognise them. To all of you gentlemen may I extend a very special welcome and wish you a long and happy involvement in the activities of the AMEU.

Ten slotte verwelkom ek ons vlytige Sekretaris, Bennie van der Walt en sy vrou Annatjie. Bennie het onlangs sy rug as gevolg van 'n val beseer en ons is baie verlig om te sien dat sy gesondheid so vinnig herstel. Ons dank aan jou, Bennie, vir die reëlings ten opsigte van hierdie vergadering.

Nou wil ek u, agbare Burgemeestersdame, Mev. Kellerman, namens al die afgevaardigdes – maar veral namens die dames – versoek om 'n klein bewys van ons dankbaarheid teenoor u vir u gasvryheid teenoor ons te ontvang. Val, my gade, sal nou die oorhandiging aan Mev. Kellerman waarneem.

Agbare Burgemeester, ons wil ook hê dat u 'n klein aandenkinkie van hierdie geleentheid met u saamneem en as 'n blyk van die hoë agting wat ons het vir u en die dorp wat u verteenwoordig, doen dit my nou groot genoeë om een van ons Vereniging se dasse aan u te oorhandig.

Mr. W.J. Seymore

Mr. W.J. Seymore matriculated in 1956 at Ventersdorp Hoërskool in the Western Transvaal before proceeding to the University of Pretoria where he graduated at the end of 1961 with a B.Sc. degree in Electrical Engineering. After a short period with the S.A. Airways he joined G.H. Marais & Partners in 1963 and is now a senior Director of the firm. He is the Vice-Chairman of the Northern Transvaal Branch of the S.A. Association of Consulting Engineers. Mr. Seymore is President of the S.A. Aircraft Owners' & Pilots' Association and as hobbies goes in for flying instruction and farming.

Mnr. W.J. Seymore.

GREATER SOWETO ELECTRIFICATION

by W.J. Seymore (Pr. Eng)

1. INTRODUCTION

This paper deals with work done by my firm in the field of electrical distribution systems. It is presented on the platform of the Greater Soweto Electrification Project. Implementation by the Councils Greater Soweto of some of the subsystems is still subject to their consideration and policy decisions. The Energy Management System is typical of such a subsystem on which decisions still have to be taken by the Client on adoption and implementation.

Most of the subsystems dealt with in this paper, are not unique to Soweto but are the result of developments that have taken a number of years to refine to the stage on which the designs for Soweto are based.

Potions of this paper have already formed the subject matter for earlier publication.

1.1 Greater Soweto

It does not happen very often that an existing city with a population of over one million is electrified from scratch. It is for this reason that this is one of the most interesting projects, not only in the Republic of South Africa, but also in the world. The city in question is Greater Soweto. It appears that this is the first time in the history of the world that a city of this size is to be electrified in totality.

The name Soweto is derived from the first letters of the words **So**uth **We**stern **To**wnships. Greater Soweto consists of three Council areas, namely the Soweto Council, the Diepmeadow Council and the Dobsonville Council. There are apporximately 107 000 potential electricity consumer.

Soweto is a city with a minimum infrastructure. Existing electricity, water, stormwater and sewerage systems are presently inadequate and overloaded.

1.2 Appointment of Consulting Engineers

Mr. David Thebehali, Chairman of the Soweto Council, approached the private sector during 1978 for assistance to improve the quality of life in an ordained and accelerated manner. This led to the formation of a consortium of engineers and planners by professional firms in the fields of engineering, architecture and planning. The firms are:–

- **G.H. Marais & Partners Inc,**
  Consulting Engineers (Electrical and Mechanical;
- **Walter Roux and Partners,**
  Consulting Engineers (Civil Structural and Roads);
- **Abramowitch, Sacks, Moss, Sack, Feldman and Associates Inc,**
  Architects and Planners;
- **De Leuw Cather and Associates Inc,**
  Consulting Engineers (Civil, Structural, Roads and Transport).

The consortium was names "Ecoplan Consortium for Soweto Project".

The Soweto Council was soon joined by the Diepmeadow and Dobsonville Councils. Planning work commenced immediately.

The Ecoplan Consortium was formally commissioned on 1978-08-10 by the three Councils to submit a report.

The first task of the consortium was to produce, in very close co-operation with the three Councils, a document which was to be called the *"Development Guidance System for Greater Soweto"*. This document identified the basic needs, i.e. water supply, sewerage works, roads, water reticulation, electricity distribution, housing – in short, a definition of what a city should contain. Based on these needs, a development guideline report was submitted by end 1978 covering all aspects for future Soweto, including the financial implications involved.

It appeared that housing and the electrification of Greater Soweto were the most urgently required. The Minister of the Department of Co-operation and Development gave his approval to go ahead with the electrification project in March 1979. The first planning report regarding the electrification of Soweto was submitted during May 1979, covering the proposed distribution system, cost estimates and financing.

1.3 Finance

A consortium of banks, consisting of Volkskas Merchant Bank, Barclays National Merchant Bank, Standard Merchant Bank and Union Acceptances Limited offered finance by way of loan stock issue for the first phase of R20 million. These funds became available during June/July 1979. The second phase comprises a R100 million stock investment by the Post Office and the third phase will be a guarantee for R50 million offered by the consortium of banks.

The financial figures as set out above, describe the situation that was prevalent at the time of the design considerations during 1980. The situation has subsequently changed in accordance with the policy of the Councils of Greater Soweto who are represented by the Director: Electrical of West Rand Administration Board, Mr M van der Spuy who, I feel sure, will provide such information on this matter as may be required by interested persons.

1.4 Economic and Sociologic Impact

The economic and sociologic impact of Soweto is probably best described as stated in the "Supplement of Municipal Engineer" of September/October 1980 as follows:

> "The electrification project of Soweto is a project of historical significance and serves as a basis to improve the quality of life not only for the one million people of Soweto but, hopefully, for all black townships throughout the country, eventually."

1.5 Cost Estimates and Programme

The total estimated cost of the project is R204 million including electrical wiring of houses.

The original programme was to complete this vast project by

1985/86. Requests from the clients forced the pace to break all records. This can be summarised as follows:–

- June 1979: Approval to Consultants to proceed with designs;
- July 1979: First tenders for minisubs were issued;
- Sept/Oct 1979: Negotiations with the Electricity Department of the Johannesburg City Council were completed to assist with the first urgent work to improve the overload situation before the next winter;
- December 1979: First minisubs were delivered to site;
- December 1979: Tenders for 40% of the reticulation system were issued;
- February 1980: Tenders for 132 kV substations, 132 kV transmission lines, 132 kV cables, 11 kV switchgear and substations were issued;
- March 1980: Approval received from West Rand Administration to proceed with housing wiring designs;
- May 1980: Balance of reticulation system designs were completed;
- May/June 1980: Contracts awarded for reticulation system and substations;
- July 1980: First contracts awarded for housing wiring;
- August 1980: First contractors established on site;
- May 1981: Substation buildings were completed;
- September 1981: 132 kV Transmission line and cable contracts completed;
- December 1981: First 132 kV substations to be completed;
- December 1981: Escom will supply power to Greater Soweto;
- December 1983: Estimated completion of electrification project.

2. PLANNING

Aspects and procedures which are to be followed with the planning of such a project, are as follows:–

(1) All available plans of existing electrical systems and other services are to be obtained and studied;

(2) All records of existing houses and other buildings whicch are to be considered as potential consumers must be obtained;

(3) All available information regarding future township extensions, and future extensions inside existing areas, namely business centres, blocks of flats, high density housing, industry development, etc., must be obtained;

(4) All reports and studies submitted by other parties are to be obtained and studied to prevent duplication of work already done;

(5) The present and future electricity consumption patterns of black people have to be studied. One has to determine what the future purchasing power of the people will be and to what extent they will purchase electric stoves, geysers, heaters, television sets and other appliances.

All this information is necessary to determine the "After Diversity Maximum Demand (ADMD)" of each consumer on which the design should be based. This will also form the basis to determine the total demand of the city to plan the bulk power supply to the city;

(6) Estimates and feasibility studies are to be done which include the preparation of suitable electricity tariffs to ensure that the Electricity Department of Greater Soweto can be operated economically;

(7) The necessary funds are to be obtained to finance such a project;

(8) A suitable power supply to the city must be investigated;

(9) A licence for the purchasing and distribution of electricity in the area is to be obtained from the Electricity Control Board;

(10) The method for the metering of electricity energy consumption is to be investigated;

(11) An electricity department is to be established for the Greater Soweto Councils to operate and maintain the system once it is installed. All aspects regarding a new electricity department, such as organisation, personnel, buildings, workshops, vehicles and equipment, etc must be investigated;

(12) Detailed programming and co-ordination is necessary to ensure that a project of this size can be completed in time.

3. STATISTICS OF THE PROJECT

I would like to give you some statistics to give you an idea of the size of this project:

(1)	Cost of the distribution system	: R160 million
(2)	Cost of the housing wiring	: R 44 million
(3)	Rate at which house wiring should be done to complete this project by end 1982	: 200 houses/day
(4)	Total number of miniature substations	: 900

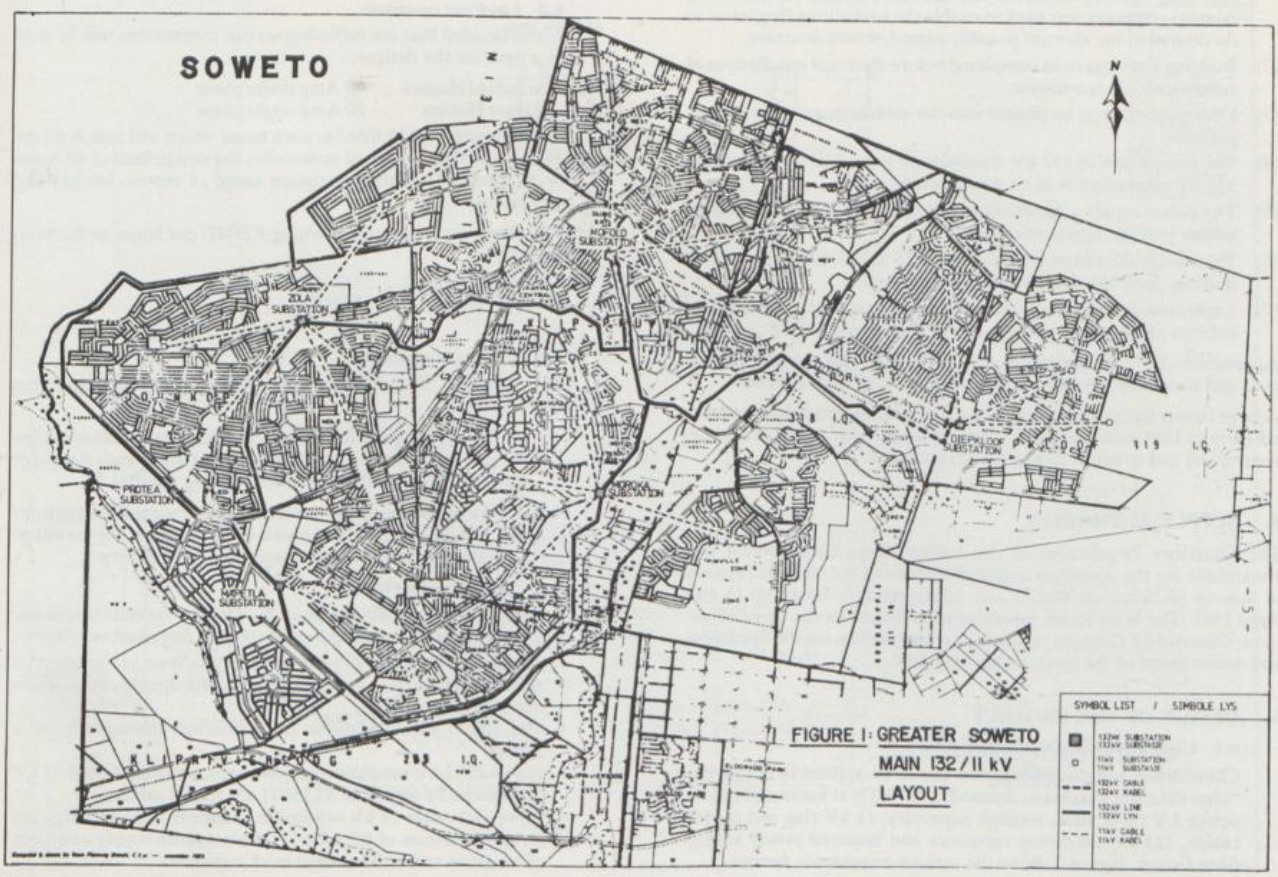


FIGURE 1: GREATER SOWETO MAIN 132/11 kV LAYOUT

(5) Number of low voltage distribution cubicles housing the kWh meters : 11 000
(6) Total length of 11 kV, low voltage of pilot cables : 2 500 km
(7) Total length of service connection cables : 3 000 km
(8) Estimated maximum demand of city by 1985 : 160 MW
(9) Estimated maximum demand at turn of century in excess of : 300 MW
(10) Greater Soweto is spread over an area approximately 15 km lengthwise and 10 km crosswise as shown on figure 1, consisting of 30 areas or suburbs.

4. CONTRACTS

Twenty main contractors have been or will be appointed for the electrification project of Greter Soweto, namely:–

- 132 kV Substation earth works;
- 132 kV Substation concrete structures;
- 132 kV Substation buildings;
- Main 11 kV Substation buildings;
- 132 kV Substation and Transformers;
- 132 kV Transmission Lines;
- 132 kV Underground Cables;
- 11 kV Switchgear;
- Temporary 22 kV Line;
- 11 kV and low voltage reticulation system (which is tha largest contract of this project);
- Supply and delivery of kWh meters;
- Housing wiring;
- Remote control and Supervisory system;
- Energy management system.

The values of the individual contracts vary from R800 000 to 90 million.

This project stimulated the economy of many industries. All the larger manufacturing companies participate in this project, namely cable manufacturers, transformer manufacturers, minisub manufacturers, low voltage distribution cubile and switchgear manufacturers, switchgear manufacturers, kWh meter manufacturers and various others. Approximately 30 factories are involved in this project.

A project of this size requires accurate planning, programming and co-ordination of the following:–

(1) Designs must be completed and orders placed timeously to ensure that long delivery materials are delivered to site on time. The inhouse computer was used to enable the Consulting Engineers to do designs in the shortest possible period;
(2) Building work has to be completed before electrical installations of substations can commence;
(3) kWh meters are to be phased into the cubicle manufacturing programme;
(4) The completion of 132 kV transmission lines, 132 kV cables and 132 kV substations is to be synchronized;
(5) The power supplies, reticulation systems and house wiring installations must be synchronized;
(6) The change over from the existing 6,6 kV to the new 11 kV system must be properly planned and synchronized;
(7) Cable trench excavations, cable laying, erection of minisubs and cubicles, service connections, etc must be synchronized.

Approximately 3 000 employees are involved in this project on site, over and above the job opportunities created at all the factories.

A large labour force was required for cable trench digging, bit it appeared early in 1981 that insufficient manual labour was available and the contractors had to resort to machine excavations.

5. SUPPLY AUTHORITY

The Electricity Department of the Johannesburg City Council was responsible for the operation and maintenance of the electrical system of Soweto on behalf of West Rand Administration Board up to end April 1981. The West Rand Administration Board, as the agent of the three Community Councils, took over responsibility for the operation and maintenance of the system after May 1981.

6. DESIGN OF THE PROJECT

6.1 Coincidence and Diversity Factors

Coincidence and diversity factors are to be applied to obtain the "after diversity maximum demand" (ADMD) at various points to design LV cable sizes, minisub capacities, 11 kV ring and feeder cables, 132 kV substation capacities and required power supply from Escom. Figure 2 shows the various coincidence factors.

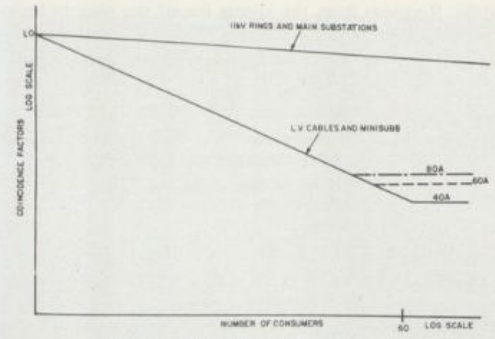


FIGURE 2 - COINCIDENCE FACTOR GRAPH

EXAMPLE: APPLICATION OF COINCIDENCE FACTORS:–

LV Feeder cable capacity:–

(1) Service connection of houses = 40 Amp single phase
(2) Load per house = 9,24 kVA
(3) Number of houses on LV feeder cable = 12
(4) Coincidence factor = 0,6
(5) Cable to be designed for a load of:– $9{,}24 \times 0{,}6 \times 12 = 66$ kVA
$= 96$ A/phase

Minisub capacity:–

(1) Number of houses per minisub = 120
(2) Coincidence factor = 0,32
(3) Calculation of minisub capacity $= \underbrace{9{,}24 \times 0{,}32}_{3\text{ kVA}} \times 120$
$= 360$ kVA $\therefore$ Use 400 kVA

132 kV Substation capacity:–

(1) Total number of houses connected to 132 kV Substation = 38 000
(2) Coincidence factors: Four main 11 kV Substations connected to 132 kV Substations = 0,92
(3) 132 kV Substation capacity $= \frac{3\text{ kVA} \times 0{,}92 \times 38\,000}{2{,}76\text{ kVA}}$
$= 015$ MVA

6.2 Load per consumer

It was decided that the following service connections will be used as a basis for the designs:–

- Standard Houses : 40 Amp single phase
- Larger Houses : 60 Amp single phase

A load limiter will be fitted at each house which will switch off the geyser when the total load approaches the design limit of 40 Amps or 60 Amps, to enable maximum usage of stoves, heaters and appliances.

The above loads give the following ADMD per house at the minisub level:

- Standard Houses : 3 kVA
- Larger Houses : 5 kVA

6.3 Voltage regulation

The Electricity Act, Act No. 40 of 1958 as revisedm Ragulation 24(2) states that:–

> "... the voltage at which electricity is supplied, shall not differ from the standard or agreed voltage by more than 5 percent for a longer period than ten consecutive minutes."

Approval was obtained form the Electricity Control Board permitting the Soweto electricity network to be designed for a voltage regulation of 8% which saves a large amount of money.

6.4 General design layout

The layout as generally designed for Greater Soweto is schematically shown in figure 3 which can be shortly described as follows:–

- The Escom bulk supply point at 132 kV is West of Soweto;
- A 132 kV closed ring system is formed with double circuit transmission lines;
- The 132/11 kV substations are connected alternatively on a circuit;
- Each 132/11 kV substation supplies approximately 4 main 11 kV substations by means of XLPE 11 kV feeder cables;
- From each main 11 kV substation a number of 11 kV rings are formed by means of PILCDSTA cables, which supply a number of minisubs and/or substation brick cubicles;

– From each minisub or brick cubicle a number of radial low voltage cables are laid to supply power to low voltage distribution cubicles. A "multiple earthed neutral" (MEN) system is designed and solid aluminium core, CNE (combined neutral/earth) cables are used. The kWh meters are housed in the low voltage distribution cubicles.

7. SOWETO ELECTRIFICATION PROJECT

A short description of the Soweto electrification project is as follows:–

7.1 Power supply

Escom will bring in a 275 kV supply from the west which will be stepped down to 132 kV at a substation just outside the Soweto boundaries. The supply will be suitable for a future load of up to 500 MVA. Greater Soweto will purchase power in bulk from Escom at 132 kV and the power will be distributed by the Electricity Undertaking of Greater Soweto at 132 kV into the Greater Soweto area.

The initial Escom power supply will be made availabale at 132 kV at the Soweto Protea substation at end 1981.

Johannesburg City Council is presently also supplying power to Soweto at 6,6 kV from the Orlando power station. The Johannesburg City Council's power supply will gradually be phased out by "Escom power" up to end 1983.

7.2 Extra High Voltage System

7.2.1 *General*

A main 132 kV receiving and switching substation, the Protea substation, is established west of Soweto. Two 132 kV transmission lines with double conductors have been erected from the position of the future Escom substation up to the main receiving Protea substation. The busbars of Protea substation are designed for 2 000 Amp to pass Escom power through this substation.

Five 132/11 kV substations are supplied from Protea substation by means of double circuit 132 kV transmission lines and 132 kV cable as shown in Figure 1.

7.2.2 *132 kV and 132/11 kV Substations*

The low profile 132 kV substations with tubular aluminium busbars were designed for the following reasons:–

– It costs less than conventional substations;
– The use of tubular busbars results in a small overall substation area;
– The reduced height of structures improves aesthetics;
– A neater design is possible.

It was also decided to use concrete structures in preference to lattice steel structures. Concrete structures have neat, clean lines which contribute to the aesthetical design of substations. The electrical symbols "A" for Amphere and "V" for Volts are used as a basis for the design of the concrete elements, as shown in figure 4.

The Protea main receiving substation is of double busbar type with pantograph motorised isolators which give a neat design and a smaller substation area. The layout is shown in figure 5.

Single busbar 132 kV designs with bus-section circuit breakers are used for the 132/11 kV distribution substations as shown in figure 6. These substations are designed for four 30/35 MVA, Ynd1, 132/11 kV transformers with automatic tap change and volt drop load compensation facilities. Neutral earthing compensators (NEC) with built in earth resistors are used to limit the earth current to 300 Amps. Chrome steel is used for resistor elements. Two auxiliary transformers, built in the same tanks as the NEC's, are installed at each substation for the auxiliary power supply. Changeover facilities are provided at the low voltage distribution board to ensure that only one auxiliary transformer is connected to the low voltage system.

The tubular busbars must withstand a natural frequency of at least 3 Hertz. The dimensions of the tubular aluminium busbars are, for mechanical reasons, 114 mm diameter with a wall thickness of 6 mm. The maximum span of these busbars is 11 metre.

Gas insulated SF6 outdoor type 132 kV circuit breakers are used in the system. Tender prices for these circuit breakers were lower than the equivalent small oil volume circuit breakers.

20 Metre long lightning spikes are installed for lightning protection of the substations. The spikes are connected to the substation earth mat. The spikes are positioned in such a way that a coverage of 30° on the outside and a coverage of 60° on the inside is obtained as shown in figure 7.

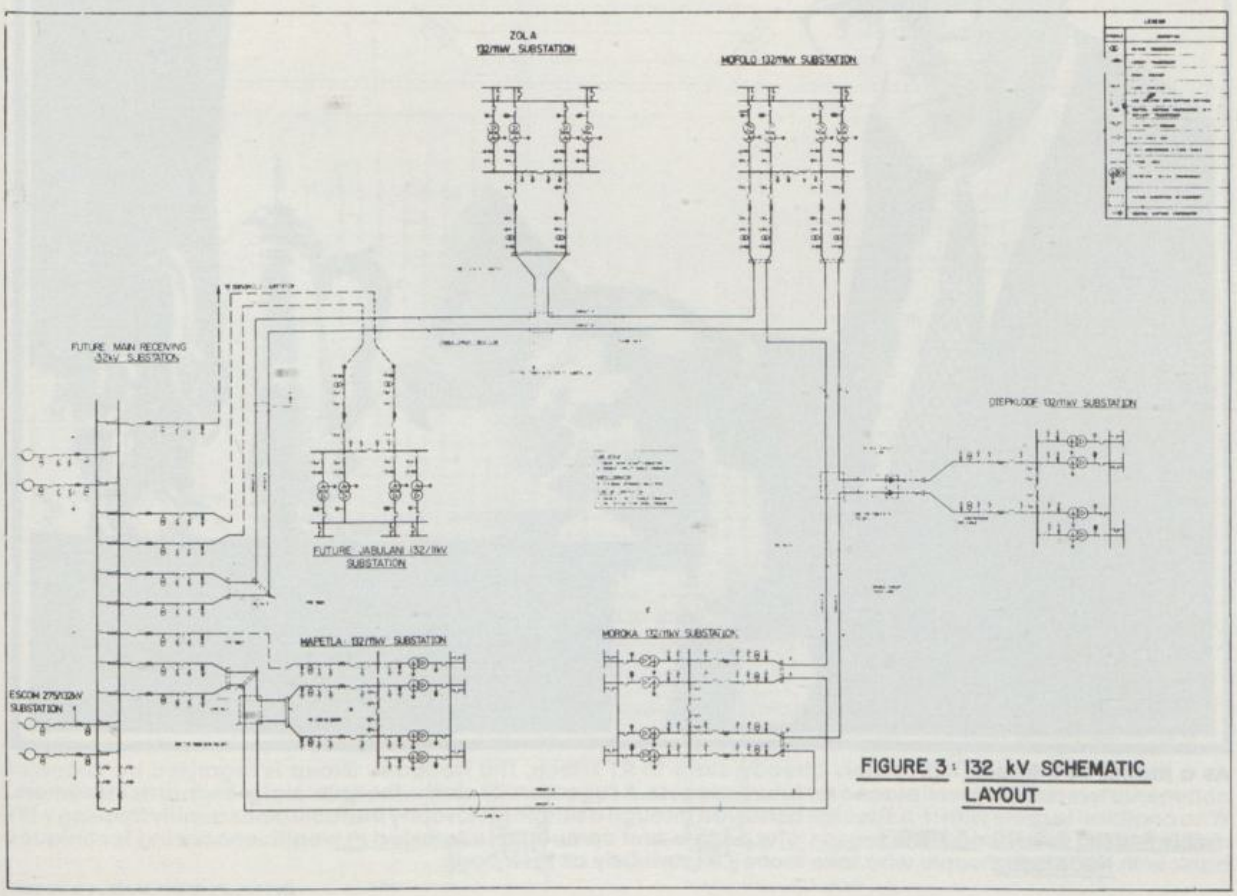


FIGURE 3: 132 kV SCHEMATIC LAYOUT

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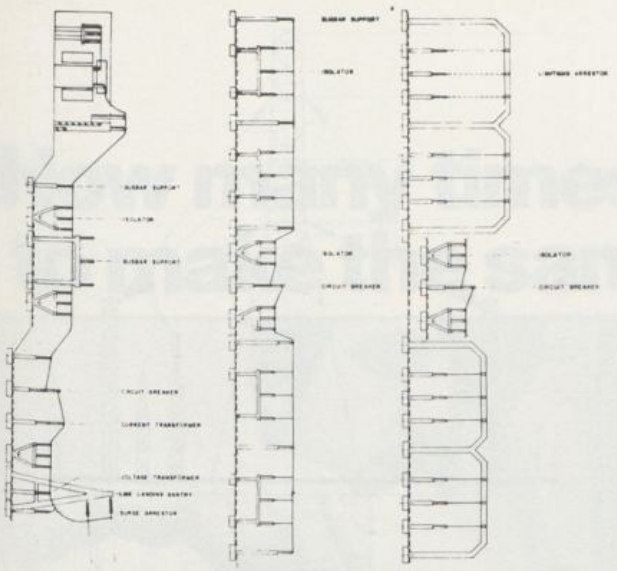

FIGURE 4 : CROSS SECTIONS OF 132 kV SUBSTATIONS

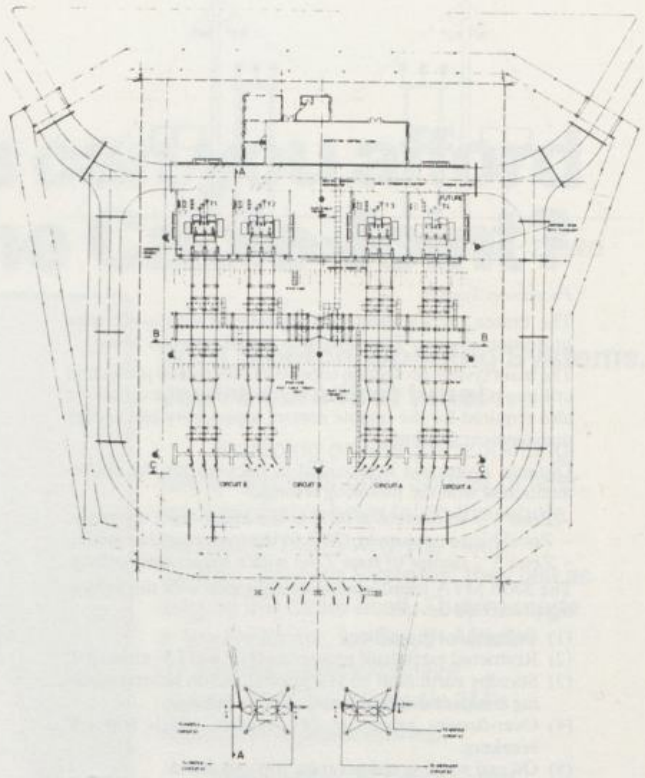

FIGURE 6 : 132 / 11 kV SUBSTATION

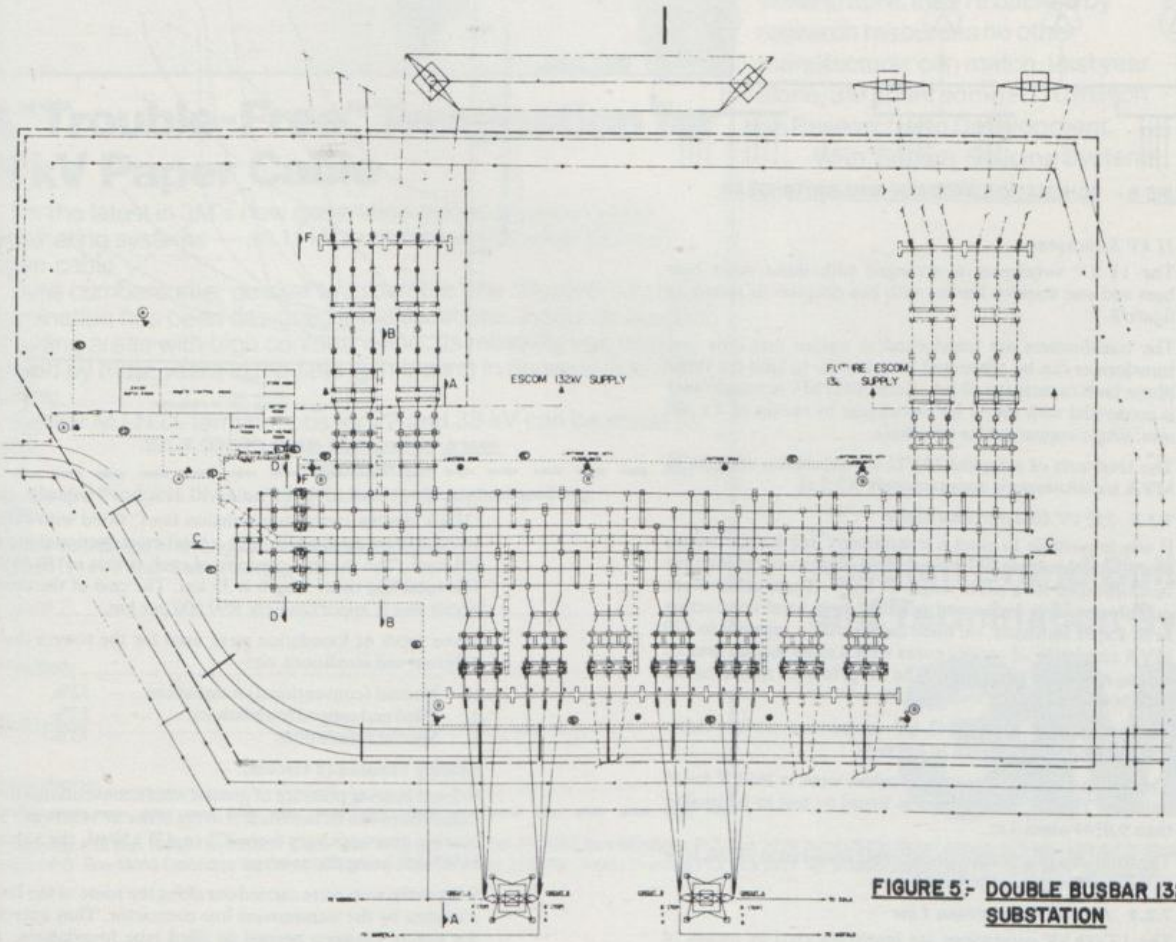

FIGURE 5 :- DOUBLE BUSBAR 132kV SUBSTATION

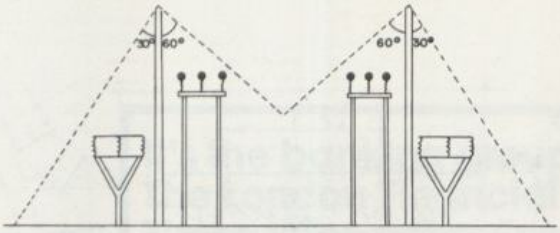

FIGURE 7:- LIGHTNING SPIKE ARRANGEMENT

Protection System

The Protea 132 kV substation is provided with a bus zone protection scheme. The substation is split into two zones.

The main system protection consists of differential protection utilizing pilot wires. The reason for this is that pilot cables are also required for the remote control supervisory and energy management systsems.

Distance protection is provided as back-up for the above-mentioned with the following settings:–

- Zone 1 : to operate at 80% in the under-reaching mode;
- Zone 2 : to operate at 120% in the over-reaching mode;
- Zone 3 : similar to zone 2 but with a longer time setting.

The 30/35 MVA transformers are equipped with the following protection devices:

(1) Differential protection;
(2) Restricted earth fault protection (HV and LV windings);
(3) Standby earth fault on HV neutral and on neutral earthing compensator connected to LV windings;
(4) Over-current relays on HV feeders which trip LV breakers;
(5) Oil and winding temperature trip and alarm;
(6) Gas operated relay (Buchholtz).

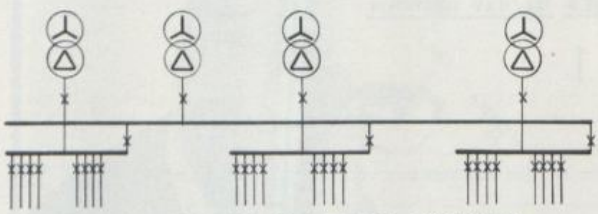

FIGURE 8:- SCHEMATIC LAYOUT OF 11kV SWITCHGEAR

11 kV Switchgear

The 11 kV switchgear is arranged with three main busbars and one standby busbar with bus couplers as shown in figure 8.

The transformers are interlocked to ensure that only one transformer can be connected for a busbar to limit the three phase fault capacity to 18 kA. Each 30/35 MVA transformer is connected with the 11 kV switchgear by means of 4 x 300 mm² single copper cables per phase.

The total cost of a typical 132/11 kV substation with 30/35 MVA transformers is approximately R2,2 m.

7.2.3 *132 kV Underground Cable*

It was impossible to erect a transmission line in one section where double circuit 132 kV oil filled single core cables have been installed for a route length of 1,6 m. These cables were manufactured in Japan and installed by a local contracting firm. Paper insulated, oil filled cables with a capacity fo 120 MVA consisting of copper cores with a cross section area of 700 sq mm have been used. The oil pressures in the cables vary between 170 kPa and 525 kPa.

The termination of the 143 kV cables at a double circut transmission line is shown in figure 9.

The field pressure tests on these cables were at 265 kV for 15 minutes. The DC resistance was found by test to be smaller than 0,0344 ohms/km.

The total cost of a double circuit cable installation of this type is R700 per metre route length.

7.2.4 *132 kV Transmission Line*

The 132/11 kV substations are interconnected by means of

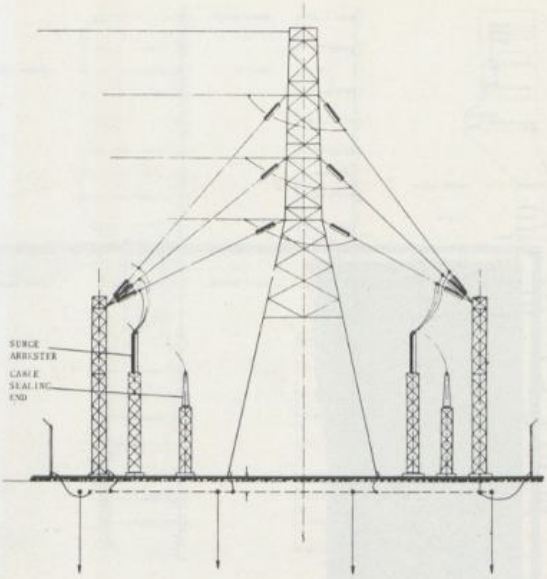

FIGURE 9:- TERMINATION OF 132kV CABLES AT DOUBLE CIRCUIT TRANSMISSION LINE

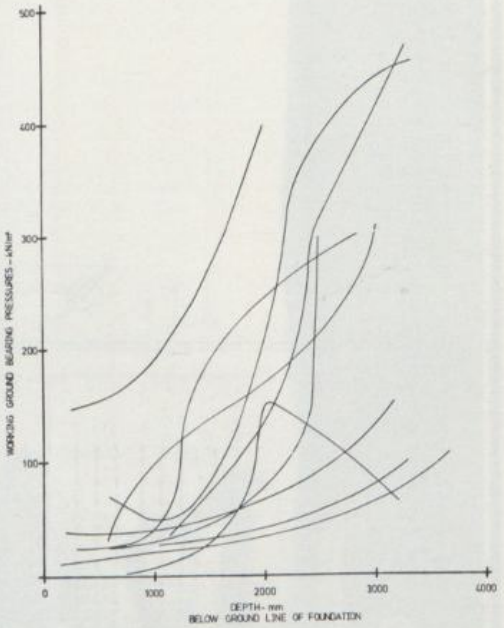

FIGURE 10:- WORKING GROUND BEARING PRESSURES BY TEST AT TOWER POSITIONS

132 kV double circuit transmission lines, fitted with ACSR 30/7/3,25 mm conductors with a total cross sectional area of 264 mm². The thermal capacity of each circuit is 150 MVA. The total line route length is 35 km. The cost of the double circuit line is apporximately R90 000 per km.

Three types of foundation were used for the towers due to different soil conditions viz:–

1. Normal (conventional) foundations – 32%
2. Piled and capped foundations – 55%
3. Special foundations – 13%

Bearing Pressure of Ground:–

Normal bearing pressure of ground where conventional tower foundations can be installed, is in the order of 345kN/m². Safe bearing pressures vary from 275 to 425 kN/m², the value of 345kN/m² being the average.

Soil profile tests were carried out along the route of the line as a routine by the transmission line contractor. They exercised the option between normal or piled type foundations, and

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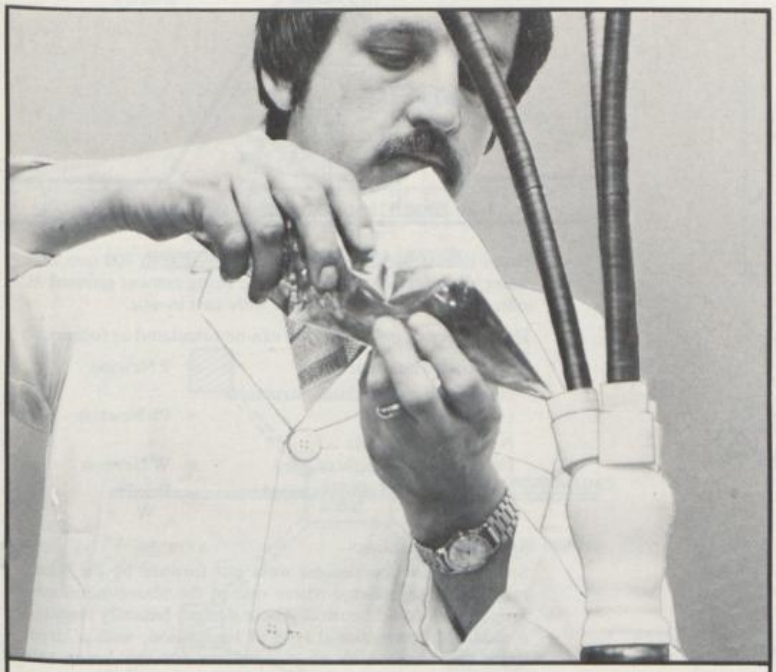

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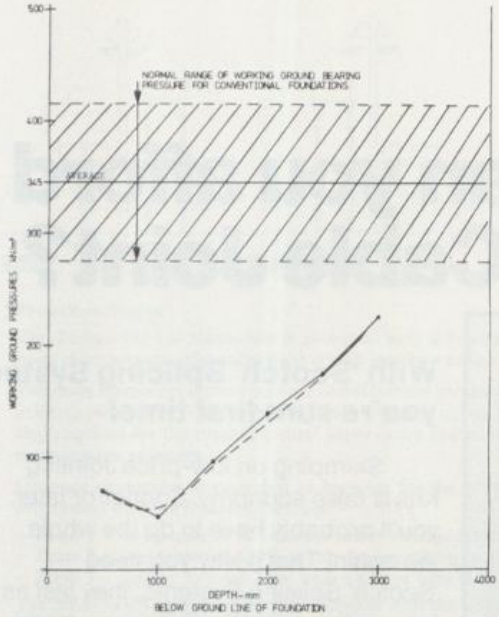

FIGURE 11 AVERAGE WORKING GROUND BEARING PRESSURES BY TEST AT TOWER POSITIONS REQUIRING SPECIAL FOUNDATIONS.

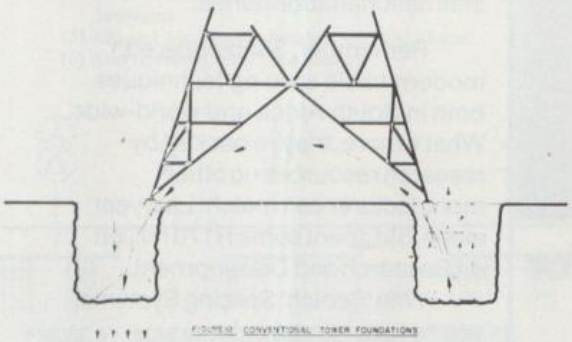

FIGURE 12 CONVENTIONAL TOWER FOUNDATIONS

then sought the approval of their choice from the Consulting Engineers. Being cheaper, quicker and easier to install, piled foundations were chosen where the ground friction contributed to the installation of piled foundations rather than normal foundations.

In instances where the ground consisted of a wet clayey type material as on the side of spruits and in other areas where large ash deposits formed the base for the foundation, the Consulting Engineers had soil profile tests carried out.

The results of the tests is summarized in figure 10, where curves based on foundation depths plotted against safe bearing pressures are given. The results of all the tests are averaged and the general foundation conditions are indicated in figure 11. It can be sseen from figure 11 that the average safe bearing pressures were well below the normal safe average.

Normal (Conventional) Foundations:–

The conventional foundations are shown in figure 12. These foundations are more expensive than piled foundations.

Piled foundations:

The number of piles per foundation installed depends upon the load to be carried and varies from 4, 8 to 12. In all cases the pile foundations were drilled to depths ranging from 1 820 mm to 4 640 mm depending on the developed friction of the ground and the load to be applied. A typical piled foundation is shown in figure 13.

Each tower leg is concreted into a cage which formed a cap over the set of piles required for each leg foundation. The purpose of the cap is to distribute the load equally among the piles.

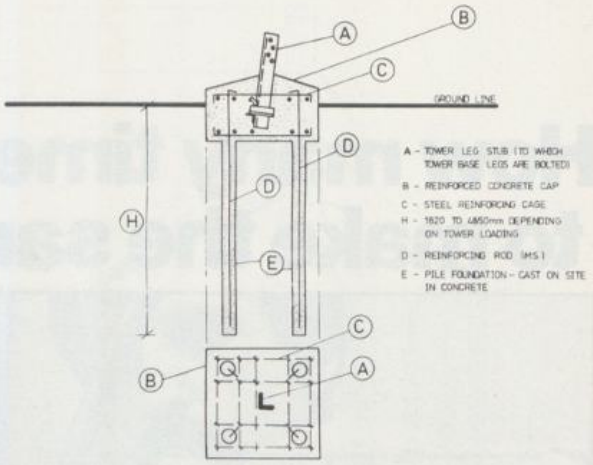

FIGURE 13 PILED FOUNDATIONS FOR TOWERS

Holes drilled for the piles varied from 100 to 400 mm diameter. Reinforcing steel rods were being cement grouted as indicated in figure 13. All piles were cast in-situ.

The number of piles required can be calculated as follows:–

Net load to be carried	=	P Newton
Net weight of foundation structure (called pile cap)	=	Pb Newton
Net safe load on pile (in addition to weight of pile)	=	W Newton
Then number of piles required	=	$\frac{P + Pb}{W}$

Special Foundations:–

Special foundation designs were put forward by the transmission line conductor where one of the above-mentioned foundations could be used. These designs basically required a modified conventional type of foundation, with a larger foundation base area to compensate for the lower safe bearing pressures that the ground in question was able to offer. A special foundation is shown in figure 14.

From the curves it can be seen that generally the bearing pressures improve with depth below ground line. As soil densities also vary with ground bearing pressures, soil had to be imported to replace the upper layers excavated. As towers produce a downward force on the one side and an upward force on the other side, the larger foundation bases are required to serve a two-fold purpose:

(a) To react to a downward force.
(b) To react to a lifting force.

Special foundations were preferred in the areas of excessively poor ground bearing pressures. These special foundations are less costly than special piled foundations with piles deeper than normal. Many of the tower positions were also inaccessible for heavy drilling plant to install special piles.

7.3 11 kV System

7.3.1 *General*

The earth fault on the 11 kV system is limited at the 132/11 kV substations to 300 A by means of neutral earthing compensators (NEC's) and earth resistances. This is in line with Escom's policy. The three-phase fault level is limited to 18 kA by the special arrangement of busbars and transformers.

Due to the low earth resistivity of the soil in Greater Soweto it was decided to lay a 7/4 mm stranded galvanised steel earth conductor in all cable trenches to form a uniform earth mat over the area which will also serve as an earth for the consumers.

The schematic layout of the 11 kV and low voltage system is shown in figure 15 and can be summarised as follows:–

- A number of main 11 kV substations are supplied with power from each 132/11 kV substation;
- A number of 11 kV ring systems are supplied from each main 11 kV substation;
- Each ring system supplies power to an average of 15 minia-

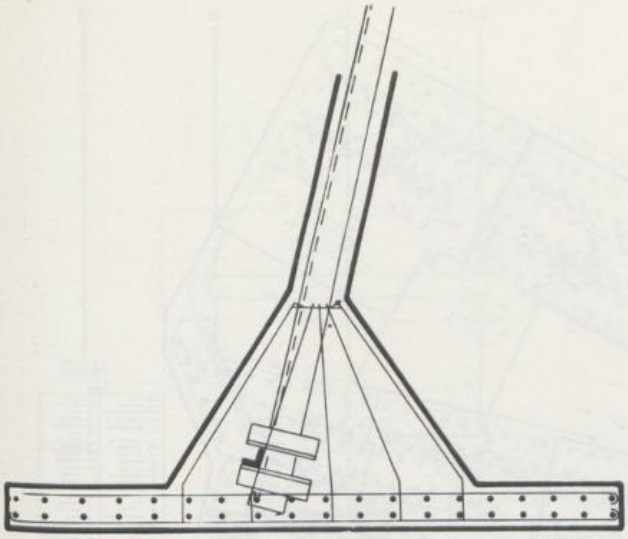

FIGURE 14 : SPECIAL TOWER FOUNDATION

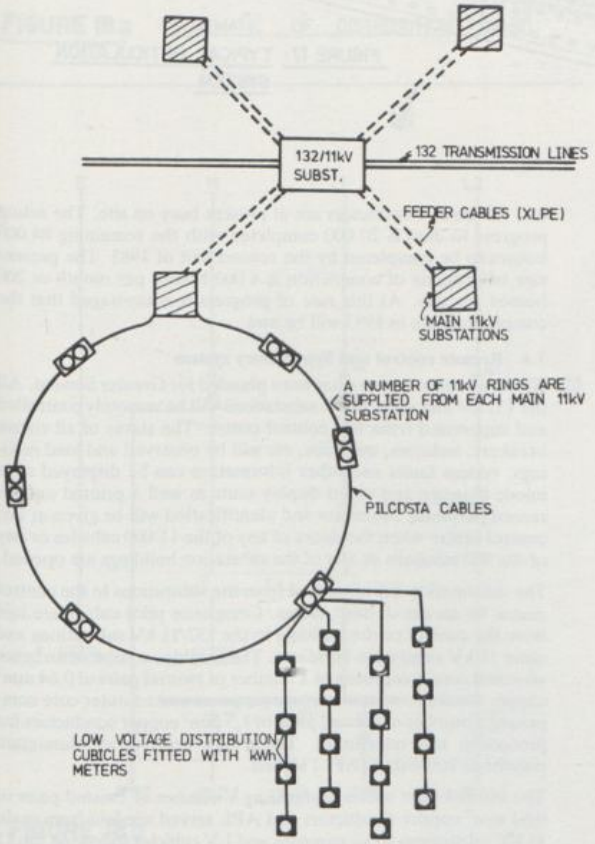

FIGURE 15 : 11kV AND LOW VOLTAGE SCHEMATIC LAYOUT

ture substations or brick cubicles (existing small substation buildings);
- Each minisub supplies power at 400 V via approximately four radial cables to low voltage distribution cubicles.

7.3.2 *Main 11 kV Substations*

Approximately twenty main 11 kV substations are to be erected in Greater Soweto. These are switching stations. Approximately four main 11 kV substations are supplied with power from each 132/11 kV substation by means of a number of 11 kV cross-linked polyethelene insulated (XLPE) steel wire armoured copper core feeder cables. The capacity of each of these substations is approximately 20 MVA.

7.3.3 *11 kV Reticulation System*

The old existing 6,6 kV system will be phased out with a new 11 kV system.

The relatively high load density due to the smaller premises makes the use of 500 kVA miniature substations an economical proposition. The township layouts, however, compel the use of 400 kVA and 315 kVA minisubs. A number of ring systems emanate from each of the 11 kV substations. The ring systems consist of 11 kV copper core paper insulated 3-core screened cables.

The minisubs are fitted with 11 kV ring main units with a T-off switch fuse unit to protect the transformer. Each of the three switches is fitted with auxiliary contacts to ensure that the status of each minisub can be indicated at the control centre.

The minisubs are provided with an electronic compartment to house the electronic eqipment for the energy management system described later.

7.4 Low Voltage Reticulation System

7.4.1 *General*

The low voltage system is schematically shown in figure 16. A multiple earthed neutral (MEN) system is used.

7.4.2 *Reticulation System*

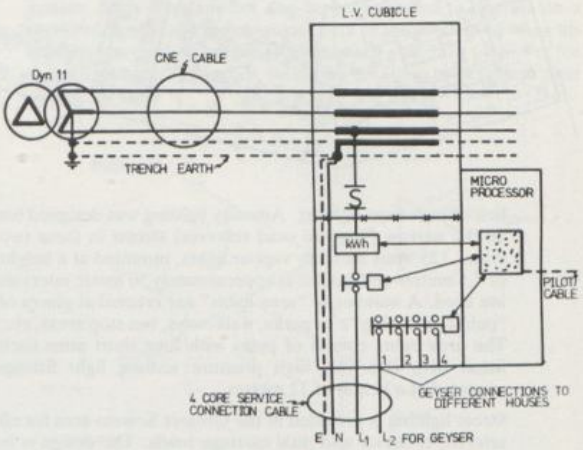

FIGURE 16 : L.V. SCHEMATIC LAYOUT

A number of low voltage distribution cubicles are supplied with power from each miniature substation by means of combined neutral/earth (CNE) cables consisting of three solid aluminium cores and the CNE portion stranded copper. The kWh meters of consumers are clustered in these cubicles. The cubicles serve between 8 to 16 consumers and house the service connection circuit breakers, kWh meters and contractors.

The cubicles are provided with an electronic compartment to house the electronic equipment for the energy management system described later.

Generally, the low voltage radial feeder cables and cubicles are, for economical reasons, erected in every second street. A typical reticulation system is shown in figure 17.

Service connection cables are laid from cubicles on adjacent stand boundaries to houses or other consumers. 4-Core service connection cables are installed, namely:–
- 1-core is the phase conductor;
- 1-core is neutral;
- 1-core is for the load shedding of the hot water geyser; and
- 1-core is the earth connection.

7.4.3 *High Mast and Street Lighting*

High mast lighting installations exist largely in the Soweto Council's area. It was decided to complete the high mast lighting installation in this area which was designed and installed by Johannesburg Electricity Department.

The other two Councils preferred normal street lighting in

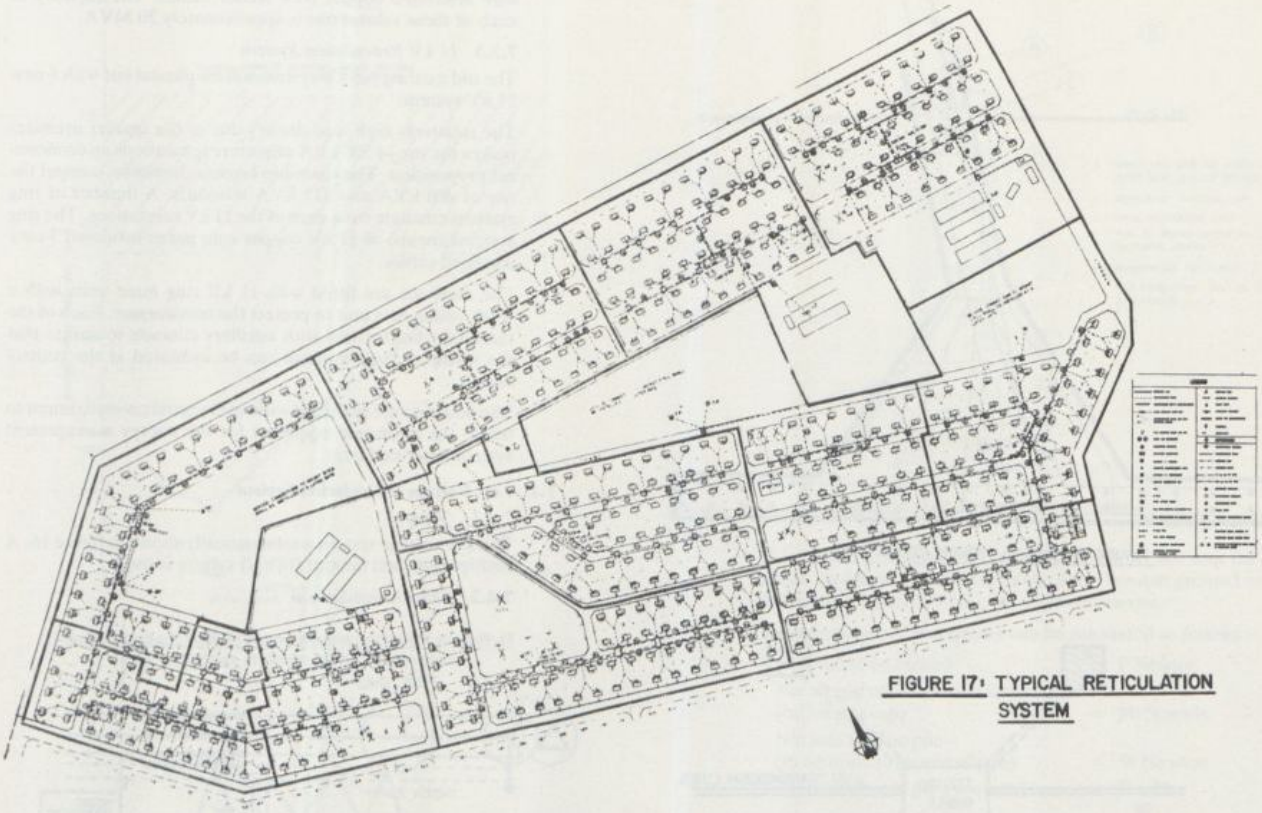

FIGURE 17: TYPICAL RETICULATION SYSTEM

lieu of high mast lighting. Amenity lighting was designed for all the narrow (9 metre road reserves) streets in these two areas. 125 Watt mercury vapour lights, mounted at a height of 7,5 metres and spaced at approximately 50 metre intervals are used. A number of "area lights" are erected at places of "public gathering" e.g. parks, walk-ways, bus stop areas, etc. The area lights consist of poles with four short arms each fitted with 250 watt high pressure sodium light fittings mounted at a height of 12 metres.

Street lighting is provided in the Greater Soweto area for all arterial, collector and dual carriage roads. The design is in accordance with the SABS Code of Practice. 250 Watt mercury vapour and high pressure sodium lights are used, mounted at 10 metre heights.

7.5 House wiring installations

The total number of houses in Greater Soweto that are included in the present House Wiring Contract is 104 000. Of these, 24 000 houses have existing electrical installatins which, although they are alive, do not comply with the latest Code of Wiring of Premises as issued by the SABS.

The House Wiring Contracts provide not only for new installations to houses, but also the upgrading of the existing electrical installations in order to comply with the latest requirements.

A 2-wire and neutral earth leakage device which was developed especially for use in Soweto is shown in figure 18. The 2-pole earth leakage device acts as a main switch but, because of the difference in pole ratings, duplicates as the geyser circuit breaker. This particular development in the design resulted in an overall cost saving to the project of approximately R0,75 m.

Typical electrical installations to certain houses are shown in figure 19. The many different types of houses in Soweto are complicated further by the fact that the tenants have made changes such as erection of ceilings, repositioning of stoves, rehanging of doors, moving internal walls and adding other fixtures. To date approximately 7 out of every 10 houses have had one or more of these alterations. The problem is, however, not serious as the design is flexible and site modifications to the conduit kits are easily effected.

The greatest difficulty to date has proved to be the fixing of conduit to walls and ceilings. Various alternative methods were tried, such as glue, nails pins, shot fixing, etc. The most successful method has proved to be the woodscrew and Fisher type plastic plug.

The house wiring contracts have been awarded to three Contractors. All three Contractors are at present busy on site. The actual progress to date is 20 000 completed with the remaining 84 000 houses to be completed by the second half of 1983. The present rate of progress of completion is 4 000 houses per month or 200 houses per day. At this rate of progress it is envisaged that the completion date in 1983 will be met.

7.6 Remote control and Sypervisory system

A central control centre has been planned for Greater Soweto. All the 132 kV and main 11 kV substations will be remotely controlled and supervised from this control centre. The status of all circuit breakers, isolators, minisubs, etc will be observed and load readings, system faults and other information can be displayed on a mimic diagram and video display units as well a printed out for record purposes. An alarm and identification will be given at this control centre when the doors of any of the 11 000 cubicles or any of the 900 minisubs or any of the substation buildings are opened.

The information is transmitted from the substations to the control centre by means of pilot cables. Composite pilot cables are laid from the control centre building to the 132/11 kV substations and main 11 kV substation buildings. These cables consist of an inner screened core comprising of a number of twisted pairs of 0,64 mm^2 copper conductors for electronic purposes and an outer core comprising a number of twisted pairs of 1,5 mm^2 copper conductors for protection and telephones. The cables are overall aluminium polythene laminated (APL) served.

The normal pilot cables comprising a number of twisted pairs of 0,64 mm^2 copper conductors and APL served are laid from main 11 kV substations to all minisubs and LV cubicles following the 11 kV and LV cable routes. Pilot cables are installed simultaneously with power cables.

This system will be protected against lightning and over voltage surges as generally described for the energy management system.

7.7 Consumer Energy Management System

As mentioned earlier, this paper deals with work done by my firm on design matters such as the Consumer Energy Management System. The Energy Management System dealt with in this paper, has been developed by my firm and the Soweto Electrification Project is a channel for what we consider to be a suitable application. The Councils of Greater Soweto have yet to decide on the implementation of proposals on an Energy Management System. I can, therefore, not discuss this system in the context of the Soweto Project. Provision has been made in the interim in the

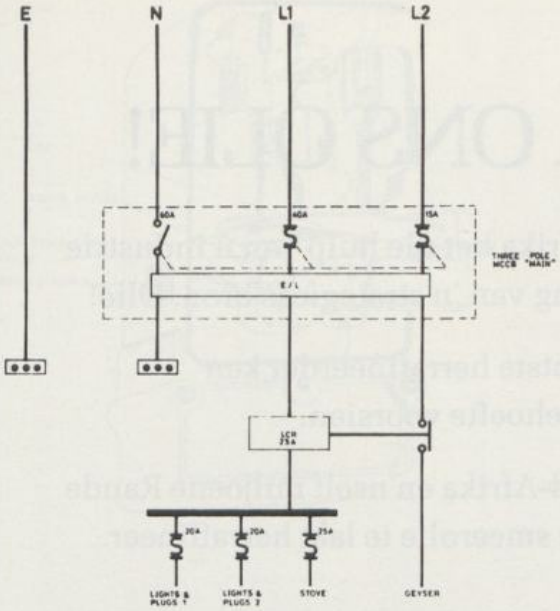

FIGURE 18a SCHEMATIC OF DISTRIBUTION BOARD

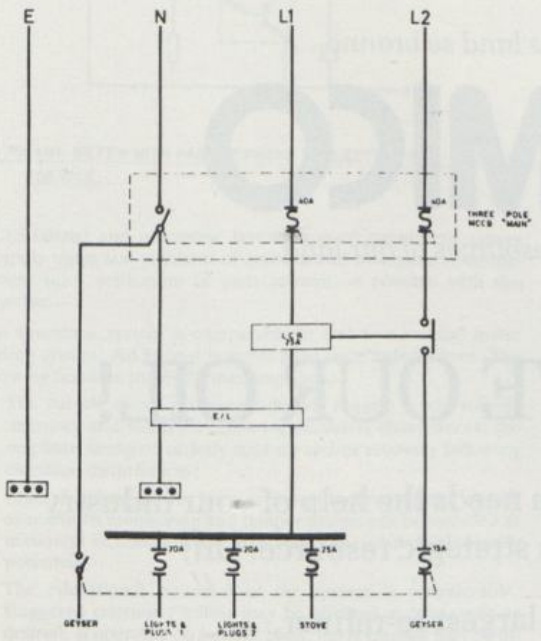

FIGURE 18b

ALTERNATIVE SCHEMATIC OF DISTRIBUTION BOARD

form of pilot cables and space allocations to keep the options open.

The development of the Energy Management System that I am going to describe, took place in our design offices in Pretoria where we constructed a proto type which may be the answer for the future. The proto type was displayed to various supply and distribution authorities and large consumer organisations such as:

- various municipalities;
- Department of Community Development;
- Department of Co-operation and Development;
- the CSIR;
- Escom

Previous papers dealt with this system in greater technical detail. It is at the moment undergoing further development for other applications.

An Energy Management System can include all or part of the following:

1. Facilities for load shedding;
2. Automatic remote metering of consumers kWh energy consumption;
3. Remote terminations/reinstatement of consumers' supplies;
4. Automtic debiting of consumers'. accounts by means of a computer.

The information can be transmitted from cubicles and all substations to the computer centre by means of pilot cables, radio communication, micro wave or carrier wave systems. The method of transmission is the most expensive part of the Energy Management System.

The information can be collected by scanning the whole area and this scanning process can be in the order of five minutes.

Conventional cyclometer dial kWh meters afford consumers the same protection as in traditional metering systems. The kWh meters are fitted with photo reflective pick-ups for automatic remote metering purposes which count the number of revolutions of the disc. These must then be wired to the micro processor handlers.

Centralised and automatic termination of consumers' power supply upon non-payment of account, and automatic reinstatement upon settlement of such account is possible with this system. Such a system can also be programmed to operate on a credit basis whereby the consumer may be informed as to when his credit is less than the prescribed amount by switching off power for a predetermined period or flickering his lights at a certain time during the day.

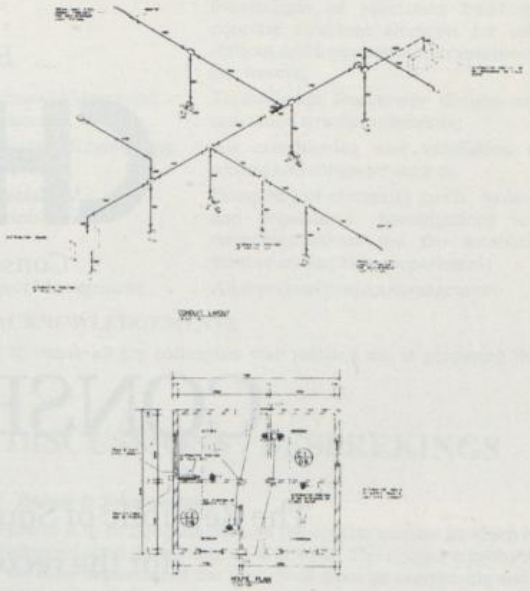

FIGURE 19 : TYPICAL HOUSE WIRING INSTALLATION

Operation of the system if outlined as follows:–

- Normally closed contractors in the low voltage cubicles will control load shedding of geysers through the 4th core of the service connection cables (Refer to figure 16). Control is by pilot cables that are looped from the minisubs to the cubicles. This method of load shedding, inclusive of all the feasibilities of this system whereby pilot cables are installed, makes it more economical than the method of superimposing data on power cables.
- Conventional cyclometer dial kWh meters installed in the cubicles afford consumers the same protection as in traditional metering systems. The kWh meters are fitted with photo-reflective pick-ups for automatic remote metering purposes as shown in figure 20. A micro processor communication handler is fitted in the electronic compartment of each cubicle and minisub;

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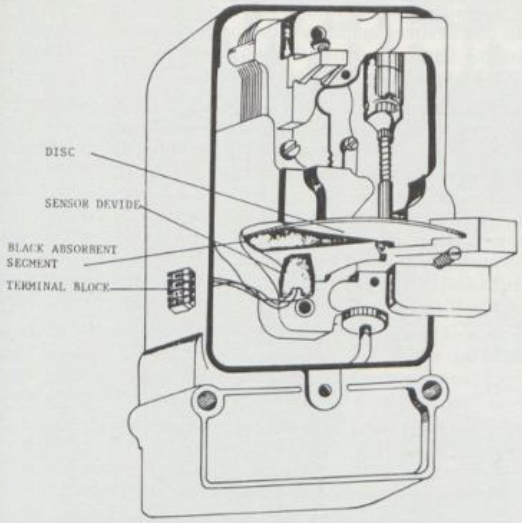


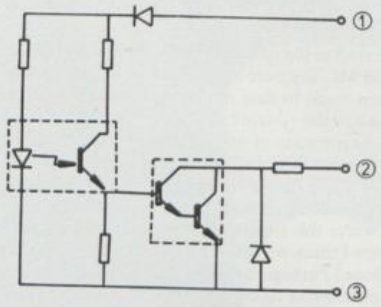


FIGURE 20: kWh METER WITH PASSIVE PHOTO REFLECTIVE PICK-UP SENSOR DEVICE

- Centralized and automatic termination of consumers' power supply upon non-payment of account and automatic reinstatement upon settlement of such account, is possible with this system.

This automatic system is comparable in cost to a manual meter reading system. Additional benefits have been noted above. The following features justify further emphasis:–

(a) The cubicle micro processors do not require a non-volatile memory and will reset following electrical disturbances, the emphasis being on orderly start-up and/or recovery following electrical disturbances;

(b) Load shedding, power termination and reinstatement, as well as minisubs monitoring and tamper alarms can be included at minimum incremental cost. The ability has substantial security potential;

(c) The educational potential of the system is considerable. Staggered consumer billing may be effected as frequently as desired. If operated on a credit basis, the consumer may be informed as to when his credit is less than a prescribed amount by switching off power for a predetermined period. Programme ability of the system will enable adaption of the ongoing needs of the three Councils of Greater Soweto.

This system will be protected against lightning and over voltage surges by means of Primary and Secondary Protection as follows:–

(1) *Primary Protection*

The primary protection comprises gas arresters. These gas arrestors will be installed on all pilot cable pairs at the termination boxes. The gas arrestors, which are also generally used by the Post Office, comply with the following minimum specifications:–

- Rated striking voltage : 230 Volts
- Surge striking voltage at dv/dt of 1 kV/microsecond for 99% of measured value : < 700 Volts
- Rated 50 Hertz, one second surge discharge current : 20 Amp
- Rated dc discharge current 8/20 microseconds : 19 kA

(2) *Secondary Protection*

Secondary protection will be incorporated in the electronic circuits to protect the communication equipment against residual surges eminating from the gas arrestors. Tranzorbs and/or Zener diodes and/or Varistors will be used for the secondary protection scheme.

The above-mentioned dual stage protection shceme will be complemented with optical isolation of the signals to and from electronic circuits.

The primary stage will mainly absorb the power in a surge while the second stage provides overvoltage protection for the electronic circuits.

Pilot cables are screened and these screens will be earthed at the termination boxes. One end of a section will be earthed directly while the opposite end will be earthed via a sparkgap.

8. CONCULSION

As can be seen form the afore-mentioned, this project includes everything from house wiring, building work, electronics to 132 kV installations. It also includes economic and administrative planning which makes this an extremely interesting project.

The electrification project of Soweto has something for most disciplines of engineering, namely:–

- Electrical Engineering : Electrical distribution and transmission system;
- Electronic Engineering : Supervisory and energy management systems;
- Civil Engineering : Earthworks for 132 kV substations, foundations of substation buildings, concrete structure elements for substations and foundations of transmission line towers;
- Mechanical/Structural Engineering : Transmission line tower designs and substation structure elements;
- Mechanical Engineering : Air conditioning and ventilation of control and computer centres;
- Financial and Administration : Compiling of electricity tariffs, by-laws and regulations. Investigations and recommendations for the establishment of an electricity department;
- Project Management : All aspects of project management.

9. ACKNOWLEDGEMENTS

I wish to thank all my colleagues who assisted me in preparing this paper.

DISCUSSIONS / BESPREKINGS

Mr. W. Barnard: Johannesburg

Mr. Seymore is to be congratulated on the concise manner in which he has enlightened us on the lighting up of Soweto. This project is probably one of the most important of our time, both from an engineering and a sociological point of view.

Soweto is within the Area of Supply of the Johannesburg City Council and its peak load was 45 MVA in 1981 and will possibly exceed 50 MVA this winter. Supply to the existing consumers is given from the Council's Orlando Power Station via a 20/6,6 kV network constructed, operated and maintained by the Johannesburg Electricity Department since 1973 on behalf of the West Rand Administration Board. The new 132/11 kV system described in the paper receives bulk supply directly from ESCOM and is intended to replace the original 20/6,6 kV network. The first consumers will be transferred to the new network shortly and as from 1 July 1982, the Soweto Urban Council will take over the operation and maintenance of both the existing and the new networks.

One of the earliest references to electricity supply in Soweto is in a paper presented to the 33rd Convention of the AMEU held in Johannesburg in 1959 by G. Masson formerly of my Department. Mr. Masson gave details of early installations in Orlando East, which mostly consisted of a 60 watt lamp in each room and a single 15 amp outlet for a plug-in stove or similar appliance and had an after diversity demand of less than 500 watts per consumer. Because of limited funds, street lighting was provided in alternate streets only, until excessive vandalism and the increasing crime rate resulted in the introduction in 1973 of high

mast area lighting which has been very successful and has now replaced street lighting, except on main roads.

For reasons of economy, the earliest reticulation schemes provided by the City Council of Johannesburg in Soweto were based on the MEN system and consisted of either one or three phase conductors mounted in vertical configuration on wooden poles above a split neutral. Because of overloading, vandalism and excessive damage from motor vehicles colliding with poles in unmade roads, this Department in 1975 recommended to WRAB that all future reticulation should be underground and be based on an ADMD of not less than 3 kW per house. For lack of funds, only one installation on this basis, in Pimville, was undertaken by the Johannesburg Electricity Department in Soweto, but these recommendations were used as a basis for the new electrification project described by Mr. Seymore.

Towards the end of his paper Mr. Seymore describes a proposed unique form of consumer energy management for Soweto. As this scheme has aroused some considerable interest, I would like to make a few general comments on it.

This is a sophisticated scheme relying on equipment designed to send discreet coded signals which can be correctly picked up by any selected individual consumer (and by no other consumer).

Incorrect signal recognition can result in paid-up consumers being cut off at the mercy of the main computer and the probability, in many cases, of these consumers having great difficulty in getting the computer to acknowledge its error. High quality ripple control relays recently installed by Johannesburg have a failure rate guaranteed not to exceed 1% over a period of three years. If we regard this as a typical expected failure rate of this type of electronic equipment, up to 400 consumers could be cut off incorrectly every year in Soweto. However, in the Soweto system, there is also the possibility of faulty signalling cables affecting the correct working of the signalling system. Telephone type cables are easily damaged and faults ware notoriously difficult to locate. Also the receiving relays which have to operate on very small currents are mounted in outdoor cubicles on dusty pavements, which could provide a further source of maintenance problems. It seems to us that the system will be subject to costly and time-consuming maintenance problems and may give rise to considerable consumer dissatisfaction.

A study made by this Department at the request of the Chief Director of WRAB showed a saving in the cost of a conventional manual meter reading and cut-off scheme compared with the remote metering and control scheme proposed for Soweto. The latter scheme requires communication cables to be laid with the power cables at an additional cost of approximately R3 million and consumers' LV cubicles all to be equipped for remote metering and cut off.

Whether or not the proposed scheme will be successful when it is eventually completed and put into operation, the experiment will be watched with great interest by other supply authorities like ourselves. In the meantime we understand metering and control will continue to be done by conventional means.

A form of energy management, which I suggest could be very successful in Soweto, would be to encourage the installation of solar in place of electric water heating. Only a few houses in Soweto have interior plumbing systems and a bathroom, but there is no doubt these will be next on the list of amenities required by residents. Although a solar water heater to SABS standards presently costs appreciably more than an electric geyser, the price difference would be recovered in a relatively short period from savings in electricity consumption.

Mr. D.C. Palser: Cape Town

The Soweto electrification project must surely rank internationally as one of the most ambitious and major projects of its kind ever undertaken. To provide the complete infrastructure to supply 107 000 consumers representing a population of around a million people in the relatively short space of four years is no mean achievement. The consultants and all who have been associated with this project are to be congratulated.

In commenting on this paper it might be of interest to draw one or two comparisons with another major, although smaller, project currently being undertaken in Cape Town. This is the new township of Mitchells Plain being built for the coloured community on the Cape Flats. When completed it will house around a quarter million people with 40 000 consumers. It is a prestigious relatively high class residential area reticulated completely underground.

The actual after diversity maximum demand (admd) at the 132 kV level for the 27 000 odd consumers already being supplied in Mitchells Plain in 2,5 kVa. This compares favourably with the corresponding but estimated figure for Soweto of 2,8 kVa.

The transmission and distribution costs for Soweto, however, appear high when compared to those for Mitchells Plain. This could well be due in part to the rather elaborate transmission system and the complex load management system. At the quoted total transmission and distribution cost of R160 million this represents a mean cost of about R1 500 per consumer. It is presumed that this cost is based on current prices and also includes the cost of street lighting and the load management system. The corresponding figure for Mitchell Plain, including street lighting, is around R1 200 per consumer based on current prices.

It is noted that most of the money for this project is coming from the private sector, presumably at ruling rates of interest. Unless subsidised in part by the Government this mean cost of around R1 500 per consumer will probably entail annual interest and redemption charges of about R170 per consumer. If the cost of wiring the houses, namely around R400 each on average, is also to be recovered via the electricity tariff rather than through any increase in house rentals, then this figure of R170 will increase to over R200 per annum per consumer. On the basis of a mean annual consumption of, say, 5 000 kWh per consumer this cost component in the electricity tariff alone represents about 4 cents/kWh.

To this cost must be added the cost of power purchased from Escom. On the basis of the estimated admd of 2,8 kVa at the 132 kV level and a mean annual consumption of 5 000 kWh per consumer this works out at a little over 5 cents/kWh on the basis of the Rand and OFS Escom tariff.

No account has been taken on the cost of management, operation and maintenance of the system. When this is included the overall cost could well be of the order of 10 cents/kWh. This does not compare favourably with Escom's corresponding domestic rate of around 5 to 6 cents/kWh.

Part of the consultants' feasibility study included the preparation of suitable electricity tariffs to ensure that the electricity department of Greater Soweto would operate economically. It would be of interest, therefore, if Mr. Seymore could comment on this subject of electricity tariffs generally, with particular reference to the overall mean unit cost for domestic consumers.

Having referred to the question of management, operation and maintenance, could Mr. Seymore also comment on this aspect and what progress has been made to date in establishing a fully staffed electricity department to run the system?

Regarding the question of voltage drop, I was interested to note that the Electricity Control Board has agreed to waive the statutory voltage variation limit of 5% in favour of a more lenient 8%, evidently because this permits a significantly cheaper system to be designed. But if the Control Board can waive this requirement for one why not for others? In these difficult times I think we would all like to save money just as Soweto has evidently done! Perhaps we should all make application to the Control Board for permission to depart from the standard conditions!

Moving on to more technical matters now, I note that XLPE 11 kV cable is being used between the 132/11 kV major substations and the main 11 kV substations, while 11 kV paper cable is being employed between these latter stations and the minisubs. What is the reason for this?

I was surprised to note that, because of the high earth resistivity of the soil, a stranded galvanised steel earth conductor is being laid in all cable trenches to form a uniform earth mat over the area. Possibly galvanised steel will stand up to Reef conditions but I very much doubt that it would last long in the corrosive soil conditions we have in the Cape. Would Mr. Seymore care to comment on this aspect?

Coming next to street lighting, it was interesting to note that the Councils of both Diepmeadow and Dobsonville have opted for conventional street lighting systems rather than the existing high mast lighting installation in the Soweto Council area. Has it been possible yet to gauge the public response to these two alternative systems of lighting?

Finally, one or two questions about the load management system. Although theoretically this system is an excellent one, permitting as it does load shedding, remote disconnection and reconnection for non-payment and remote metering and automatic billing, is it likely to work reliably in practice? What about vandalism and violent blows to the relatively vunerable street cubicles? Won't this cause problems? In addition to the cubicle door alarms, wouldn't an impact type alarm in the cubicle also be of assistance? Regarding the remote metering system, is this installed and working yet? If so, with what results?

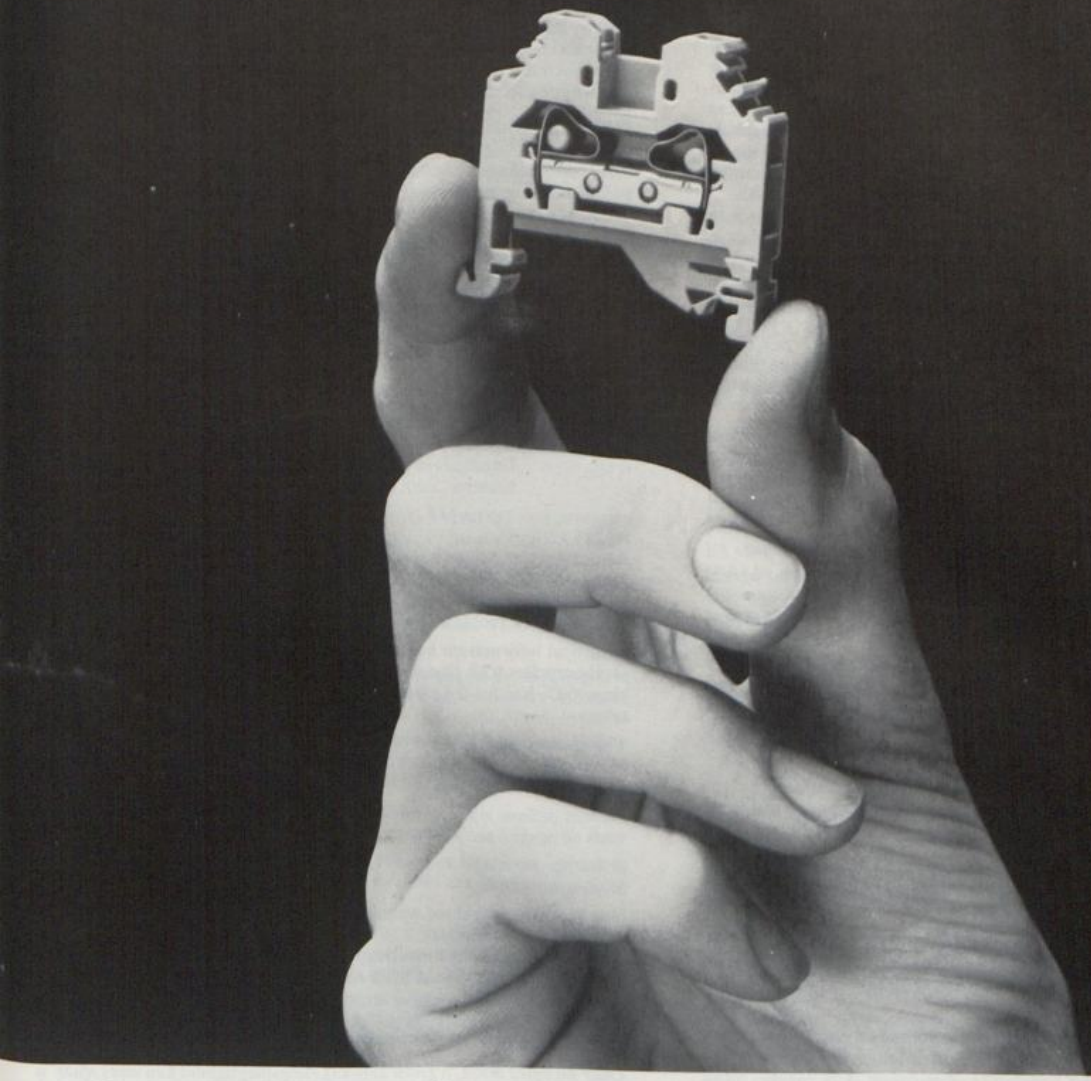
Mr. Seymore's comments on these and the earlier questions posed would be appreciated.

Mnr. G.C. Theron: Oranje-Vaal Administrasieraad

Ek is seker daar is ander baie meer bevoeg as ek om oor die ekstra hoë spanningstelsels kommentaar te lewer en ek wil derhalwe by die 11 KV benetting inval.

1. Ek merk, sien figuur 15, dat XLPE kabels tussen die 132/11KV substasie en die hoof 11 KV substasies gebruik word terwyl die res van die 11 KV verspreiding met papier geisoleerde kabels gedoen word. Ek sal graag van die referent die rede vir die gebruik van die twee tipes van kabel wil verneem.
2. Besonderhede van die beskerming op die 11 KV ringkabels vanuit die hoof 11 KV substasies word nie verstrek nie maar ek aanvaar dit

Within your grasp!



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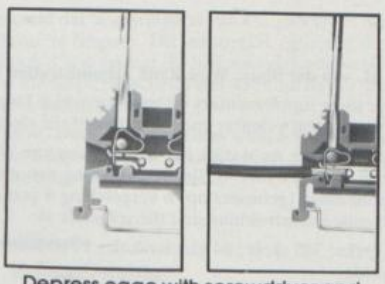

Depress cage with screwdriver and insert conductor.

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is waarskynlik deur middel van relês met oorvrag en aardfout elemente. Die vraag ontstaan nou of ringskakeleenhede met sekerings na die transformator enige doel dien. 11 KV Sekerings om 315 of 400 KVA transformator teen oorbelasting te vrywaar is nie baie suksesvol nie. Na my mening sou 'n eenvoudige drieweg skakelaar op die 11 KV kant van die transformator met termiese beskerming om 'n uitklinkspoel op die L S hoofskakelaar te aktiveer meer doelmatig wees.

3. Die laagspanning retikulasiestelsel volg 'n heel standaard patroon behalwe vir die ongewone gebruik om kabels tussen elke tweede huis deur die erwe te neem na die huise wat na die ander straat front. Die persele in hierdie tipe van dorpsgebied is so klein dat enige uitbreidings aan die huise waar die verkoopskema inwerking tree noodwendig tot op die erfgrense gaan en dit is onredelik om die eienaar dan met serwitute te beperk of anders kan beskadiging van die kabels verwag word. Soweto is reeds 'n bestaande en beboude stad en dit sal interessant wees om te verneem hoe uitvoerbaar hierdie beplanning in werklikheid is gesien in die lig van ontwikkeling om die huise.
4. Die lasbeheerstelsel is vir my 'n bietjie duister – miskien 'n bietjie te doeltreffend. Volgens item 6.2 en figuur 18 is daar 'n lasbeperker in elke huis wat die waterverwarmer, vermoedelik 3 KW, afskakel as die totale aanvraag 40 of 60 ampere bereik. Bykomstiglik is daar in elke L S kiosk 'n kontaktor wat afstandbeheer word om dieselfde gesamentlike doel te dien – sien figuur 16 wat terloops nie 'n verbinding na die lewendige kant van die kontaktor toon nie maar vermoedelik wel deur die K W K meter sal gaan. Vir die doel van hierdie beheer vanuit die kiosk word 'n 4-aar diensaansluitingskabel gebruik.
   Voorwaar 'n duur metode om 'n gordel en kruisband te dra om te verseker dat die broek nie afval nie.
5. Soos die referent te tereg sê vind ek ook die beplande energie beheerstelsel uniek en hier verwys ek spesifiek na die meteringstelsel waaroor reeds baie gespekuleer is.
   Ek wil graag by die volgende paar filosofiese gedagtes volstaan.
   5.1 Dit is 'n hoogs gesofistikeerde stelsel blykbaar nêrens ter wêreld nog in werking nie, die onderhoud en bedryf waarvan hoë-vlak tegnici sal vereis – 'n kommoditeit wat in Suid-Afrika skaarser as diamante is.
   5.2 Meterlesers van standerd 6 of 8 kwaliteit is volop en soos die armes, sal altyd by ons wees. Of hulle meterlees of nie, eet moet hulle nog en werksgeleenhede is juis waarna gesoek word.
   5.3 Is dit dan reg om die verbruiker met die kapitale koste van miljoene rande te belas terwyl sy familielede werk soek.
   5.4 Rekeninge moet nog gelewer word en die geld moet nog gevorder word en dit is waar die knoop lê en geen mate van outomatisasie gaan dit uitskakel nie.
   5.5 'n Krediet-meterstelsel bly nog vir my die ideale oplossing maar tot dusver dra ek nog nie kennis van so 'n meter wat al die oplossings vir die probleme bied nie.
6. Ten slotte gaan die referaat na my mening mank aan 'n groot leemte naamlik meer finansiële besonderhede van die projek. Na alles is dit geld wat praat. 'n Inkomste en uitgawe rekening met bedryfskostes sou insiggewend gewees het.

   Die voorgestelde tariefstruktuur sou seker nie onvanpas gewees het nie. Word die huisinstallasie- en aansluitingskostes teen die huiseienaar of huurder gedebiteer of vorm dit deel van die infrastruktuur?

   Ek stel voor dat hierdie aspekte en bedryfsondervinding van die skema 'n interessante onderwerp vir 'n referaat op die volgende konvensie kan wees.

   Ek wil graag die referent baie bedank vir die meesterlike wyse waarop hy die sluier gelig het oor 'n saak wat hom sekerlik na aan die hart lê.

Mr. M. van der Spuy: West Rand Administration Board

I have some supplementary information which I would like to present to you to give you a clearer understanding of the electrification of Soweto.

Groter Soweto, as 'n stad, het 'n bevolking van 12 miljoen mense – dit moet u vergelyk met 'n Blanke bevolking van ongeveer 4 miljoen vir Johannesburg (gebaseer op 'n vergelyking 4 jaar gelede gedoen). Die bestaande infrastruktuur sluit die volgende in:

303 kerke; 305 skole; 64 kleuterskole; 1 700 handelsprojekte; 115 sokkervelde.

Dit is belangrik om daar op te let dat die hele elektrifiseringskema totaal ekonomies moet wees.

All loans are hard loans, normal interest rates are payable on the open market – not one cent of subsidy in any form is obtained from the Government. The only assistance is in the form of a guarantee for the amount of R206 million with a proviso that this amount is not to be exceeded under any circumstances.

Hierdie is 'n groot addisionele finansiële vrag wat elke huishouer in Groter Soweto moet dra, ongeveer R2 000 per perseel wat amper R30 per maand per perseel vir die volgende 25 jaar. Dit is 'n karige bedrag as 'n mens in gedagte moet hou dat die huisbewoner huidiglik huishuur en belastings gesamentlik van ongeveer R31 per maand moet betaal.

The infrastructure up to the meter cubicle will be paid for by all residents – irrespective of whether they use electricity or not. The costs of housewiring and house connections will be recovered from the tenant or the householder directly. Maintenance and operational costs of the system will be recovered via the charge per unit consumed.

Will the Soweton be able to pay this, was an important question which had to be answered.

The world wide so-called energy crisis has escalated the prices of coal, paraffin and wood to such an extent that electricity has become the cheapest overall method of supplying light and heat energy to a dwelling in Greater Soweto. Bearing in mind that no natural timber resources exist in the Soweto area, all wood has to be imported into the area.

A survey covering a statistical sample of 1 250 households during 1977 indicated the following monthly expenditure on energy in Soweto, where no electricity is available (winter months).

	R/month
Coal	14,41
Wood	3,11
Paraffin	5,30
Gas	0,51
Candles	2,49
Other	0,16
TOTAL	R25,98

At present-day prices, using an escalation rate of 15% per annum and noting that a bag of coal cost R1,95 at the time of the survey and is sold today at R6,96, the monthly expenditure on energy is approximately R45 during the coldest winter month.

Statistical information based on the 24 000 households which are presently supplies with electricity indicates that the occupants spend on average 60% less for the same amount of energy than those without electricity.

The average income level of Greater Soweto is based on the combined income of the breadwinner and other members of the household who are economically active.

Present income is averaged at over R500 per month, so that the energy costs envisaged are well within the means of the residents.

A further problem area not touched on by the speaker is that of the existing consumers.

Nog 'n probleem-gebied wat nie deur die spreker aangeraak is nie, is die bestaande verbruikers.
Daar is op die oomblik elektrisiteit versprei oor die hele Soweto-gebied – 'n 6,6 kV stelsel vanaf Stad Johannesburg. Hierdie stelsel voorsien amper 24 000 persele – maar is totaal oorlaai en kan nie verder uitgebrei word nie – aldus die bou van 'n nuwe stelsel soos deur Wally Seymore hier voorgedra.

Daar sal egter nooit 'n groot aanskakelingsplegtigheid kan wees waar 'n 100 000 verbruikers eensklaps aangeskakel gaan word nie. Die huidige 24 000 verbruikers wat oor die hele gebied versprei is, moet nog onafgebroke elektrisiteit verkry – en as gevolg daarvan sal minisub gebied by minisub gebied – al 900 van hulle – volgens 'n bepaalde plan aangeskakel word.

An organisation for the maintenance and operation of Greater Soweto has been created. The 350 persons (all races) at present employed took over responsibility in terms of the Factories Act during August 1982 and the organisation will be expanded to operate and maintain the whole system.

As mentioned before, tariffs will include the operational and maintenance cost of the network as well as minor new works. The major infrastructural cost of the new system will not be recovered in the electric tariffs, but via Council infrastructural charges which will be applicable to all residents.

Greater Soweto has in fact not got a very high density of population and, because of the high infrastructural cost relating to electricity, water, sewerage and roads, active steps are being taken to increase living density by means of high rise buildings and additional rooms being added to existing dwellings.

Mr. G. Davies: Pietermaritzburg

Section 6.1 of the paper discusses the coincidence and diversity factors. Unfortunately Figure 2 is not scaled. However, analysis appears to show

that the curve used approximates to the function,

$$F = \log^{-1}(-0{,}3685 \log N + 0{,}1758)$$

Where = coincidence factor

N = number of consumers (houses)

Will the author please confirm the form of this curve.

It is also not clear in this Figure on the curve labelled "11 kV ring mains and main substations" whether the axes are multiplied by a factor or whether in fact different scales apply. Furthermore, in respect of the upper curve, it is not clear whether the definition "number of consumers" on the abcissa refers to number of consumers or to number of rings and/or main substations.

We do not basically disagree with the L.V. diversity factors as set out in the paper except that the department with which I am associated uses an out-of-balance factor which decreases significantly as the number of L.V. consumers increases. We have found that it is necessary to incorporate this factor to obtain accurate voltage drop results. It is also usual to include this when determining the size of small transformers up to 100 kVA which conditions, of course, does not apply in Soweto.

It is also stated that the network was designed for 8% voltage regulation. Will the author please advise whether this voltage regulation is at the metering terminals in the street or at the distribution board in the consumer's premises. We would also like to know the breakdown of the 8% in respect of the high voltage regulation, the low voltage reticulation and the service connections from the metering kiosk to the consumer's distribution board if applicable.

We would also like to enquire whether the L.V. reticulation is designed entirely manually or whether any of the now accepted computer designs have been applied. Our own experience has been that the use of computer design invariably results in a considerable saving in cable costs and is considerably quicker than the old "hit and miss" method.

It is also noted that the feeders to the main 11 kV substations comprise XLPE cables whereas the 11 kV rings use paper insulated PILCDSTA cables. In view of the past unsatisfactory performance of XLPE cables, a trend which apparently is still continuing overseas, I would enquire whether the authors are satisfied that XLPE cable will be satisfactory, particularly as they have opted for paper insulated 11 kV cables for other sections of the reticulation.

In Section 7,3 it is stated that the earth fault current on the 11 kV system is limited to 300 A by means of neutral earthing compensators and earth resistances. Would the author elaborate on the methods employed to achieve this low fault current and comment as to whether the use of resistance earthed neutrals has necessitated the use of 11 kV cables having the increased insulation thickness required for unearthed systems?

Mr. V.A. Raynal: Affiliate

Graag wil ek die referent gelukwens met die manier wat hy daarin geslaag het om so 'n groot skema tot 'n referaat van 36 bladsye te konsentreer.

I am particularly interested in the Soweto Electrification Scheme because I was in charge of the operation and maintenance of electricity supplies in Soweto for several years before the commencement of the Ecoplan Scheme. For the record, there are 2 apparent errors in the text, viz. in Section 7.3.1, the reference to "LOW" resistivity should read "HIGH" resistivity and in Fig. 16 – LV Schematic Layout – a connection should be shown between L1 and L2.

I should be pleased if Mr. Seymore would reply to the following questions:

1. **11 kV Cable:** Why were two types of cable used viz: XLPE insulated and PLSTS?
2. **LV Cable:** The SABS produced a specification for CNE cable which provided for a waveform type of combined neutral earth conductor. Why was this type of cable not used?
3. **132 kV Cable:** Why was it decided to use OIL FILLED cable instead of solid-insulated cable? Johannesburg Electricity Department's experience is that repairs to oil filled cable are both lengthy and expensive.
4. **Co-incidence factors (Section 6.1):** How were these arrived at, because they differ from those presently being adopted for "Rational Norms" for township reticulation?
5. **Innovative Wiring:** Was this type of house wiring considered by ECOPLAN and why was it not used?
6. **Cable Damage:** What precautions have been taken to protect buried cables in Soweto?
7. **Load Growth:** What provision has been made to cater for increased load in erven in Soweto?
8. **Blueprint for Future:** Is the Soweto Electrification Scheme to be taken as a blueprint for future schemes in Black townships in South Africa?

The following are comments on questions (6) and (7) above:

6. The electrification of Soweto has been in reverse sequence to the normal servicing of townships where electricity is usually the last service to be installed after road and pavement final levels have been completed and sewerage, water, drainage and telecommunications have been installed.

   The majority of services have yet to be installed in Soweto, which will conceivably lead to damage to the extensive network of buried cables.

7. The design of the LV reticulation in Soweto has resulted in a preponderance of service cable, to the extent of 3 000 km – a distance approximately from George to Beit Bridge and back. Increased load in Soweto appears inevitable, particularly because of the scarcity of land for expansion and Soweto can apparently only expand upwards, i.e. by building two and three storey buildings to cater for population growth. This, in turn, will lead to high load densities which could be difficult to meet in the designed LV reticulation system, particularly because the majority of service cables are abnormally long and are laid through private property.

Mr. C. Adams: Port Elizabeth

I only have two questions which I would like to ask the speaker.

Firstly, with regard to the increased volt drop of 8% I would like to know how this is divided between the high voltage network, the transformer, and the low voltage network.

Secondly, can Mr. Seymore tell us what is going to happen to the 6,6 kV network. Will this be scrapped, or integrated into the new network?

Mnr E. de C. Pretorius: Potchefstroom

Ek vind die ontwerplas van 40A per wooneenheid (in sommige gevalle 60A) besonder hoog. In Potchefstroom se Kleurlingwoonbuurt (Potchefstroom het 'n stroombrekertarief) is die algemeenste stroombrekerkeuse, ek skat in 80% van alle gevalle, 30A. Slegs enkeles se keuse is die volgende hoër grootte, 45A en nie 'n enkele verbruiker het die volgende hoër grootte, 60A gekies nie.

Wat gebeur as die KWH-seinkabels beskadig word? Ek ys om te dink wat gaan gebeur as verbruikers agterkom dat hulle chaos kan veroorsaak deur die seinkabels doelbewus uit aksie te stel.

Ek wil nie 'n groot debat ontketen nie maar kan Mnr. Seymore ons miskien ietsie vertel van die tarief vir huishoudelike verbruikers.

Ek sal dit waardeer as 'n gelinieërde grafiek by figuur 2 beskikbaar gestel kan word of is dit, soos die vrouens dit stel, nie te resepte nie?

Iewers in die referaat word gemeld dat 'n lisensie van die Elektrisiteitsbeheerraad verkry moes word, sover my kennis strek, word lisensies net aan opwekkingsondernemings uitgereik.

Die geraamde koste van R204 miljoen: is eskalasie in ag geneem? In die afgelope paar jaar het eskalasie skoon hand uitgeruk. My Raad het so pas 'n tender aanvaar vir 20 MVA-transformators. Die tenderprys is 160% hoër as 'n tender vir identiese transformators wat slegs ietwat meer as 4 jaar gelede aanvaar is.

Mnr. L.D.M. de Wet: Geaffilieerde

Ek wil Mnr. Seymore gelukwens met 'n uitstekende referaat. Ek is seker hierdie referaat sal deur baie elektrotegniese ingenieurs in die toekoms as 'n handleiding gebruik word vir die ontwerp van elektriese verspreidingstelsels.

Daar is 'n paar interessante aspekte in die referaat waaroor ek graag meer inligting sal waardeer en ek sal bly wees as Mnr. Seymore dit sal kan verskaf.

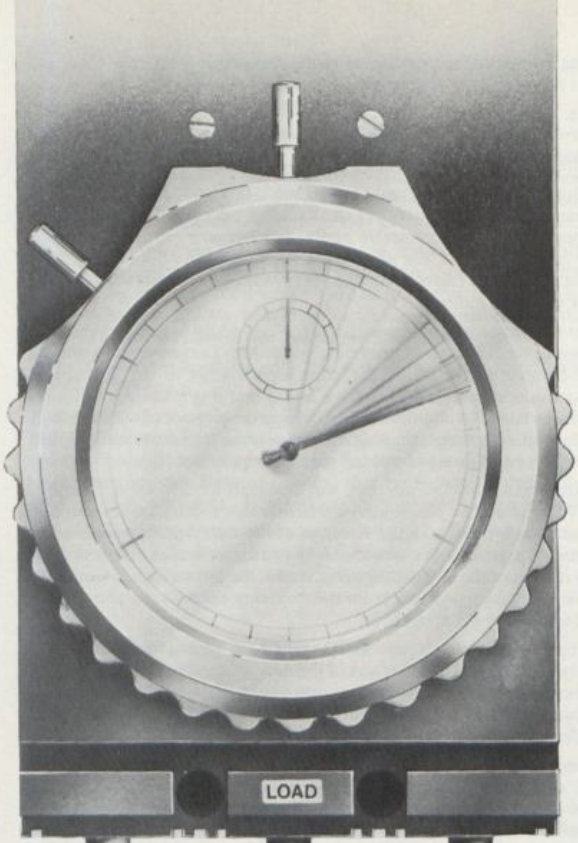
1. In die verslag is gemeld dat 'n sparingsval van 8% gebruik is met die doel om kapitaalkoste te bespaar. Dit veroorsaak egter dat die verliese in die stelsel ook 8% is en met die hoë energiekoste wonder 'n mens of dit nie oor die langtermyn beter sou wees om liewer maar 'n hoër kapitaalkoste te gehad het nie.
2. Finally, Mr. President, I would like to know what tower footing impedances have been adopted for the double circuit 132 kV line and what failure rate from lightning is expected.

Mnr. G. Stewart: Geaffilieerde

Ek het twee vrae vir algemene inligting:

In verband met die 11 kV gevulkaniseerde poliëteleen kabel. Die aardfoutstroomaanslag is beperk by 300 amp. Ek neem aan dat die staaldraad pantsering van hierdie kabels is net vir meganiese beskerming teen beskadiging en dra nie deel van die aardfoutstroom nie.

TRIPS ON TIME...



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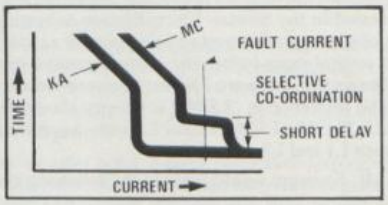

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Fuchs Seltronics

With regard to thermal resistivity of the soil in Soweto – having seen areas of clay – I wonder if Mr. Seymore could let us know what the average and the maximum thermal resistivities were.

Regarding payment for electricity, was not installation of prepayment meters in the houses considered, as this had been contemplated in the early days?

Mnr. P.J. Botes: Roodepoort

Ek wil dan ook graag langs hierdie weg vir Mnr. Seymore gelukwens met die voordra van 'n puik referaat. Ek wil graag net 'n paar vrae vra, ek het gereken iemand anders sou dit vra. In die referaat word genoem dat die N.D.M.A. van tussen 3 kVA en 5 kVA gebruik is in die beplanning en dat op die minisub vlak 'n syfer van 3 kVA gebruik word.

Roodepoort voorsien nog Dobsonville waar 'n N.D.M.A. van ± 1 kVA gerealiseer was, ek sou dus reken dat hierdie syfers heelwat hoog is. Mnr. van Ahlften het my attent gemaak dat in die norme vir elektrisiteit verspreiding in blanke residensiële dorpsgebiede 'n D.M.A. van 2,5 to 4.00 kVA vir die middelinkomstegroep gebruik. Ek sal graag Mnr. Seymore se kommentaar hieroor wil hoor.

Ten slotte, aangesien ek nog elektrisiteit aan Dobsonville verskaf sal ek graag wil weet wanneer ek van die las verlos gaan word.

Mr. D.H. Fraser: President

What is the average number of circuit breakers controlling the 11 kV rings at each main substation and is each ring supplied exclusively from one main substation or do the rings interconnect with adjacent main substations? The cable used for the rings has a copper conductored, paper insulated and screened construction. Bearing in mind the manner in which the rings are operated and the nature of a typical domestic load curve, is the slightly increased rating of a screened cable of significant advantage when weighed against the extra jointing expertise required for screened cable and the usually higher cost of screened construction over belted cable? What are the reasons for using copper conductored cable in preference to aluminium?

Mr. W.J. Seymore: Affiliate

1. Mr. Barnard stated that the Energy Management System appears to be a sophisticated scheme and that consumers can be cut off with incorrect signals.

   During my presentation, I said that the Councils of Greater Soweto have yet to decide on the implementation of proposals on an Energy Management System and that the presentation was, therefore, not in the context of the Soweto Project. Information was only given on the prototype design. If somebody, however, should decide to have such a system installed, one can expect teething trouble during the early stages of operation, but we do not see any serious problems with the pilot cables. There is nothing new in this concept, although the application may appear to be new. Remote Control and Supervisory Systems operate throughout the country and similar principles are used by the Post Office for modern telephone systems.

   The system is designed to use standard or normal kWh meters and, if a supply in the area is lost or the connection from the control centre is lost, the energy readings can still be updated by sending somebody out to the cubicles to take the meter readings and updating the information in the computer when the supply or connection is rectified.

2. Mr. Palser said that the cost of the Soweto Project namely R1 500 per consumer appears to be high compared to that of Mitchells Plain of R1 200 per consumer.

   One must make sure what is allowed for if the cost per stand is given. It quite often happens that a cost per stand for reticulation or transmission systems is given but it is not always spelt out what is included in such cost: A cost per stand can be for reticulation only including or excluding service connections or it can be all inclusive including external power supply and transmission systems. The cost of the Soweto Reticulation System is approximately R1 200 per stand including service connections to houses but excluding main 132 kV and 11 kV power supplies.

   The total cost of the Distribution System is approximately R1 500 per stand including 132 kV transmission systems and substations, main 11 kV substations, buildings, vehicles and equipment for the Electricity Department. The costs can be subdivided as follows:

1. Reticulation System including service connections to houses:	63%
2. 132 kV transmission lines and 132 kV substations:	10%
3. Three main 11 kV substations:	1,5%
4. Remote Control and Supervisory System	1,5%
5. Buildings for the Electricity Department as well as vehicles for operation of the system	2,5%
6. Internal house wiring	21,5%
TOTAL	100%

3. I am not in a position to give any figures on proposed electricity tariffs and maintenance costs. The electricity tariffs are prepared by the Councils. Mr. van der Spuy is the Director (Electrical) of the West Rand Administration Board and the Head of the Electricity Department of Greater Soweto and he may be in a position to give further information.

4. The question was asked why two types of 11 kV cables were selected.
   Mr. Barnard has mentioned that the existing system is supplied at 6,6 kV. Fortunately 11 kV cables were installed in the Soweto area and it was decided to utilise the existing cables as much as possible on the ring systems. New ring system cables are to be connected to the existing cables and it is for this reason that it was decided to use the same type of cables, namely paper insulated, copper cored screened cables. Alternative prices were asked in the tender documents for various types of cable to be installed between the main 132/11 kV and main 11 kV substations as feeder cables. With the tender prices available, it was decided that cross linked polyethylene copper cored armoured cables were the most economical to use as main feeder cables.

5. In antwoord op mnr Theron se vraag kan ek bevestigend antwoord dat oorstroom en aardfoute relês gebruik word vir die beveiliging van ringkabels. Die primêre beveiliging van voerder kabels tussen 132/11 kV en hoof 11 kV substasies is Solkor relês met oorstroom en aardfout as reserwe beveiliging.

6. Die sekerings wat in die minisubs geïnstalleer word, is nie vir oorvrag beveiliging nie maar slegs vir foutstroom vir beveiliging van die transformator. Die individuele kabels op die laagspanning kant word met stroombrekers beveilig teen oorvrag.

7. Die vraag was gevra hoe uitvoerbaar die installering van aansluitkabels op erfgrense is om huise aan die afterkant te voer. Hierdie metode was vir koste oorwegings en daar was lang samesprekings tydens die ontwerpstadium met Johannesburg Stadsraad se Elektrisiteitsdepartement gevoer, wie op daardie stadium die verantwoordelike persoon vir die stelsel was. Dit was op hierdie stadium besluit om laagspanningkabels op erfgrense te lê so na as moontlik aan die grense. Hierdie kables word op alternatiewe grense gelê sodat daar wel geleentheid is vir die uitbreiding van huise tot op die grense aan die kant waar kabels nie gelê word nie. Hierdie metode van verbruikersaansluiting skep dan nie so 'n groot probleem nie.

8. Alhoewel daar lasbeperkers by individuele huise geïnstalleer word, kan daar nogtans 'n groot aantal warmwatersilinders aangeskakel wees wanneer spitsvragbeheer toegepas moet word. Dit is moeilik om vooruit te bepaal hoeveel warmwatersilinders op 'n slag nog aan kan wees op so 'n stadium maar dit was beraam dat indien slegs 6% van die warmwatersilinders op so 'n stadium aan is wat met 'n outomatiese vragbeheerstelsel afgeskakel kan word, dan is dit betalend vir die installasie van so 'n vragbeheerstelsel. Met die hoeveelheid kabels wat bestel is vir aansluitings, is die addisionele koste van 'n vierde aar vir die aansluitingskabels minimaal.

9. Mr. Adams asked how the voltage drop figure of 8% is built up.
   I have not got the exact figures with me. From memory, the voltage regulation on the low voltage system is 5,8% and on the high voltage system 2,2%.

10. Mr. Raynal mentioned that there is an error on page 25, Section 7.3.1 in that "low earth resistivity" should read "high earth resistivity". This is correct. The resistivity is high.

11. The question was asked why wave form CNE LV cables are not used on the system.
    Alternative prices were asked in the tenders for LV cables, similarly as for the 11 kV cross linked polyethylene cables as mentioned earlier. It was decided to use the most economical cable, based on the tender prices, namely the CNE LV cable described in the paper.

12. The question was asked why innovated wiring was not considered.
    I mentioned in my presentation that we asked for various alternative prices for the wiring of houses and it appeared that the conventional conduit on surface was the most economical system to use.

13. The question was asked why electrical services are installed first which is the wrong way round, and that roads and civil services should be installed first.
    The Councils of Greater Soweto decided that housing and electrification were the most urgently required. The Councils are, however, presently busy with the installation of civil services and roads under the control of the TPA. There is continuous co-operation between the different parties, namely the Contractors for the electrical installations and the Contractors for the civil installations. The telecommunication installations were completed a few years ago by the Post Office.

14. Mnr. Pretorius het gemeld dat die ontwerplas van 40 Ampère vir hom hoog lyk.
Die 40 Ampère aansluitings is nie te hoog vir die normale huise nie aangesien daar voorsiening gemaak moet word vir stowe en warmwatersilinders. Dit laat dan ook toe vir interne groei van die verbruik van verbruikers.

15. Die gelyktydigheidsfaktore wat gebruik is, is inligting wat ons met verloop van tyd versamel het en dit gee redelike akkurate resultate. Die standaarde waarna verwys is, is tot op datum nog nie beskikbaar nie.

16. Dit was aanvanklik nodig om aansoek te doen vir 'n lisensie vanaf die Elektrisiteitsbeheerraad totdat die Wet gewysig was wat afsonderlike lisensies vir Gemeenskapsrade nie meer genoodsaak het nie. By die verkryging van munisipale status is die verkryging van 'n lisensie nie meer nodig nie.

17. Die totale beraamde koste van R204 miljoen laat wel toe vir toekomstige prys eskalasies.

18. Mnr. de Wet het gemeld dat met 'n spanningsregulasie van 8% die verliese ook met 8% styg en of dit in aanmerking geneem was.
Dit is korrek dat die verliese sal styg met 'n styging in spanningsval maar nie tot dieselfde waarde nie aangesien verliese nie direk eweredig aan die spanningsval is nie. Tydens die ontwerpstadium was dit ekonomies geag om met 'n hoër spanningsval syfer te werk want die aanvanklike installeringskoste het verhoog alhoewel dit 'n geringe styging in lopende kostes sou meebring.

19. The expected lightning failure rate in the area is 0,5/km/year.

20. Mr. Davies asked whether the graph of Figure 2 is drawn on a log-log scale.
This is correct. Both the abscissa and the ordinate are on the log scales and the number of consumers is applied to both curves. The top curve is for the calculation of 11 kV rings and main substation capacities and the lower curve for the calculation of LV cables and minisub capacities.

21. The voltage drops are calculated up to the terminals of the houses.

22. The question was asked why 300 ampere earth fault current was selected. Mr. Stewart has already answered this question in stating that cross linked polyethylene cables can only withstand a 300 ampere earth fault current. The value 300A is also in line with Escom's latest policy for the limiting of earth fault currents on LV systems of consumers. In fact, to save on design costs, the standard Escom NEC's with earthing resistors were ordered for the Soweto Project.

23. Thermal resistivity readings asked for by Mr. Stewart, were only taken in the section where the 132 kV cables were to be installed. It was not warranted to take thermal resistivity measurements for the rest of Soweto. The thermal resistivity figures are as follows:

(a) Average – 1,3° cm/W
(b) Maximum – 1,35° cm/W

24. Mr. Fraser, the President, asked what the average number of circuit breakers per main substation is.
On average a main 11 kV substation is provided with four incoming and eight outgoing circuit breakers plus a bus coupler. That gives a total of thirteen circuit breakers. Ring systems are exclusively taken from specific main substations and different main substations are not interconnected.

25. It was decided to use copper cored cables because the majority of these cables are to be connected to existing copper cored cables.

26. Ek vra verskoning aan mnr. Botes dat ek nie in my referaat gemeld het dat Roodepoort Munisipaliteit krag voorsien aan Dobsonville nie. Dit is wel korrek dat Roodepoort aan hierdie gebied krag voorsien. Dit is egter nie moontlik om 'n spesifieke datum op hierdie stadium te gee tot wanneer Roodepoort moet voortgaan met kragvoorsiening aan Dobsonville nie. Die Roodepoort toevoer sal afgeskakel word sodra die retikulasie en die hoofvoerderkabels na Dobsonville voltooi is.

27. Mnr. Botes het gemeld dat die 3 na 5 kVA vir hom te hoog lyk aangesien die huidige vrag van Dobsonville slegs 1 kVA is.
Dit is wel korrek dat die gemiddelde gediversifiseerde vrag van Dobsonville tans 1 kVA is. Die retikulasie stelsel vir Dobsonville is ontwerp vir 3 kVA om voorsiening te maak vir toekomstige stowe en warmwatersilinders. Ons beskou die 3 kVA nie te hoog nie aangesien daar reeds gebiede in Groter Soweto is waar die gediversifeerde vrag in die omgewing van 2 na 2,5 kVA is. Die 4 kVA gediversifiseerde vrag word slegs gebruik in gebiede waar daar baie groot huise is.

28. A number of similar questions were asked by various persons and I trust that I have answered all the questions.

R.J. WEDDERBURN

Born and educated in Durban. Academic education at Durban High School up to standard 9. Technical education at Natal Technical College continuing to National Engineering Diploma with additional subjects required by the South African Institute for Electrical Engineers. Associate membership gained July 1967.

Join the Electricity Supply Commission, Natal Southern Undertaking test department in 1963 where he was involved with power station and substation protection for 14 years. Trasferred to Escom head office at Megawatt Park in 1978 where he was responsible for the design of protection schemes for the Natal region for the next three years. Joined GEC Measurements (Pty) Ltd in January 1981 as Chief Engineer.

Part time lecturer for 6 years in the Electrical Department of the Natal Technical College.

Represented Natal as a member of the Natal Cycling Union track team on five occasions and gained his Natal Colours on two occasions.

Is an active member of the Mountain Club of South Africa, Natal and Transvaal sections, and is keen on rock climbing.

Mr Ron Wedderburn

PROTECTION OF MUNICIPAL ELECTRICITY DISTRIBUTION NETWORKS

by R.J. Wedderburn

1. SUMMARY

Municipal Substation protection tends to be standard throughout the Republic. This paper will describe the usual protection relays that are used, the reason for this choice and the advantages and disadvantages. The paper goes on to describe the latest trend towards solid state relays and how this could affect both switchgear and substation design.

2. INTRODUCTION

Almost every municipality in the Republic which controls its own power supply distribution network relies on the Electricity Supply Commission – ESCOM – to supply its power requirements, as very few have their own generating capability. Municipal incoming supply voltages from the Escom grid range from 275 kV to 3.3 kV, the former being very recent and the latter being rapidly phased out in favour of higher voltages. The greatest majority, however, are fed at 11 kV, with ESCOM providing a voltage controlled supply to the municipality in parallel with its own 11 kV reticulation system via auto tap change step-down transformers.

The protection of these distribution supplies is therefore a joint responsibility, with Escom providing the protection at the point of supply and the municipality taking over the responsibility for protecting the distribution network from that point onwards.

3. PROTECTION

3.1 The Functions of Protection

The main functions of protection in a distribution network are to safeguard the continuity of supply and to prevent or minimise damage to plant connected to the network. There are critical areas in every distribution network and, in the event of failure of a component section of the distribution network, either during overload or other unnatural service conditions or acts of God, it is the function of the protection to reduce the effects of the failure. This is achieved by removing or disconnecting the faulty component or section from the network as quickly and selectively as possible, thereby ensuring a minimum interruption of supply and possibly minimising damage to the plant involved in the faulure.

If a fault were to occur on a distribution network, say through a tree falling onto the overhead line conductors, the protection associated with the faulted section of the network should sense the fault and disconnect the faulted section. This should occur before the protection associated with, say the Escom supply, is allowed to operate and disconnect the whole distribution network.

Similarly if an underground cable is damaged through being spiked by a pick during road works, the protection associated with the cable should sense the fault and disconnect the supply to the cable before the whole network is disconnected.

From these two examples it will be seen that the main function of the protection is to ensure the continuity of supply to the system as a whole, by the provision of protection for every section of the network. In addition the protection will normally operate quickly enough to limit the amount of damage to the faulted section of the network and minimise possible danger to personnel or the general public.

Thus protective relaying can be summed up as a feature within the network which will minimise interruptions to service and damage to plant when electrical failures occur.

3.2 The Effects of System Faults

The consequences of distribution network failures are:–

(a) Interruption of supply
(b) Damage to plant
(c) Danger to personnel and the general public

The costs incurred through interruptions to supply will naturally vary tremendously, but a general rule of thumb is that the value of a kilowatt-hour lost is approximately 40 to 60 times the cost of generating that kilowatt-hour. In addition to the cost there are the consequential inconveniences suffered by consumers who are paying for their supply of electricity and who expect some form of continuity of supply. The costs involved in point (b) will also vary tremendously. However, these could be equalled to the cost of providing adequate protection. The cost of protection is usually small im comparison to the actual capital invested in the network and to maximize the return on this invested capital the network must be loaded as much as possible. Therefore it is necessary to consider just how much is required to be spent on protection to keep the cost of repairing damage to plant within limits.

Regarding point (c), who can put an accurate value on human life? Once a life is lost who on this earth can restore that life? Therefore municipalities must be responsible for providing adequate protection for their network to limit the danger to their personnel and the general public to a minimum.

3.3 The Requirements of Protection

There are five basic requirements which determine the quality of protection equipment. They are reliability, selectivity, stability, speed and sensitivity. The protection must have these qualities if it is going to perform its function correctly. When a fault occurs on the distribution network it has to:

(a) detect the fault correctly
(b) sectionalise the faulted portion
(c) isolate it

If the fault is transient and the system is equipped with automatic reclosing facilities, it must restore the supply to the circuit or circuits which were isolated.

3.3.1 *Reliability*

Reliability is a quality which is closely tied to design. If the protection has been designed to operate under all fault conditions which may occur on the distribution network then its reliability will be high. It is also a function of serviceability

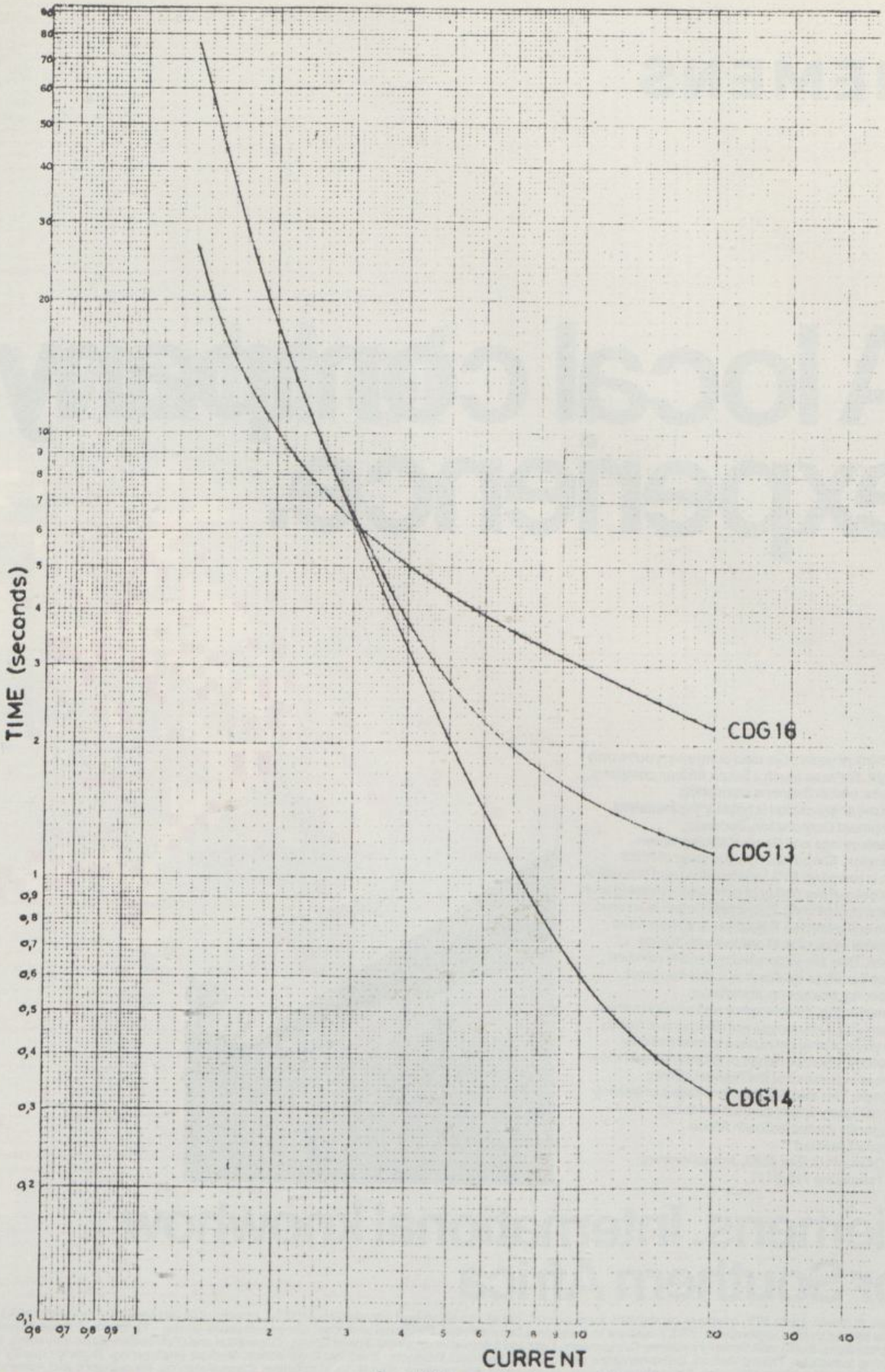

Fig. 1 Family of Curves

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during its full operational lifetime. Deterioration in service may take place and this could in time interfere with its correct functioning. For this reason it is normal practice to provide duplication of equipment or "redundancy" on the higher transmission voltages and also on critical sections of the network.

3.3.2 *Selectivity*

Protection is arranged in zones which should cover the distribution network completely. When a fault occurs, the protection is required to select and trip only the nearest circuit breaker to the fault. This property of selective tripping is also called discrimination. The two general methods used in municipal distribution networks are:

(a) Time graded protection systems using inverse definite minimum time (IDMT) relays, such as the CDG relay, where the equipment protecting the successive zones is arranged to operate in times which are graded. This grading is arranged so that, with the occurrence of a fault, although a number of protection points may respond, only the protection closest to the fault will complete its tripping function. The other protection points will not complete their operation but will reset after the fault has been isolated.

(b) unit protection systems using linked relays such as in the Translay or Solkor pilot wire systems, where the protection is usually achieved by means of a comparison of the input and output quantities at the boundaries of the protection zone. This unit protection can be applied throughout the network and, since it is restricted to particular zones, does not need to be time graded and can be relatively fast in its operation.

3.3.3 *Stability*

This is a particular quality required by unit protection and refers to the ability of relays to remain inert to all load conditions and faults outside or external to the protected zone.

3.3.4 *Speed*

Speed is a prime requirement of the functions of protection in a distribution network. For the few municipalities which generate their own power and which are linked to the Escom grid, this quality is of major importance, as loading on the network produces phase displacements between the voltages at different points. This factor increases the probability of synchronism being lost when the network is disturbed by a fault. The shorter the time a fault is allowed to remain on the network the greater can be the loading of the network.

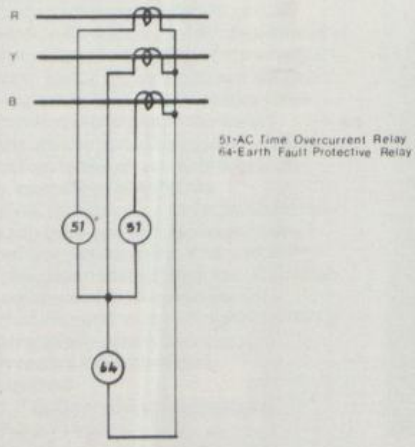


Fig2 Typical Feeder Protection System

In addition to maintaining stability, damage to plant and equipment should be limited. Fault currents, if allowed to remain for any length of time, can cause overhead conductors to burn through and cause transformer and machine core laminations to weld together. However, the cost of protection must be equated to the cost of the equipment being protected. Therefore, for the normal distribution network where the requirements for fast operation are not very severe, a time graded system is adequate but, for generating plant and EHV systems, the highest possible speed is usually a prerequisite.

3.3.5 *Sensitivity*

Sensitivity is often equated to the minimum operating current or pick up current of the protection relay and the protection is said to be sensitive if the primary operating current is low.

When referred to a particular relay, it is not only the setting which is being referred to, but also the actual volt-ampere or VA of the relay. In some instances relay settings, in an effort to make them more sensitive by setting them low, actually impose a very high burden on the current transformer and, in effect, make the system less sensitive.

4. THE APPLICATION OF PROTECTION

4.1 Fuses

With the inception of electric power supply, protection as such did not exist, and it was possible for the power station attendant, in an emergency, to open a switch manually and even swat out the arc with a duster.

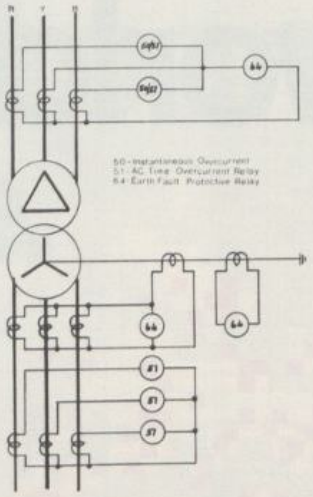


Fig 3 Typical Medium Voltage Transformer Protection System

The earliest form of protection was the fuse and, although it has very severe limitations, it is still very widely used today on distribution networks throughout the world. The fuse, as used today, is a vast improvement on the earlier form and, with the application of high rupturing capacity (HRC) fuses which limit energy let-through under fault conditions, some consideration should be given to the type of duty the fuse will be performing. Fuses suffer from the disadvantage of having to be replaced before power can be restored.

On low voltage (380 volt) systems an approximate value of the fuse to be used can be obtained from the following expression:–

$$\text{Short circuit MVA} = \frac{\text{Transformer kVA x 100}}{\text{1000 x percentage impedance}}$$

However, high voltage systems have factors which should be considered when selecting fuses.

4.1.1 *Motor Protection*

If motors are connected to the network, the starting current taken by the motor should be considered. The starting current will depend upon whether the motor is a wound or squirrel cage rotor, and also the method of starting i.e. direct-on-line or not. The worst case is a direct-on-line squirrel cage motor where the starting current is of the magnitude of seven to eight times full load current and this current inrush can last for anything up to 10 seconds, as the normal motor starting characteristic is almost constant current/time.

4.1.2 *Transformer Protection*

For transformers, current inrush on switch-on, depending on the point on the wave, can speak at approximately 20 times normal full load current. This causes a problem with fuse selection and also instantaneous protection, but the latter will be discussed separately.

Many South African municipalities use oil-immersed fuse switch units on 6.6 kV or 11 kV supplies and it is practice for the manufacturers of these units to recommend tables of fuse ratings. Table 1 is representative of these tables and it will be seen that the ratings recommended exceed the normal full load current of the transformer.

Table 1.

Minimum fuse ratings recommended for Distribution Transformer Circuits				
Transformer 3 - Phase kVA Rating	11 kV		6.6 kV	
	A Fuse Rating Amp	B Fuse Rating Amp	C Fuse Rating Amp	D Fuse Rating Amp
200	25	25	36	32
300	32	32	45	40
315	32	32	50	45
400	40	36	63	50
500	45	45	80	80
600	63	50	90/100	80
630	63	63	90/100	80
750	80	63	140	100
800	80	63	140	100
1000	90	80	140	140

4.2 Inverse Definite Minimum Time Relay Protection

The inverse time-current protection required to give selectivity was a development of the induction disc watt-hour meter. The substitution of contacts for the indicating register gave early protection engineers a relay which could allow grading on a time-current basis. This development occurred in the early 1920's and very few changes have been made since then, although in looks it has a vastly improved form.

This protection was, at its inception, for overcurrent protection only, and it was only when C.L. Fortescue, investigating phase balancers for rotating machines, observed that certain symmetrical relations between phase currents and also between voltages recurred frequently. This led to his investigation of the general problem of unbalance, and ultimately to his discovery of the fundamental principles of the Method of Symmetrical components which he published in 1918.

This allowed for a simple method of calculating the zero sequence component of the unbalanced circuit which, in turn, allowed the protection engineer to use the inverse timecurrent relay to protect the system for single phase to earth faults, as he could now calculate the earth fault current and set the relay accordingly.

The standard inverse definite minimum time overcurrent relay has the characteristic that the time of operation is inversely proportional to the fault current level, the actual characteristics being a function of both "time" and "current" settings. BS142:1966 lays down the accuracy for this type of relay. Limits of accuracy were considered by various national and international committees. BS142:1953 incorporated the work of these committees and laid down the parameters for relay accuracy. This has now been superseded by BS142: 1966.

Using the tolerances allowed for in this specification, the minimum permissible grading margin between relays at each section breaker is approximately 0,5s, where the breaker fault current interrupting time has been taken as 0,1s. With faster modern circuit breakers the minimum grading margin could be reduced to say 0,45s or 0,35s.

4.2.1 *Time Current Characteristics*

There are four basic relays, each one having its own time current characteristic. They are:–

(a) Standard inverse definite minimum time overcurrent
(b) Very inverse definite minimum time overcurrent
(c) Extremely inverse definite minimum time overcurrent
(d) Definite time overcurrent.

These are shown graphically in figure 1. The first three basic relays are very often combined with a high set instantaneous overcurrent relay. This allows for a reduction in the tripping time at high fault levels and improves the overall grading of the network, as the discrimination between relays can be improved.

4.2.1.1 *Standard Inverse*

This is the relay most commonly used on municipal distribution networks, either with or without the high set instantaneous overcurrent element. It is often called the 10-3 relay because its basic characteristic curve at the maximum time multiplier setting of 1.0 allows for a tripping time of 3 seconds when a fault current of 10 times the primary current setting of the relay is applied to the relay. For example if a relay is connected to a 600/5 Amp CT and has a plug setting of 6.25 on the plug bridge and a time multiplier setting of 1.0 we would get the following expression:–

$$\text{Relay primary current setting} = \frac{600 \times 6.25}{5} = 750\text{A}$$

$$\text{Fault current} = 10 \times \text{relay primary current setting}$$
$$= 10 \times 750 = 7500\text{A}$$

If this current is plotted on figure 1 to 10 on the horizontal "current" axis, which is equal to 10 times plug setting, a time of 2 seconds will be read off the vertical "time" axis.

4.2.1.2 *Very Inverse*

This type of characteristic is normally used to obtain greater time selectivity when the limiting overall time factor is very low. The steeper inverse curve gives longer time grading intervals. Its operating time is approximately doubled for a reduction in setting from 7 to 4 times the relay current setting. This permits the same time multiplier setting for several relays in series.

4.2.1.3 *Extremely Inverse*

This characteristic lends itself to co-ordinating with fuses, as the operating time is inversely proportional to the square of the current i.e. $I^2t = K$. This relay is widely used for protecting plant against overheating is usually an I^2t function. Examples of the plant which should be protected by this type of relay are:–

(a) Power transformers
(b) Earthing transformers or compensators
(c) Cable networks

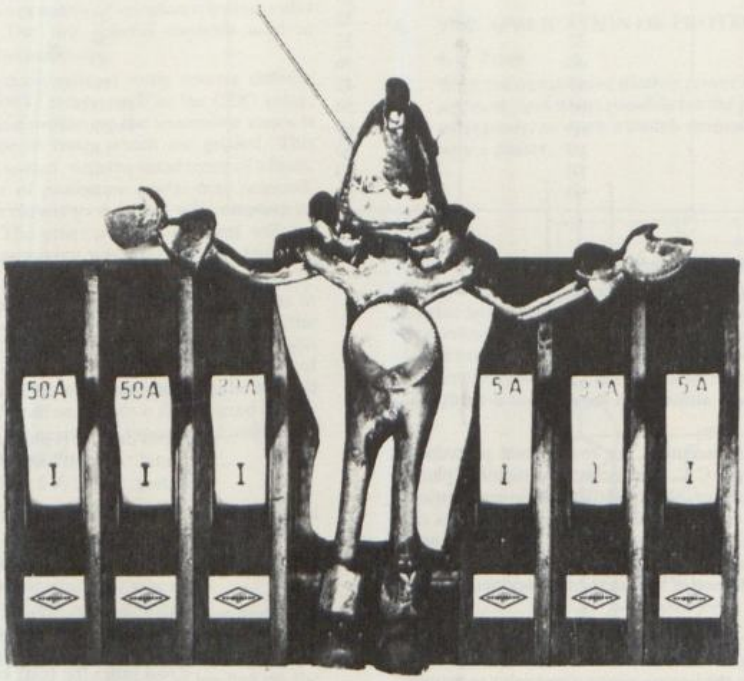
As mentioned above, this characteristic can be used for accurate discrimination with fuses which, with the standard inverse relay, is virtually impossible.

4.2.1.4 *Definite Time*

The transistorised definite time relay provides for the co-ordination of several relays in series, where the system fault current varies very widely due to changes in source impedance and there is relatively no change in time with the variation of fault current.

4.2.2 *Feeder Protection*

This normally takes the form of two overcurrent and one earth fault relay. The reasoning behind this configuration is that, for a phase-to-phase fault, either both overcurrent relays will sense the fault or at least one will do so, depending upon which two phases are faulted and also with phases are coupled to the overcurrent relays. A typical protection system is shown in figure 2. It will be seen from this that any single phase to earth fault will be sensed by the earth fault relay coupled between the CT star point and the overcurrent relay star point. It could be argued that for at least two types of phase to earth fault i.e. faults involving those phases which are coupled to overcurrent relays, the overcurrent relay would sense the fault. This is true, but the earth fault relay can be set very much more sensitively than the overcurrent relay and, in systems where neutral earthing compensators are used together with earthing resistors, the earth fault current can be too low to be sensed by the overcurrent relays.



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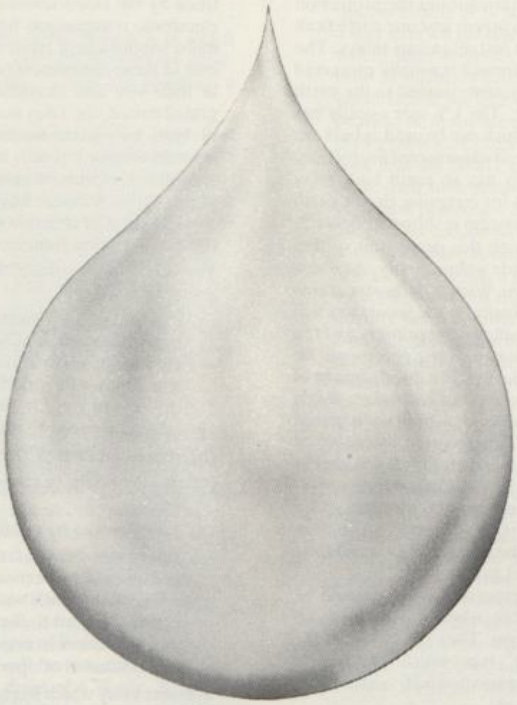

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4.2.3 *Transformer Protection*

4.2.3.1 *Medium Step down Transformers*

On the primary side of the transformer the protection usually consists of two overcurrent and one earth fault relay together with high set instantaneous relays. The secondary side of the transformer is usually protected by a restricted earth fault system coupled to the earth neutral of the star winding. The LV side usually has IDMT overcurrent relays which can be used as back-up protection for outgoing circuit overcurrent protection. The earthed neutral usually has an earth fault relay which is used as a back-up for outgoing circuit earth fault protection. A typical system is shown in figure 3.

The problems associated with this proteciton system are mainly on the primary side where, firstly, there are only two overcurrent relays. With a delta-star transformer, single phase earth faults on the secondary will appear as phase-to-phase faults on the primary and the magnitude of the current in two of the phases will be equal but have opposite polarity. The disadvantage of this system is that only one type of secondary single phase to earth fault will be sensed by both overcurrent relays on the primary side. Therefore if by nature of the fault only one primary overcurrent relay can sense the earth fault on the secondary and that primary overcurrent relay is faulty, there would be no back-up for the secondary earth fault relay. There is no built in redundancy to safeguard the transformer should the transformer LV breaker fail to trip.

Secondly, the high set overcurrent relays should be capable or remaining stable when the high inrush currents occur with switch on. They should be of the "low transient over reach" type which will not be affected by the off-set transients which occur when transformers are switched on.

4.2.3.2 *Small Step-down Transformers*

These probably only require LV overcurrent and earthfault protection plus a restricted earth fault system to protect the LV winding as the HV side is usually protected by fuses.

4.3 Differential Protection

This type of protection was first developed by Merz and Price (1905) for the protection of generators. From the original balanced current scheme came the balanced voltage scheme, where there are two relays, one on each side of the protected section. These relays were connected in series by the pilots. The elementary form has been developed into a wide range of schemes using biased relays.

4.3.1 *Cable Protection*

Cables form a high proportion of the municipal distribution network. Pilot wire protection, although limited in the field of application, is an ideal form of high speed unit protection suitable for cables and also very short transmission lines. The systems most commonly used are the Solkor and the Translay – so much so, that these names have been accepted by some as meaning different types of protection. In both these systems there are three CT's, one on each phase, at each end of the cable. The secondaries of the CT's are connected to a summation transformer. The secondaries of both summation transformers are connected to each other by means of a single pair of pilot wires, and the operating coils of the relays are connected across or in series with the pilots. Under through fault conditions, for a Solkor system for example, a circulating current flows around the pilot loop and the relay operating coild remain inoperative. However, during internal fault conditions with fault current fed from both ends, the currents in the pilot loop oppose each other and the currents then flow through the relay operating coils. With a single end feed situation, the relay coil at the far end is energised in parallel with the relay at the supply point end. The remote end relay will operate at approximately 2.5 times setting current therefore, if a fault current on a single end feed is more than 2.5 times the fault setting current the breakers at both ends of the cable will be tripped.

4.3.2 *Transformer Differential*

Large transformers require high speed unit protection. This usually takes the form of an overall differential protection system where the current flowing into the transformer on the primary side is compared with the current flowing out of the transformer secondary side. The ratios of the CT's and their method of connection must be matched with the transformer windings so that the protection will not operate for through faults.

5. SOLID STATE RELAYS

The protection requirements of power systems have largely been fulfilled by the electromechanical relay. The transistor and its associated electronic components have to a large extent only been used on the more sophisticated types of protection relay. However, as the relative cost of these components decreases with the improvements being made in their size and manufacture and with the introduction of the integrated circuit, the relay manufacturer is turning away from the traditional type of electro-mechanical relay to the solid state relay. The microprocessor has also made an impact with the introduction of protection relays with memories, the only disadvantage with this new type of protection is that to keep the circuits active they have to be connected to some form of constant supply and this creates a slightly greater drain on the substation battery.

The advantages gained, or to be gained from the use of this type of protection are:–

(a) because of amplification of the measured signals, the source need only provide low power. This means that CT and VT burdens are very much lower and their size could be reduced. This advantage is something with switchboard manufacturer has been waiting for, as the size of the CT chamber of most 11 kV switchboards is fairly large compared to the actual circuit breaker size.

(b) the accuracy is greater, therefore selectivity will be improved.

(c) the flexibility of circuitry allows for new and improved characteristics.

(d) relays would be unaffected by the number of operations.

(e) relays can be housed in a rack type configuration which allows grouping of protection systems. This cuts down the necessary interconnection which was a feature of the traditional type of relay. It could also lead to the grouping of all the protection systems within the substation in one set of panels, the disadvantage of this being the confusion of operators.

The one relay which has not been replaced to any great extent by a solid state version is the IDMT overcurrent relay. However, with the introduction of the micro-processor, which can be accurately programmed to conform with the BS142:1966 IDMT curves, this barrier has been removed and there are relays either on the market or about to be launched, which will perform identically to the inverse current time relay.

In addition, with the state of the art as it is today, the relay can be built to provide the functions either two or three IDMT overcurrent relays in one module. Furthermore the characteristic of the IDMT relay can be changed, by means of a switch, from a standard inverse to either a very or an extremely inverse characteristic. This allows for far greater flexibility when grading a system. One of the major problems encountered with this new concept was the need to provide the relay with "overshoot" and "reset". This is necessary if the new relay is to be used in a system already equipped with the traditional IDMT relay.

The modular type of relay system can include autoreclose, unit protection, IDMT and instantaneous overcurrent and earth fault protection, breaker tripping, alarms, intertripping, transformer differential protection, and restricted earth fault protection.

6. CONCLUSION

Modern municipal distribution networks are going to be called upon, if they have not already been, to provide protection which can cope with network situations which were not anticipated when the network was designed. Modern technology is providing a new concept of "plug in" protection which was not dreamed of some years ago and which can cope with these requirements. The characteristics of the relay can be altered, very simply, to meet these grading situations. The municipal engineer now has a new tool which he can use to make his task of system grading a lot easier.

ACKNOWLEDGEMENTS

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DISCUSSIONS / BESPREKINGS

Mr. E.G. Davies: Pietermaritzburg

I would like to compliment Mr. Wedderburn on the lucid way in which he has given a summary of a very wide topic. His explanations are good, to the point, and are a very good general guide. There are, however, a number of points I would like to discuss:

1. In his introduction, Mr. Wedderburn makes the point that protection of distribution supplies is frequently a joint responsibility, with Escom providing the protection at the point of supply and the municipality taking over the responsibility for protecting the distribution network from that point onwards. In this context it must be borne in mind that there must be full co-operation between the two to ensure that adequate time exists on the municipal network so that discrimination over a reasonable number of circuit-breakers inside the municipal system can be attained. This of course must be carefully considered in terms of the fault level and the maximum duration that any item of plant can carry through fault current without exceeding its thermal limitations.

2. **Solid State Relays**

   I have read Mr. Wedderburn's comments in this regard with very much interest and would note that we have in this municipality used solid state relays on our newest major substation. This has posed on serious difficulties, since it is accepted that the standing current drain on the battery charger at a major substtion is always made up of such items as semaphores, indicating lamps, etc. so that the additional burden imposed by the electronic relays has been quite negligible. However, the issue changes substantially when one looks at solid state relays for the numerous small substations that are dotted throughout a municipal area, which typically have 30 Volt D.C. tripping and between 3 and 10 circuit-breakers installed. For a fairly typical installation with 6 circuit-breakers it will be seen that a standing load of 1 Watt per relay creates a total drain of 6 Watts. While in power terms this is extremely small, this 6 Watts represents a current of approximately 0,2 Amps which is rather greater than the normal standing drain on most switch tripping units available today. I would note that the battery charging arrangements on most switch tripping units are extremely simple and a call could therefore be made for improved switch tripping units capable of providing reasonable standing drain supply for the solid state relays. The unfortunate effect of course is to push up the cost of a switch tripping unit, but I do not think this will have any major impact when the current cost of circuit-breakers in a substation is considered.

   Mr. Wedderburn comments that, because C.T. chambers could be reduced, the cost of switch boards would be reduced. On manufacturer stated that, in altering the C.T. rating from 15 VA to 2,5 VA, he would expect a saving of approximately R45 on a switchboard costing approximately R7 000. This of course is utilizing the same size C.T. chamber. I do not envisage that any switchgear manufacturer will start utilizing smaller C.T. chambers until all his customers are prepared to accept the small C.T.'s which can now be brought into use as a result of the use of electronic relays.

   Since some users are very conservative in their approach to electronic relays, and others prefer switchgear which requires no switch tripping units at all, it is doubtful that universal acceptable of 2,5 VA burden C.T.'s will take place for many years and I therefore do not in fact see reduction in C.T. chamber size despite the fact that some consumers may in fact specify electronic relays in the future.

   While relays of the electronic type can be mounted in rack type configurations, I doubt that, for the average municipal distribution system, this is relevant since generally circuit breakers are kept as individual panels in workshops and then sent out to site for installation. There are therefore great benefits in having the protection mounted on the switchgear as an integral part. Because of the physical size of the switchgear, the protection mounting does not impose excessive space requirements.

   The situation is totally different when one looks at major substations and high voltage equipment, where interconnection costs become a major factor.

3. **Protection of Cable Networks in High Volt Level Municipal Systems**

   While the concept of protecting cables with a combination of inverse definite minimum tipe lag relays together with pilot wire cable protection appears at first glance to be straightforward matter, in practice this is not so. The first problem is that of protecting the cable from over currents. This is traditionally undertaken by use of IDMT relays set such that the pick-up current of the relay corresponds to a small overload on the cables rating. This, in practice, for a cable of say 240 mm² cross section, would typically be set at about 500 Amps on a current transformer of say 400 Amp primary rating. On a system having a fault level of say 10 kA or greater, the C.T. can be expected to saturate. Under these conditions we anticipate an operating time of the relay of 2,2 seconds for the 10 – 3 type of relay for a time multipliers setting of 1. So, in practice, we set the time multiplier in such a way that we get discrimination between relays. However, unfortunately what happens all too frequently is that there is insufficient time to maintain discrimination throughout the system and the net result is that we lose this discrimination. The solution therefore appears to lie in the use of pilot wire protection at the same time. By applying pilot wire protection on all legs of any particular run, it will be seen that the IDMT relays now perform a back-up function and, as such, their time settings can all be identical, since, in any event, the pilot wire protection is far faster than the IDMT and will always take the correct section out. The unfortunate draw back of this approach is the fact that, as one gets further and further out into the system, one frequently has a greater fall off in cable size than in fault level, with the net result that long tripping times on small cables will frequently be in conflict with the thermal capabilities of these cables. Another problem is of course the fact that the above presupposes a cable network which runs from circuit-breaker to circuit-breaker, whereas in practice this is not the case. A typical installation would have ring-main units interspersed along the length and present pilot wire protection does not tolerate any significant load off-take along the run of the cable. This does not, in any event, co-ordinate with fuse characteristics. So, therefore, pilot wire protection cannot always be applied and one is back to the stage of using IDMT relays and not being able to get adequate discrimination.

   It is also of note at this juncture that the use of definite time over-current relays would be tantamount to the use of IDMT relays for saturated C.T. conditions. This, however, is not frequently used, firstly, because of the non-conventionality of such protection but possibly more importantly as a result of the approximate 50% extra cost of an over-current relay over the inverse definite minimum time type of relay. In principle, however, on very solid networks this could be applied were the financial side to be remedied. I would also think that the realisation of the definite time over-current relay will be far simpler and cheaper in electronic form than the present inverse definite minimum time lag type and this may cause a certain amount of re-thinking in protection of very solid networks.

   I also note that Mr. Wedderburn refers to the use of high set instantaneous over-current relays. These are of course very useful on certain high impedance items of plant, such as transformers or motors, but are not really applicable to cable networks, since they are very poor at discriminating in which section of cable the fault has occurred. From the above it would appear to me that there is a definite need for a newer type of relay to be developed using a pilot wire system such that up to the full load of the cable can be taken off the cable. I would suggest that such a form of protection should be applicable both to feeders where ring mains units are connected and to solid cable feeds and thereby permit us to utilize the full capabilities of the IDMT relay for time grading as well on such feeds where there is no circuit-breaker at the far end of the circuit to provide the stabilising current than any such pilot wire scheme requires. I believe that such a scheme would be a far more viable proposition than either of the above two and certainly financially more appropriate than the protection which at this stage is totally uneconomic, namely, distance relays. While the distance relay will certainly provide the coverage, it is totally inappropriate in terms of protection costs.

   I would envisage the ideal form of protection for the municipal network as having three fundamental elements. The first element would be a traditional IDMT relay. The second would be a differential type circuit which will sense the amount of load being taken off within the protected zone. Should this current exceed the rated current it will then bring an extremely inverse definite minimum time relay into play. This will then trip, but in such a manner as to permit co-ordination with the fuses protecting transformers on ring main units.

   Because of the crossing of characteristics, the extremely inverse characteristic cannot be utilised at all unless its operation is suppressed below 3 times the load current. This relay of course does not exist on the market at this stage. We have considered the impact of a fuse; in this case I have chosen a 90 Amp fuse being the largest type normally found on ring main units, an IDMT with an extremely inverse characteristic with operation suppressed below 3 times for load current and a traditional inverse IDMT relay. The extremely inverse relay has been set so that the pick up applies at rated current where this corresponds to the 3 times rated current point on the normal extremely inverse curve. It will be seen that adequate clearance exists between this and the 90 Amp fuse so that, in the event of a transformer fault, the 90 Amp fuse will blow before the very inverse section operates. The inverse IDMT is now used in the traditional fashion to maintain discrimination down the line as far as possible.

   Because of the fact that we have a much faster differential protection on each section of operation, it is highly likely that we will need less

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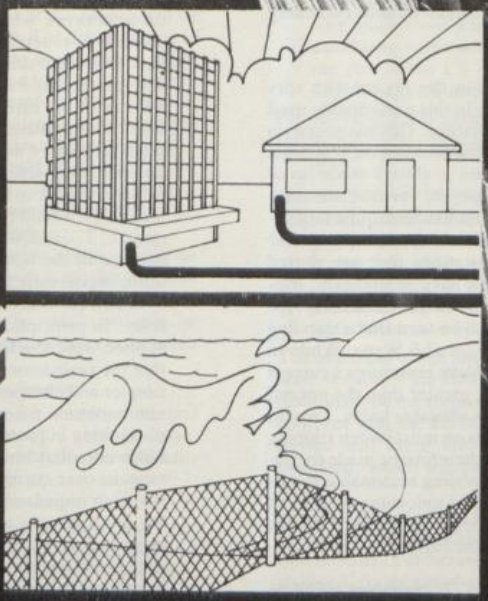

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substations utilizing circuit-breakers along the run and better use can be made of the very much cheaper ring main units that are available. I therefore believe that a far more economic situation would be realised were a relay of this type to become available. Particularly when one looks at Mr. Wedderburn's comments regarding microprocessor usage, I would feel that implementation of such a relay would not be unrealistic and should in fact be available at a price competitive with the present summated cost of an inverse definite minimum time lag relay and a differential pilot wire relay such as Solkor or Translay.

Where municipal electricity undertakings are supplied at voltages of 132 kV and upwards it is usual for Escom protection to cover faults in the consumer's main transformers and the council should ensure such protection is correctly set.

The speaker mentions the effects of the costs of system faults. As a matter of interest, the United Kingdom valuation by consumers of kW hours lost is about £1.50 at net 1980 prices. The Finnish figure converted to Pounds is £1.60.

With regard to reliability, the department that I am concerned with does from time to time, as is common with all other undertakings, have protection malfunctions. When this occurs, the distribution section invariably puts the blame on circuit-breakers which, due to inactivity for a long period of time, are sluggish. I personally consider that these maloperations are more likely to be due to badly designed current transformers which become heavily saturated during fault conditions.

It is interesting to note that about a month ago, during a major shutdown, we were able to trip-test a large number of circuit-breakers which had not been trip-tested or operated for 20 years or more. The number of switches which did not trip correctly was minimal.

Referring to Table 1, showing fuse ratings, would Mr. Wedderburn please indicate why there are two ratings for 11 kV and two ratings for 6,6 kV fuses.

Mr. N. Kirschner: Affiliate

The speaker has given the background to what has become standardised practice for distribution system protection. With the advent of static relays, there is talk of replacing conventional electromechanical relays with static equivalents. At E.H.V. levels, the complex protection used and the operating requirements have virtually ensured the obsolescence of the electromechanical relays.

But the use of this high level technology – often microprocessor based – at the 11 KV level is debatable. Dit is soos die gebruik van 'n hoofraam IBM 370 (drie-seventig) om die voorraad van 'n plaaslike kafee te beheer!

The paper makes mention of the fact that the IDMTL relay was developed from a watt-hour meter nad it is significant that, although the production of energy meters is much higher than relays, no static watt-hour meter has been able to match the long term accuracy and robustness of the house service meter at a comparable price.

The average 11 KV substation usually has a nickel cadmium tripping battery of 11 AH, and this battery is not suitable to handle a standing load. Most static relays do impose a standing drain on the battery and this can be disasterous.

By contrast, modern electromechanical IDMTL relays are available which have an accuracy equal to static equivalents, impose no battery drain and, furthermore, have the ability to operate and maintain their time characteristics even if the current transformers energising them are fully saturated.

Mention has been made of Solkor protection and it may be of interest to delegates to learn that the latest Solkor, designated Solkor Rf, offers significant improvements over the existing Solkor R but remains compatible with existing equipment.

Besides higher operating speeds, Solkor Rf has the facility for simple pilot monitoring that does not degrade the operation or stability of the equipment in any way. An additional advantage of the latest protection is that, with fault current fed from only one end, both ends will operate at the same value so that intertripping is not required for internal faults, such as under conditions of low infeed at the remote end.

Mr. C. Adams: Port Elizabeth

The field of protection is a wide one, and Mr. Wedderburn has done a good job of high-lighting those facets applicable to the smaller distribution systems. The problem in writing any paper like this is in deciding what to leave out, rather than what to include.

The section on the functions and requirements of protection is clear and self explanatory, requiring no comment. However, I have some questions on the section on "The Application of Protection".

In the subsection on "Fuses", the expression given will indicate the maximum fault level the fuse has to clear. However, the rating of fuse to be used must be related to the full load current of the item being protected with due allowance for surges, rather than to the fault level of the system.

Port Elizabeth gebruik die standaard kurwe – *Omgekeerde Definitiewe Minimum Tyd* (ODMT) relês vir oorstroom beveiliging wat aangevul word met oombliklike hoë-instelling relês. Ek sou graag wou weet hoeveel plaaslike owerhede die omgekeerde of uiters-omgekeerde kurwe relês op hul stelsels gebruik.

Ek wil graag weet naastenby watter grootte transformators die skrywer in gedagte het wanneer hy praat van "klein", "medium", en "groot". Portt Elizabeth gebruik drie kategorieë naamlik:

1. Tot 800 kVA, waar beveiliging op hoogspanning en laagspanningkant deur middel van sekeringe is. Dit word gebruik om 6,6 kV of 11 kV te verlaag na laagspanning.
2. Tot 10 MBA, wat gebruik word om van hoër spannings te verlaag na 6,6 kV of 11 kV. Die beveiliging hier bestaan uit 3 pool ODMT en oombliklike oorstroom-relês aan die hoogspanningkant met beperkte aardfout aan albei windings; laespanning-reserwe aardfout, temperatuur en Buchholz-relês is ook aangebring.
3. Bo 10 MVA, waar afgesien van bogenoemde beveiliging, differensiaal-relês ook aangebring word.

Die enigste tyd wanneer ODMT-oorstroomrelês aan die laagspanning stroombrekers aangebring is, is wanneer dubbele sekondêre transformators gebruik word en diskriminasie tussen hoogspanning en laagspanning relês nodig is.

Geen melding word in die referaat gemaak van transformatorvoerders wat algemeen gebruik word nie. Ons beleid hier is om die hoogspanning-kabel te beskou as deel van die transformator, dus word die hoogspanning-beveiliging na die sendkant van die lyn verskuif. Teenstroombeveiliging word aan die laagspanningkant van die parallelle transformator-voerders aangebring en tweerigting-inter-uitklinking geïnstalleer.

Although solid state relays have been available for many years, it seems that few protection engineers want to be guinea pigs and be the first to install these relays on a widespread basis. This is understandable, given both the reliability of electromechanical relays and the problems that have arisen in other fields when electronic equipment has been installed in hostile environments. However, given the benefits possible and the considerable development work done on solid state relays, they must obviously be about to make a much stronger impression on the protection field.

One factor not dealt with in the paper, which I feel will be of considerable interest to all muniucipalities, is that of relay maintenance. It is easy to know when maintenance is insufficient, as sometimes catastrophic failures occur, but excessive maintenance is both expensive and liable to create other problems due to one of Murphy's Laws "If you fool around with a thing enough it will eventually break". I would be interested to know other people's ideas on the fequency of maintenance required.

Mr. E. De C. Pretorius: Potchefstroom

I also wish to add my quota of thanks and praise to the speaker for his paper on a subject which is seldom ventilated at AMEU gatherings.

A shortcoming – I say this with due deference to the speaker – in the paper is the omission of a section on protection transformers, particularly current transformers. The effect of saturation of current transformers on the operation of protection relays, especially unit protection, is not always appreciated.

In section 3.2 the speaker states: "The costs incurred through interruptions to supply will naturally vary tremendously, but a general rule of thumb is that the value of a kWh lost is approximately 40 to 60 times the cost of generating that kWh". Could he explain how he arrives at this (to me) seemingly inflated figure. If this is a fact, please keep it away from the press because I fear the reaction of our consumers next time there is a power failure!

I fully endorse the speaker's views on equating the cost of protection with that of the equipment being protected. Especially on our rural distribution system (approximately 500 consumers) we follow this principal very religiously. Elsewhere, wherever feasible, we make use of fuse protection (HV and LV) instead of automatic circuit breakers with no ill effect. (By employing fuse protection one can save considerably on cabling costs where fault level is the ruling factor).

Referring to "Transformer Protection", Section 4.1.2, what do the letters A, B, C and D in Table 1 signify?

The speaker points out that the ratings recommended in Table 1 exceed the normal full load current of the transformer which, in effect, means the HV fuses are solely there to clear HV faults. Overload protection, of course, can quite easily and inexpensively be achieved on the low voltage side of the transformer.

In Section 4.2 he refers to C.L. Fortescue, the father of symmetrical

components. I often wonder how many nightmares could be attributed to this gentleman!

In Section 4.2.1.3 he asserts that discrimintion with fuses where standard inverse relays are used is virtually impossible. This is not my experience.

What do the expressions "medium" and "small" step-down transformers encompass?

In conclusion, could the speaker perhaps briefly sketch the application of distance relays for the protection of HV overhead lines and their merits and deficiencies. (One particular drawback is their enormous cost!).

Mr. A.H.L. Fortmann: Boksburg

With regard to the use of IDMT O/C protection by both Escom and the Municipality, it is generally known that the time multiplier settings of the municipal relays are governed by the Escom settings and not by the fault duration capacity of the municipal equipment. This is especially true to supply voltages in the 11 – 33kV range.

Thus it is not usually possible to achieve more than two stages of grading on the municipal network.

However, as used to be the case, the provision of an earth point for the network at the supply voltage was the municipalities' responsibility, so that earth fault IMDT protection was entirely under the municipalities' control. Operating times could be based on equipment ratings and it is possible to achieve up to five stages of discrimination.

The question is: How long can one allow an earth fault on a cable network to persist before it develops into a three-phase fault thus defeating the advantage gained, taking 1 000 amps as the earth fault value and a symmetrical fault level of 350 MVA?

Secondly, in Boksburg E/F and O/C relays are set to operate in approximately equal times assuming maximum E/F and fault current respectively. This arrangement generally leads to the E/F relay operating before the O/C element, and is usually satisfactory.

It has also been found that, where one can get away with discrimination steps 0,35 secs. apart on O/C, this time interval is unsatisfactory with E/F protection due to the high burden of the relay coils causing additional magnetising current to feed the set of CTs, thus desensitising the relay as mentioned in the paper.

Mr. Malcolm Barnes: Affiliate

1. The speaker refers to the so called "standard" approach to the application of protection, particularly the use of the common IDMT relay. It seems that the relay setting and the associated C.T. ratio is often chosen on the basis of the thermal rating of the circuit. I believe that this can create reliability problems in the performance of the relay system in a situation where a high fault level exists. Current transformer ratios and relay settings should be chosen on the basis of the fault level. Can the speaker comment?
2. Why does the speaker feel that it is necessary to introduce "overshoot" and "reset" valves into solid state relays when "overshoot" is normally taken into account when calculating the co-ordinating margin between two relays (usually 50 insec is allowed for overshoot)? If eliminated, the co-ordinating margin can be reduced. The "reset" time of a solid state relay is very short and that on an electromechanical relay relatively long. Why do you feel it necessary to reduce the performance of a modern relay to that of an older relay?
3. The speaker refers to the use, on larger ransformers, of high speed overall differential protection. In most cases, high speed protection can be provided cheaply and effectively on transformers using high-set overcurrent relays, restricted e/f protection and Buchholz relays. For what size of transformers does the speaker justify the use of overall differential protection?

Mr. M. van der Spuy: West Rand Administration Board

Mr. Wedderburn is to be congratulated on covering a very involved subject in a clear and understandable way.

With the advent of the solid-state and microprocessor type relay, one enters the realm of electronic type reliability and serviceability. Can the speaker give us some indication of the reliability of electronic type relays as compared with electro-mechanical units;

Because of the large variation of manufacturing standards, pertaining to Quality Assurance, it would be interesting to know whether these units are built to an industrial Quality Assurance standard or to a military specification or do they approach Nuclear Standards?

Mr. E. Auton: Affiliate

I join with the other speakers in applauding Mr. Wedderburn for his interesting paper and particularly for the fact that in his slide-illustrations showing applications of his new solid state relays at the U.K. Electrens Exhibition 1982, two of his photographs were of gear manufactured by Hawtan Siddely.

I have two contributions which I hope will be of interest to the delegates based on some 20 years or more of experience in the manufacture of fused ring main units.

My first observation is that Mr. Wedderburn's papaer would have been more comprehensive if he had been able to develop the very important aspect of "co-ordination" which covers the relationship between the L.V. side protection of transformers protected by H.V. fused switchgear. The rating of H.V. fuses recommended in Table 1, especially column A, are based on U.K. standards and where the discrimination is essentially based on the pre-arcing time of the L.V. fuses of specified maximum current ratings. The widespread use of L.V. switches and circuit-breakers on the L.V. side of transformers up to 1 000 kVA can completely destroy any discrimination between primary and secondary protection, causing degradation of the H.V. fuses and even more likely, spurious tripping of the H.V. ring main unit.

This is not only expensive in terms of material cost but prolonged interruption of supply can result from the H.V. switching operations involved. Mr. Davies has just stated that his problem with Solker pilot-wire protection with tee-off loads arises from L.V. faults and those certainly could be minimised by correct application of principles of protection grading.

Special care should be taken to avoid applying H.V. fuses of a very close rating to the full-load current of the transformer. This will result in over heating of the fuse and a possibility of partial melting, which could result in an impairment of its short circuit breaking capacity.

These remarks are inteded to be a lead-in to my main theme of protection for the interest of delegates to this conference. It will be recalled that until about 18 years ago, the conventional H.V. control for a 500 kVA transformer was an oil circuit breaker used with two oil-switches to form a Ring-Main Unit. A design was then conceived which combined an H.V. fuse-switch with two ring-switches in a single oil-filled tank, and which is now the basis of our standard minisub and distribution substation. This yielded considerable savings over the cost of previous installations. There are however residual problems of correct fuse application and protection co-ordination referred to in my opening remarks.

However, Siddeley now has a contribution to make on the subject of protection which is different from the approach made by the author. His Company has a business to manufacture protective relays for incorporation into switchgear: my Company has integrated its protection and current transformers into a new Ring-Main Unit based on a new oil-free equipment which embodies an 11 kV circuit breaker and ring-main switches in an SF6 gas filled (Sulphurhexafluoride gas) tank.

The protective device is a plug-in unit, precalibrated for standard transformer sizes, and is self powered from the current transformers, thus avoiding any dependence upon the reliability of switch tripping batteries or other auxiliary supplies – even the circuit breaker is based on a 'rotary-arc' principle, in which the power to drive the arc is obtained from a built-in coil assembly.

This form of integrally protected ring-main unit is fully adaptable to the protection co-ordination requirements of any form of L.V. protection and could be extended to accommodate conventional relays if required for standardisation pruposes.

Mr. Ron Wedderburn: Affiliate

Mr. President,

I wish to thank all the contributors both for their contributions and their questions, and to say that, to keep the content of the paper within the confines of the electrical protection most commonly found in municipal substations, only certain types of protection and protective relays were discussed.

Mr. G. Davies

The problem of a lack of available grading time afforded to municipalities by Escom would appear to be rather prevalent. However, without studying each case, it is difficult to generalise and give an answer which could be applied to every case. The use of either standard inverse relays incorporating "hi set" instantaneous elements or very inverse relays is usually the only alternative left to the municipal engineer to effectively grade his system. This problem can be attributed to the very rapid increase in fault levels in certain parts of the Republic of South Africa brought about by the tremendous increase in Escom's generating capacity.

Fault duration is a factor of current transformer ratio selection and relay setting. By calculation of the fault levels, municipal engineers should be able to select an optimum current transformer/relay setting ratio which will keep the fault duration with the limits of the plant being protected.

The burdens imposed upon substation batteries by the standing drain of solid state relays has been a problem which the manufacturers are aware of and they have been attempting to decrease the standing drain of this

type of protection. This drain is at present in the order of 30 milli-amps and this is a vast improvement on the original level of standing drain.

The A.C. burden of the solid state relay has been decreased from 3 VA to 0.5 VA over the full setting range of the relay which is from 10% to 200% of Cape Town rates. Modular relays can either be mounted directly on the front panel of the breaker or in ' 19" rack. In addition the relay can still be withdrawn from the case, thereby retaining a very necessary feature. Therefore the static relay, while including the advantages of athe electro-mechanical relay, brings modern technology into the normal field of protection at a cost which is almost equal to that of the older relay.

Protection of cable networks which have a number of tee-offs is extremely difficult using the standard "unit protection" concept. The idea put forward that pilot-wire protection which includes an "abnormal curve" inverse factor is something which will have to be pursued separately, as an "off the cuff" answer, I feel, would be unsatisfactory.

Current transformer design as such was not attempted within the confines which I set for my paper, as I feel that this could quite easily be a topic for a paper at some future AMEU conference.

Mr. N. Kirschner:

As mentioned in my reply to Mr. Davies, there are advantages to be gained by the use of static relays. The inclusion of microprocessors in the area of standard 121 kV protection can only be justified if the cost of the protection remains almost equal, and, with modern technology, this has been achieved. The benefits gained by this approach far outweigh the disadvantages, such as substation battery drain, if the drain is kept minimal. As previously stated the burden imposed on the battery is approximately 30 milli-amps for a standard single or three phase overcurrent relay. With the combined two-phase overcurrent and one earth-fault relay the burden will be less than 60 milli-amps and the AC burden will be 0.5 VA.

Mr. C. Adams:

The sizes of transformers relative to standard types of protection systems are usually grouped in a rather loose format, as the MVA rating and voltage ratio should be considered together with cost of transformer replacement etc. However I would classify a small size transformer as one equal to or less than 5 MVA, a medium size transformer being one that is equal to or less than 10 MVA and those equal to or greater than 10 MVA as large transformers, the protection of the transformers in these three groups being selected to meet the requirements of the particular transformer and the system to which it is connected.

The protection of transformer feeders as such, where the HV breaker is situated at one end of a cable or transmission line and the transformer at the other with no HV breaker on the HV side, was not dealt with in the paper. The transformer is normally connected to the LV circuits via a breaker and the transformer and transmission line or cable protection is required to trip both LV and HV transmission line or cable breakers. These feeders can be grouped into two types of feeder i.e. short transformer and long transformer feeders. The first type, which is the type most likely to be encountered by municipal engineers can normally be protected by pilot-wire unit protection with pilot-wire intertrip connections between the transformer protection and both breakers. The second type of feeder is usually protected by some form of impedance or phase comparison protection scheme in confunction with transformer differential protection with suitable intertrip signals between both points of supply.

Mr. A.H.L. Fortmann:

The first point regarding inadequate grading time being provided by Escom has been covered in my reply to Mr. Davies.

The question regarding cable faults, their duration and the possibility of earth faults developing into phase-to-phase or three-phase faults depends largely upon the relay setting, the fault level and the type of cable. The cross-linked P.V.C. cables which are being used by more and more municipalities are either individually screened or protected by a single screen around all three conductors.

Earth fault relays are sometimes set at the 10% plug setting multiplier. This low setting imposes, by virtue of the 3 VA setting burden, a burden of approximately 300 ohms on the current transformer secondary. Care should be exercised when selecting current transformers and the ratio to be used so as to enable the engineer to select a plug setting multiplier of 20 to 30 per cent.

Mr. E. Pretorius:

Distance inpedance relays were not covered in my paper as I feel they could, if the papers committee agrees, form the basis of a paper or part of a paper at some future AMEU conference.

Mr. M. Barnes:

I agree current transformer ratio selection and relay settings should be selected for fault levels and not be governed by overload requirements. However transformer and cable protection settings should be selected so that transformers and cables are not unduly overrated.

Overshoot and reset are problems which are encountered when grading a system using electromechanical IDMT relays. Static or solid state relays, if allowed to reset instantaneously, would do so to the detriment of the system grading, particularly in a system using overhead transmission lines and automatic reclosing. On successive trips, after automatic reclosing, IDMT relays take a finite time to reset. If the breaker is closed onto a fault, relays may not have reached their "rest" point and "fast" tripping of electromechanical relays upstream of a statif relay could occur.

Mr. M. van der Spuy:

Within our company, industrial electronic equipment is purchased and then tested rigorously to military specification levels. The reason being that, should military spec. equipment be purchased, this equipment would still have to be checked before being used in our relays. These tests naturally eliminate components which do not meet specification, and include computer checked heat – run tests on all transistors, integrated circuits etc.

Mr. G. Auton:

The co-ordination of protection relays and fuses requires relays which have an extremely inverse characteristic. The table given in the paper was quoted as being representative only, as each fusegear manufacturer will quote its company's recommended fuse rating for each particular rating of fusegear.

Thank you Mr. President, I trust that I have answered all the questions put to me.

Dr. Andy Eriksson

Dr. Andy Eriksson graduated from the University of Natal (Durban) in 1969 with an M.Sc. degree in Electrical Engineering and recently completed a Ph.D thesis on the electrical engineering aspects of lightning (December 1979).

A Registered Professional Engineer, he is also a member of the I.E.E. (London), the S.A. Institute of Electrical Engineers and the Institute of Electrical and Electronic Engineers (USA).

At present he is the head of the Electrical Power Department of the National Electrical Engineering Research Institute of the South African Council for Scientific and Industrial Research. He has responsibility for research and development projects in the fields of High Voltage and Insulation, Lightning research, Electrical Earthing and Overvoltage Surges in Transmission and Distribution Systems.

He is the author of over 50 CSIR Research and Contract Reports as well as about 20 papaers in various technical journals and conference proceedings.

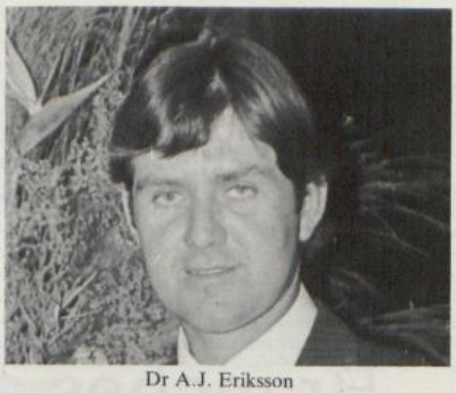
His involvement in international study groups and lightning has done much to enhance South Africa's image and record of achievement in this field.

He is:

(i) The Technical Secretary of the Working Group on Comparative Lightning Parameters, which has been established by the International Commission on Atmospheric Electricity.

(ii) A member of the CIGRè Working Group on Lightning (33-01) of Study Committee No. 33 – Insulation Co-ordination and Overvoltages.

(iii) The corresponding member of the IEEE Working Group on the lightning performance of distribution lines.



Dr A.J. Eriksson

STUDIES ON THE LIGHTING PERFORMANCE OF DISTRIBUTION LINES

Dr. A.J. Eriksson, Assistant Director NEERI (CSIR)

1. INTRODUCTION

Unacceptably high system outage rates and equipment failure rates have long been of concern to supply authorities operating distribution systems in areas experiencing regular thunderstorm disruption. Common experience, even in areas of comparatively low lightning incidence, indicates that lightning is frequently the single most important cause of faults in distribution systems. Typical annual outage rates are reported to vary from about 6 - 7 per 100 km per year (in Britain) [1] to well over 30 per km per year (in Florida in the USA) [2].

South African experience has been very similar – notably in the Transvaal region where available fault statistics demonstrate that over 80% of summer distribution line faults, are lightning or thunderstorm related. Sample annual outage rates lie in the range of 20 - 46 faults per 100 km per year [3]. Fault analysis does indicate that a large number of complex and inter-related factors are responsible for system outages and it is difficult to separate out individual contributory aspects. Table 1 below depicts a summary of fault performance reported in the central distribution area of the Rand and Orange Free State region of ESCOM – as determined by Ackerman in a three year period (1977-1979) for some 1 300 km of rural 6,6 kV and 11 kV overhead lines [3].

Table 1: Summary of distribution system faults

Type of fault	Mean percentage of all faults over three years
Insulator damage	13,5%
Arrester failure	5,7%
Conductor down	10,6%
Trees	5,3%
Cable faults	4,2%
Transformer faults	2,1%
Unknown	42,3%

NOTE: Factors individually responsible for less than 1% of faults, or apparently not storm related, have been excluded in this summary.

Of the above factors, insulator, arrester and transformer faults are the most likely to be directly lightning related. In a separate analysis Ackerman has reported transformer annual failure rates varying between about 1% and 7% – dependent upon type and manufacture while average surge arrester failure rates of about 2,5% were observed [4]. (Individual variations in surge arrester failure rates for various manufacturers ranged between 0,3% and about 10%).

A general consensus of opinion in the technical literature – in view of the considerable capital investment in distribution systems and the substantial disruptions in consumer supply – is that more practical research needs to be directed toward improving the lightning performance of distribution networks and equipment, and important programmes have been initiated in several regions of the world in the last decade [5].

In view of the local problems, the National Electrical Engineering Research Institute (NEERI) of the CSIR undertook a field measurement project in 1975 in an operational rural 11 kV distribution system [6]. After two years of study, although much data on surge characteristics was acquired, it was evident that the system interactions and complexities of a densely interconnected practical system made it extremely difficult to arrive at a clear understanding of the basic mechanisms whereby lightning disturbances arise in such systems. It was considered that such a fundamental understanding was a prerequisite to dealing with the problems of system lightning performance. A literature survey established that there were many diverse – and in some instances conflicting – theoretical approaches to the interactions of lightning upon distribution systems, but there was a dearth of meaningful field measurements.

Consequently, a joint project between NEERI and ESCOM was initiated in 1978 [7], involving the construction of 10 km test line length of representative rural wood pole distribution line construction, and the establishment of several research stations along this test line. The primary objectives of the project were to study the fundamental characteristics of lightning disturbances, and thereafter, to examine the influence and response of surge arresters, as well as the implications for practical line design.

This project, as well as related studies concerned with improving the lightning performance of distribution lines, is co-ordinated in a task force of the CSIR High Voltage Co-ordinating Committee. This task force includes representation from the AMEU and the SAR, as well as from NEERI and ESCOM – and several of the ESCOM regions.

The test line project is now in the fourth year of operation and the balance of this paper comprises an overview of the research programme and a summary of the results obtained thus far.

2. PROJECT DESCRIPTION

2.1 Test line and operation

The 10 km line is of a standard wood pole construction, as shown in Figure 1, and is located in relatively open country some 30 km East of Pretoria.

A stranded earthing conductor was buried around each pole footing during erection, but at this stage of the project no overhead shield wire has been erected. Instead, the earth conductor is run up each pole to terminate in a loop some 2 m below the cross-arm support brackets. Throughout construction, attempts were made to maintain a comparatively high impulse insulation level along the line (about 500 kV), in order to extend the range of measured surge voltages.

During the first two years of the project, the line was operated unenergised, with the one end being short-circuited to a low impendance earth electrode, and the other end terminated open-circuit with spark gaps. This phase of the programme concentrated upon the fundamental study of surge voltage characteristics and direct stroke incidence.

In the third year of operation, three phase sets of distribution class surge arresters were positioned at 1 km intervals along the line length, but the line was still left unenergised. The measurements were now concentrated upon a study of surge arrester discharge currents and of the modified surge voltage characteristics recorded on the now protected line.

In the fourth season of operation (still current at the time of writing), the arrester studies were continued and steps were also taken to energise the line at 11 kV toward the end of the season, in order to include examination of power follow-current effects during arrester discharge.

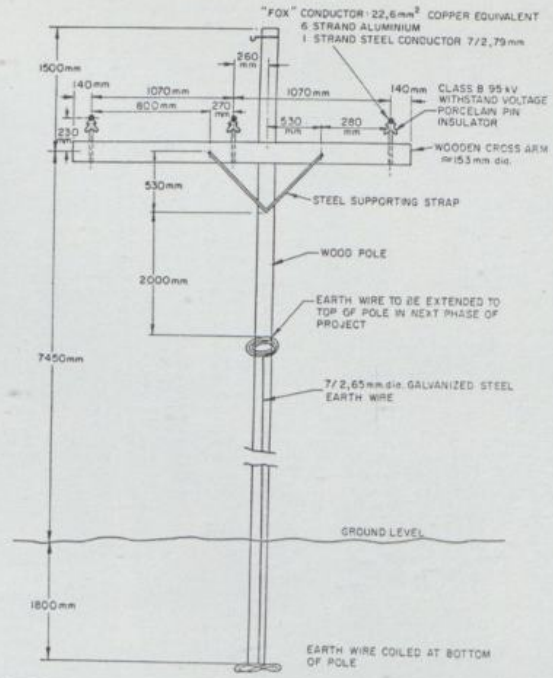


FIGURE 1 *TYPICAL POLE STRUCTURE FOR THE TEST LINE*

Wat almal behoort te weet van die krag agter Suid-Afrika.

Ons kan jou vertel dat Evkom een van die sewe top-elektrisiteitsprodusente in die wêreld is. Of ons kan jou vertel hoe ons duisende mense aanstel om in meer as 90% van die land se elektrisiteitsbehoeftes te voorsien. Hoe ons groeiende voorsieningsnet help om die uitwerking van stygende brandstofkoste teen te werk. Hoe ons onsself voorbefei om teen die einde van hierdie eeu in meer as 40% van Suid-Afrika se totale netto energievereistes te voorsien.

En vir jou as Suid-Afrikaner sal dit waarskynlik baie beteken.

Maar vir ons beteken dit meer dat jy as individu — iemand wie se enigste kontak 'n elektrisiteitsrekening aan die einde van die maand is — meer van Evkom se ander sy weet.

Ons het nog altyd geglo dat grootte op sigself nie 'n aanduiding van sterkte is nie.

Inteendeel, dit is ons beleid om ons grootte te gebruik om die mense wat van ons gebruik maak, te help.

En ons weet dat jy as Suid-Afrikaner die heelpad vierkantig agter ons staan.

Ons voel presies dieselfde oor jou as individu.

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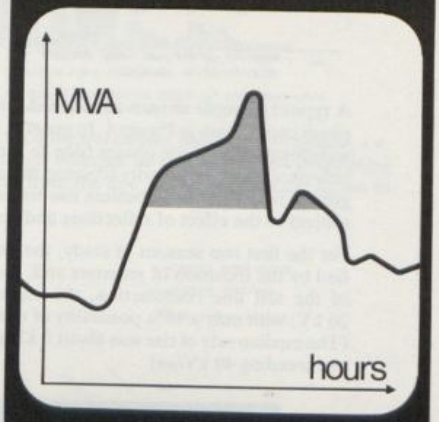
The Problem



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2.2 Research stations and measurement techniques

Initially, two recording stations were positioned on the line. The first was located approximately 1 km off-centre along the line length and concentrated upon the study of overvoltagesurge waveforms. The second was located at the open-circuited line termination, where the emphasis was upon the study of surge arrester discharge currents.

Each station is designed for automatic operation, including local diesel power supplies which are started automaticcally at the commencement of lightning activity in the test line area. The instrumentation includes automatic oscilloscope surge recording systems (both digital and photographic storage techniques being used), together with lightning flash counters for accurate registration of the regional lightning activity.

The locations of surge-inducing ground flashes in relation to the line route, are determined in several ways. These include use of the NEERI all-sky camera flash location system, together with closed circuit television recording and subsequent triangulation in conjunction with time-to-thunder-ranging. Equipment for these measurements are also located at each station and are selectively operated from the CSIR using a remote radio control and monitor system.

Direct strikes to poles and the subsequent pole flashover currents, as well as arrester discharge currents, are registered using magnetic link brackets, which are positioned on the earth lead at every pole. In a few instances, working in collaboration with a distribution line research programme being conducted in the USA [5], automatic surge current waveform recorders have also been installed in surge arrester earth lead connections, in order to study surge arrester discharge operations is shown in Figure 2.

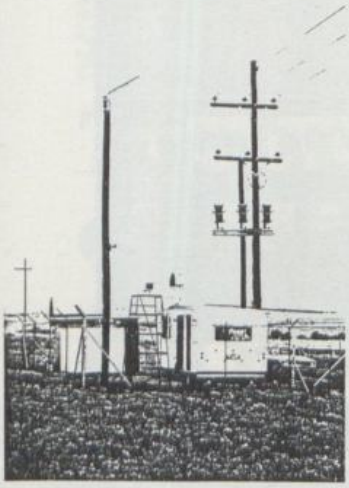

FIGURE 2

GENERAL VIEW OF NEERI 11 kV TEST LINE OVERVOLTAGE RECORDING STATION

3. SUMMARY OF RESULTS

3.1 Station performance

Measurements on the test line commenced at the beginning of the 1978/79 storm season and, at the time of writing, the project is now in its fourth season of operation. A general summary of average storm and overvoltage surge activity is shown in Figure 3. (In general, all surges having voltage amplitudes in excess of 12 kV trigger level are registered.)

On average, about 80 - 90 storms are observed in the test line area each season with the recording stations being operated on about 60 - 70 of these. (In some instances, the storms are too weak, or too remote to justify operation). Only about 30% of all storms are sufficiently close or active to cause surges upon the line, but it is found that these 'surge producing' storms are the most active of the season in that they are responsible for over 60% of all the lightning registered in the area. The annual average ground flash density in the region is about 6,5 flashes km^{-2} $year^{-1}$.

3.2 Overvoltage surge performance

By far the most common lightning disturbance event on the line arises through the occurence of a ground flash reasonably close to the line and the corresponding induction of an overvoltage surge into the system. Approximately 130 such events are recorded on the 10 km line length each season (i.e. surge voltages in excess of 12 kV). In terms of the regional ground flash density, this is equivalent to about two surges per km of line, per ground flash per km^2 per year.

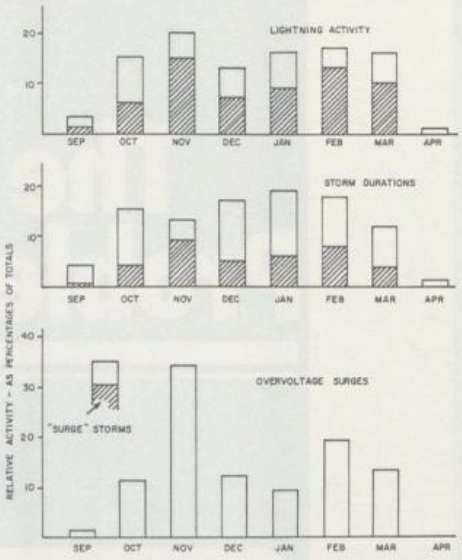

FIGURE 3

MONTHLY STORM AND SURGE ACTIVITY – AS AVERAGED OVER THE 1978/79/80/81 SEASONS.

A typical example of such an induced surge is shown in the three-phase oscillogram in Figure 4. In general, such surges are of similar waveform on all three phases (due to the horizontal line configuration), of positive polarity (corresponding to the normal negative ground flash) and with absolute rise-times of the order of 5 - 22 μs, subject to the effect of reflections and line response.

For the first two seasons of study, the line was operated unmodified by the inclusion of arresters and, for the particular geometry of the test line construction, the median surge amplitude was 26 kV, with only a 10% possibility of exceeding a level of 100 kV. (The median rate of rise was about 5 kV/μs with a 10% probability of exceeding 40 kV/μs).

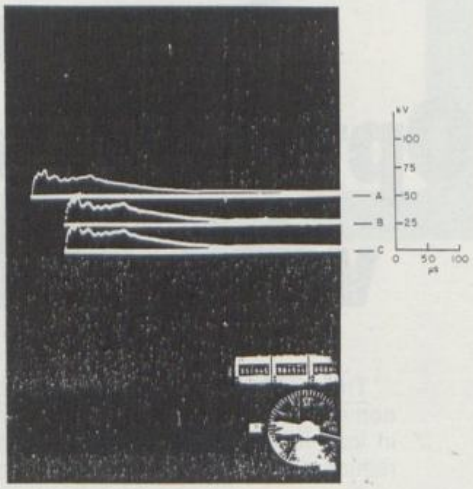

FIGURE 4

EXAMPLE OF THREE PHASE RECORDING OF INDUCED VOLTAGE SURGE.

Figure 5 shows a summarising histogram of measured induced surge voltage amplitudes for the original unprotected line, together with the subsequent measurements obtained during the third season, when arresters were installed along the line. The protective effect of the arresters is very clearly demonstrated in the limitation of all overvoltages to below 40 kV. (The nominal spark-over levels of the arresters used, varied from about 25 to 35 kV).

3.2 The influence of flash position

An important aspect of research during the first two seasons of operation was to relate the recorded surge voltage magnitudes to the distances from the line of the corresponding inducing ground flashes, since this gave a unique opportunity to assess various

theoretical approaches to the induction mechanism, and also provided a basis for extrapolating the test line work to different distribution line arrangements.

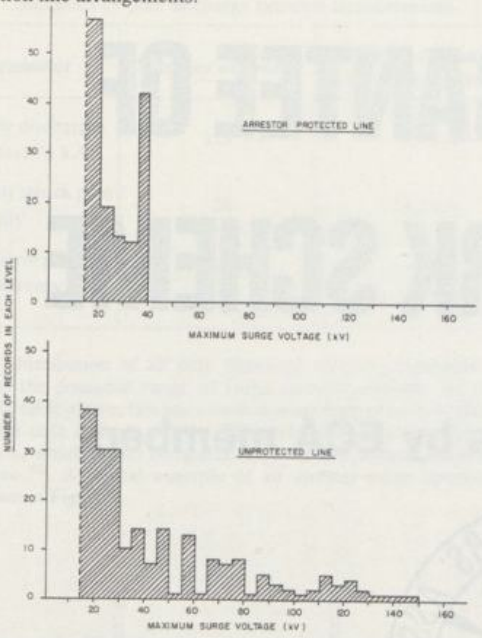

FIGURE 5 *SUMMARISING HISTOGRAM ILLUSTRATING EFFECT OF ARRESTORS UPON INDUCED SURGE OVERVOLTAGE DISTRIBUTION.*

Thus far, nearly 50 such measurements have been obtained, i.e. measured induced surge voltages in relation to the originating ground flash distances from the line, and these date are shown in Figure 6.

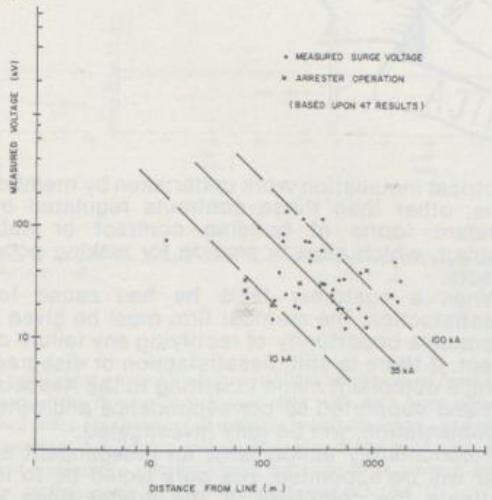

FIGURE 6 *RELATIONSHIP BETWEEN OBSERVED SURGE VOLTAGES AND GROUND FLASH LOCATIONS.*

A simple analytical model of the inducing mechanism has been found to show comparatively good agreement with these data and illustrative predicted trends for various stroke current amplitudes are also shown in this figure. Depending upon the stroke current magnitude, it is seen that flashes at distances in excess of 1 km from the line can still induce surge amplitudes higher than 40 kV, and this therefore defines the possible extent of lightning disturbance area in the vicinity of a practical distribution line.

3.3 Direct stroke incidence

Apart from induced surge events, the other cause of disruption in a distribution system is the direct stroke to the line itself, and many such events have been studied in the course of the test line project.

Direct stroke incidence N_s to lines is frequently expressed in terms of the relationship:-

$$N_s = (2R + b) L N_g \times 1 \times 10^{-3}$$

Where R = the attractive range on each side of the line in m
b = structure width in m
L = line length in km
B_g = annual ground flash density

Substituting the observed test line data into this relation yields a derived value for

$$R = 67{,}5 \text{ m}$$

In previous work [8], the writer has proposed that the observed incidence of direct strikes to structures of varying height can be accounted for in terms of a structure mean attractive radius R_a;

$$R_a = 16{,}3\ H^{0{,}61}$$

where H = structure height in m

Applying a balue H = 8,0 m for the test line yields

$$R_a = 58{,}0 \text{ m}$$

which shows reasonable agreement with the above four year estimate for R.

Earlier methods for determining direct stroke incidence to lines assume a structure attractive range

$$R = 2H$$

In the case of the test line, this would yield a predicted average annual direct stroke incidence $N_s = 2{,}1$ flashes per year, which is over four times less than the observed direct stroke performance.

The data of Table 2 also indicate that the incidence of pole damage is approximately double the direct strike incidence, since multiple flash-overs are common.

Normalising in terms of line length and ground flash density yields an average expected pole damage rate N_P

$$N_P = 31 \text{ poles/100 km/flash km}^{-2}$$

Since the average pole spacing on this line is about 100 m, this corresponds to a percentage pole damage rate of about 3% per flash km^{-2}. (It should be noted that in nearly all instances, pole damage on the test line has veen very minor, involving only superficial splintering and no poles have thus far warranted replacement.)

3.4 Pole discharge currents and arrester performance

The data of Table 2 indicate that more than 180 poles experienced discharge currents in excess of 1 kA (the threshhold of magnetic link sensitivity). This is again due to multiple pole flash-overs in the event of direct strikes and is equivalent to about four poles discharged per direct stroke. Thus far, all measured pole discharge currents have been of negative polarity, as might be expected.

The overall sample of measured discharge current data therefore comprises a mixture of direct stroke and related pole flash-over

The observed direct stroke incidence is summarised below:

Season	Mean flash density km^{-2} year^{-1}	No. of poles directly struck	No. of poles damaged through flash-over	No. of poles displaying discharge currents 1 kA
1978/79	6,8	6	10	6**
1979/80	6,2	15	30	63
1980/81	6,1	8	28	48
1981/82*	5,6	5	8	19
4 year means	6,2	8,5	19	

NOTE: * This season was still incomplete at the time of writing
** Complete pole discharge data were not obtained in the first season.

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currents, and these may be separately analysed, as shown in Table 3 below:–

Table 3: Summary of pole discharge currents measurements

Parameter	Number of events	Median discharge current amplitudes
All pole discharges in excess of 1 kA	123	6,4 kA
Directly struck pole data only	28	19,2 kA
Equivalent ground flash currents	28	37,2 kA

The distribution of all pole discharge current amplitudes indicates the potential range of surge arrester currents. As shown in the table above, this has a median amplitude of 6,4 kA. Analysis of the data indicate only a 10% probability of exceeding about 20 kA, which agrees comparatively well with measurements elsewhere [9]. A typical example of an arrester surge operation is shown in Figure 7.

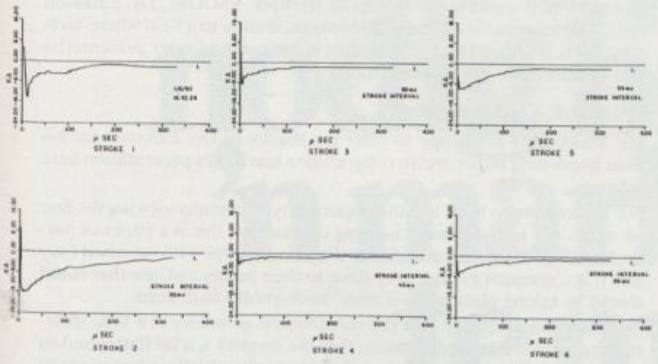

FIGURE 7

FIRST SIX STROKES OF AN EIGHTEEN STROKE DIRECT FLASH SURGE ARRESTOR DISCHARGE OPERATION RECORDED ON THE TEST LINE.

The equivalent ground flash current data are obtained from summation of the directly struck pole data with data from adjacent flashed poles – in the event of multiple pole flash-overs – and again, the resultant distribution and median value shows good agreement with the reference distribution of lightning peak current amplitudes, as frequently adopted in engineering practive [10].

Thus far, in the course of these studies, no surge arresters have been damaged on the test line during lightning discharges – despite in some instances, severe multistroke discharge duty – although a number of disconnect operations have been encountered in the case of one manufacturer. All arresters are tested at the beginning and end of each storm season and so far have retained their operating characteristics unaffected by the observed lightning discharge duties. (All arresters installed on the test line have a 10 kA rating.)

The effects of line energisation on surge arrester performance have yet to be determined, and this will be one of the primary objectives of the forthcoming year of operation.

4. COMMENTS AND IMPLICATIONS FOR SYSTEM DESIGN

This project has now reached a transition phase, in that much of the fundamental influences of lightning upon such a distribution line are clarified and further research is now moving into more direct engineering studies. At this stage a number of conclusions regarding line design and system operation may already be noted.

4.1 System insulation level

It is evident that the majority of lightning disturbances arise through induction from nearby flashes and give rise to comparatively low overvoltage levels. (99% of indirect surges are below 200 kV.

The adoption of a co-ordinated basic insulation level around 200 kV therefore [11], will minimise outages due to indirect surge flashovers. No substantial advantages will accrue from an insulation level much higher than this, however, since the other main cause of disturbance – i.e. direct strikes – will in any case still cause flashovers.

4.2 Arrester sparkover levels

In the course of laboratory tests on surge arresters rated for 11 kV systems, sparkover levels in the range 24 - 40 kV are frequently observed. This contrasts with the median amplitude of induced surges of 26 kV and implies that many minor induced surges can give rise to relatively unnecessary surge arrester operations, with consequent regular discharge of power frequency currents in practice. Many such operations will also be of a multistroke nature, with the prospect therefore of exceeding the block thermal ratings [12].

Alternatively, a moderate rise in sparkover level could dramatically reduce such unwarranted line outages without seriously affecting the system protective margins. For example, an increase in sparkover level from 25 kV to 45 kV would reduce line trips due to arrester operations on induced surges by over 20%.

The adoption of more tightly specified minimum (and maximum) sparkover levels is therefore advocated (e.g. levels of 45 - 55 kV would appear reasonable).

The smaller protective margin (in relation to the equipment insulation level of 95 kV) place more emphasis upon the location of arresters in relation to terminal equipment such as transformers, and integral mounting with transformer tanks is therefore also advocated.

4.3 Arrester discharge rating

The median surge arrester discharge current is in the region of 6 - 7 kA. Given the prospects of multistroke operation and successive power follow discharges, this implies that 5 kA rated arresters could well prove inadequate. An arrester rating of 10 kA is therefore recommended in areas experiencing a moderately high incidence of lightning. This choice is already borne out by improved experience reported from certain areas, using a 10 kA rating [3].

4.4 Direct stroke performance

Direct stroke incidence is likely to be higher than commonly suggested and, given a more optimised choice of system insulation level (as well as arrester sparkover level), the final limit of system performance will be determined by direct stroke incidence.

The role of pole footing impedance and the relative advantages of overhead shield wires are as yet unresolved. In the latter instance, however, although pole damage rates may be reduced, the presence of shield wires is not expected significantly to improve performance of systems having insulation levels in the region of 200 kV.

5. CONCLUDING REMARKS

The preceding remarks are based upon still relatively small samples of data, which were acquired upon one specific geometry of distribution line. Although generally self-consistent and in agreement with the conclusions emerging from related studies, their general application may be regarded as contentious.

Research on the test line project will continue for several years yet, in an effort to clarify a number of other aspects – such as the influences of power follow current on arrester discharge characteristics – and the role of shield wires.

In the interim, it is hoped that this paper provides a useful summary of what has been learnt in this project thus far, and that it may serve also as a catalyst for further consideration of the problems of distribution line lightning performance.

This project would not have been possible without the considerable involvement of the Electricity Supply Commission. Their collaboration, as well as that of the writer's colleagues in the National Electrical Engineering Research Institute (NEERI) of the CSIR is therefore greatly appreciated. The permission of the Director of NEERI for the opportunity to prepare and present this paper is also gratefully acknowledged.

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DISCUSSIONS / BESPREKINGS

Mr. G. Hellström: Escom Western Cape

I would like to thank and commend Dr. Eriksson for his interesting presentation, and for making the interim results of this studies and experiments available to the engineering profession. I think he well deserved the 'thunderous' applause!

The eventual results and recommendations from this research, together with the 'ground flash density map' produced by Dr. Eriksson's department at the CSIR, will enable Engineers to cater for the effects of lightning in a more scientific and predictable manner than has been done to date. Effective overhead line design, of course, is based on achieving the most cost-effective balance between various parameters – some obligatory, some dependant on local conditions – of which lightning incidence is a particularly 'striking' one! It is indeed interesting to note that the excellent reference work produced by the SAIEE – the "Code of Practice for Overhead Power Lines for Conditions Prevailing in South Africa" – cautiously avoids any reference whatsoever to lightning. I would hope that sufficient positive data will become available to include this aspect in the second revision, which I believe the SABS is currently preparing.

To close, I would mention that a very important related factor still requires general consensus – that is, "Acceptable level of performance" for overhead lines. I feel that Escom and the AMEU could render a great service to those involved in the research and design of overhead lines if we could properly define and assign a quantitative value to "Acceptable level of performance", since it has a great effect on theoretical calculations and the economics. It is a factor which is highly contentious as far as certain consumers are concerned – those who expect perfect performance!, but on the other hand I am sure that consumers would prefer that a particular level is aimed for and hopefully attained than to have no such reassurance regarding expected quality of supply.

Mr. B. Stromnes: Affiliate

Severe local environmental conditions can in many instances be such than an acceptance of international standards does not necessarily satisfy local demands on electrical equipment.

A series of such factors is known, such as soil resistivity ultra violet light intensity, temperature, pollution, rainfall, salinity, presence of chemicals, lightning intensity etc.

South Africa is a prime example of a region with severe lightning induced disturbance to which we, as manufacturers, supply equipment.

We therefore fully support the initiative taken by NEERI and ESCOM to give us a better knowledge of the environment where our equipment is to be used, thus enabling us to design it in such a way that acceptable fault ratings are achieved.

We have already seen ESCOM modify their specification for distribution type surge arresters based on the data obtained from the experimental line, as well as theoretical work. The high current short duration test has been changed from 100kA 4/10 μs to 30kA 30/80 μsec impulse test.

It will be very interesting to see whether, in the light of data presumably being collected with the line energised and the effect of the follow current after sparkover, this requirement will be modified.

Further, the arrester behaviour under multiple stroke conditions on the energised line can possibly lead to further revisions.

Reference (p.6) is made to rate of rise with a median value of 5kV/μs. Does this refer to induced surges only and, if so, is any data available for direct stroke surges?

A new generation of surge arresters, namely the ZNO based design, has been making inroads into the HV field and it is also being marketed for lower voltages.

One salient feature of the ZNO arrester is that it has no follow current, giving a good protection without line outages.

It would be of great interest to manufacturers and users alike if this new generation of equipment could also be evaluated on the experimental line.

There could be a future saving of considerable magnitude if we could have field experimental results as a basis for local specifications for ZNO arresters used in the distribution network.

We strongly support the recommendation of integral mounting of arresters with transformer tanks.

I would finally express our thanks to NEERI, ESCOM, Dr. Eriksson and his colleagues for a most valuable contribution to a field where facts have been missing. Dr. Eriksson has in his usual manner presented a well balanced and informative paper.

Mr. M.P.P. Clarke: Randburg

Mr. President I am happy to offer my thanks to Dr. Eriksson for his most interesting paper and to congratulate him on his presentation here today.

For the many who have had the opportunity of actually viewing the line on which this research work is being carried out, this is a paper of particular interest and I have no doubt that all will agree with me when I say that it is a research project very close to their hearts and one that could almost be taking place in their own "back-yards" as it were.

Certainly some will say that the construction geometry is a little different from their standards, others, that the country is a bit flatter and so on, but everyone will surely agree that the results which are beginning to flow from this work – and are now reflected in the paper – very largely confirm their own experiences and findings on their respective networks and, most important, begin to quantify these experiences.

For this reason we cannot but be grateful to both the CSIR and ESCOM for making this work possible and I know that I echo the feelings of all supply authority engineers when I say a big thank you to both organisations for their respective shares in the project.

While many will have guessed at the severity of conditions on distribution networks during lightning storms based on their own experiences, I am sure that most will be as surprised as I was to learn just how high the induced voltages are and more especially how high they are even when discharges take place at substantial distances from any given lines.

But for the comfort that does flow from the research so far is that we can begin to design from a sounder basis and to select equipment that will be just that much more suitable under severe service conditions and be able to do this with a greater measure of confidence and understanding.

For me the most surprising information to come from the paper is a simple statement to the effect that after virtually 4 seasons, only minor damage has been noted to the wooden poles and this limited to "superficial splintering".

Having been involved on many occasions in replacing poles that have been shattered to match-wood – and on one occasion no less than 5 adjacent poles with one lightning discharge – I am truly amazed that not a single pole has been so damaged to date.

I would appreciate the speaker's comments on why he feels this kind of damage has not been experienced. Could it be for instance just a matter of luck or statistics; could it have anything to do with the type of pole, the tree species or method of treatment, or has it anything to do with the power frequency current flow which to date has not applied to the test line?

Would the speaker think there is a need to research this aspect as a separate but specific part of the project, or will this in fact be done?

I would also like to know whether there are any plans to research the effects of different fault levels when the line is energized? As was mentioned in a paper yesterday, we live with steadily rising fault levels and

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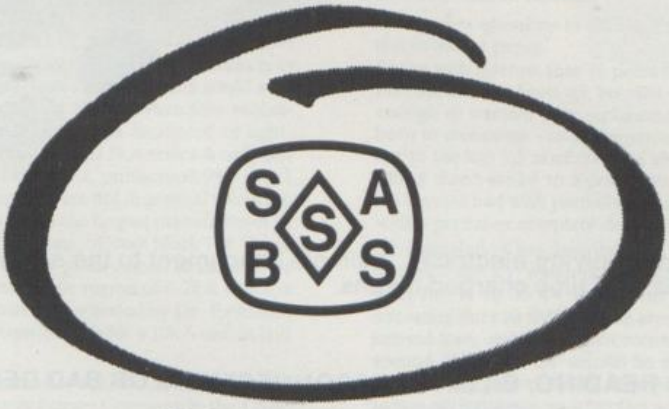

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very often protective systems that are not being upgraded at the same rate. I am not convinced that we know as much as we need to about the effects of power frequency follow currents on lines under storm conditions and, with this, the effect of increased fault levels. Perhaps Dr. Eriksson could re-assure us on this point?

In section 4.2 the speaker refers to arrestor spark-over levels and to integral mounting of surge arrestors with transformers. Would he elaborate on this? Does he consider that there is a need for some standard code or recommendation to cater for this on transformers designed for use on overhead line networks particularly susceptible to lightning? Or is there a case for "factory fittings" of arrestors on certain types of transformers to ensure optimum protection?

Mr. President, I look forward to Dr. Eriksson's comments on the various points which have been raised but even more, I look forward to a further paper in a year or two's time when the next phase of the research has yielded results.

Thanks again to him and his team for the work being done, and thanks to you and the Executive for having arranged for the presentation of this most interesting and important paper.

Mr. A.H.L. Fortmann: Boksburg

With regard to follow-through current, does Dr. Eriksson think that the burning down of overhead lines, is due mainly to the current caused by the lightning strike – which, because of the extremely high voltage, is probably very high but also of very short duration, or due to follow-through current?

We in Boksburg consider it significant that, since two new points of supply from ESCOM have been established and, associated with these, an appreciable increase in fault level on the 11 kV network, there has been a marked increased in 11 kV lines burning off in the rural areas, which would seem to indicate that the follow-through current with a larger duration than the lightning current, is a bigger culprit than the current associated with the lightning stroke itself.

Secondly, could Dr. Eriksson enlarge a little on the question of attractive range and how this is determined.

Also was the value R = 2H as determined with earlier methods merely an assumption, or how was this established?

Mr. E.B. Martin: Affiliate

I would like to congratulate Dr. Eriksson on a most interesting and informative paper and also the CSIR and Escom for the construction of the test line described in the paper which I am sure will produce most valuable results. It is only through research work of this nature that one can obtain accurate knowledge of the effects of lightning in practice on distribution lines and hence draw up designs and specifications. A specification attempts to reproduce in the laboratory the practical conditions encountered in the field and is of little value if this objective is not achieved.

I would like to comment on Section 4.3 of the paper in which Dr. Eriksson states that "The median surge arrester discharge current is in the region of 6-7kA. This implies that 5kA rated arresters could well prove inadequate and an arrester rating of 10kA is therefore recommended in areas experiencing a moderately high incidence of lightning". These ratings presumably refer to arresters 5kA series A or B and 10kA light duty as covered in BSS2914 and IEC publication 99-1, but I would like to point out that these categories are not in general use in the United States of America, which country is the largest manufacturer of distribution arresters. In athe USA the terms "Æmall block" or "large block" arresters are normally used. A good quality small block arrester could well withstand discharge currents in the region of 6-7kA which is the median surge arrester discharge current suggested by Dr. Eriksson, but would possibly not meet the full requirements for a 10kA unit as laid down in BSS2914.

In this connection delegates may be interested in the results of field performance tests carried out by the Detroit Edison Company in the USA. These were:

1. Large block arresters demonstrate to inherent performance superiority to small block arresters. Therefore their greater cost is not justified in the Detroit Edison System.
2. Large block arresters are statistically more prone to failure than small block arresters.
3. Most surge arrester failures are unrelated to lightning, the prime causes are product quality and mechanical damage.

The Detroit Edison survey, which covered approximately 200 000 units in service, indicated the following failure rates per 1 000 per annum:

1. Surge current related failures – 1.41 for large block arresters
   – 0,79 for small block arresters
2. Non surge current related failures (which would include mechanical damage, moisture ingress and external flashover:
   – 1.96 for large block arresters
   – 1.42 for small block arresters

Overall, only 40.3% of failures were due to surge currents while 59,7% of failures were non surge current related failures.

Similar results were obtained from a survey of distribution arrester failures conducted by Ontario Hydro, which showed approximately 85% of failures as being due to moisture ingress compared to only 5.9% due to surges and 4.5% due to contamination. It was only observed that "there did not seem to have been any reltionship between the size of the valve blocks and the discharge withstand capability of the arresters. Some small block arresters pass the tests while other large block arresters failed".

There seems to be a growing realisation that discharge currents do not flow through arrester valve blocks in the same uniform manner as current through an electric cable where, if one doubles the cross sectional area, one would also double the current carrying capacity. Surge currents seem to establish preferential paths through the valve blocks and also seem to show a preference to flow around the periphery of the block. Failure normally occurs with the disintegration of the insulation material applied around the circumference of the blocks with consequent internal flashover over the sides of the blocks and burning of the spark gap structure. This emphasises the importance of constructional details such as insulating the circumference of the blocks by means of ceramic collars fired into the block surface instead of suing plastic insulating coatings. The method of security an effective and durable seal against ingress of moisture into the arresters is also of vital importance.

I would also point out that small block arresters as manufactured in the USA have higher spark over levels as compared with the figures called for in the BSS and IEC specifications. A typical small block 12kV arrester would have a maximum 1,2 x 50 microsecond sparkover value of 57kV as compared to 44 kV for a large block arrester which fits in better with the maximum value of 55kV suggested by Dr. Eriksson and, as he points out, this higher sparkover level could dramatically reduce line trips due to arrester operations. By comparison the maximum value permitted in the BSS and IEC specifications is 43kV.

Mr. President, it thus seems that it is not advisable to insist upon arresters being rigidly in accordance with the requirements of the BSS and IEC specifications as the work by Dr. Eriksson as well as report from the USA indicate that these may not truly reflect service conditions and that more emphasis should be placed on how the supplier manufactures and control his arrester in large volume production than what a few laboratory tests say it can do. For example, the question of sealing arresters against moisture ingress is something which is not even touched upon by the abovementioned specifications.

Mr. President, I thank you for the opportunity of being able to contribute to the discussion on Dr. Eriksson's most informative paper.

Mr. C.T. Gaunt: Affiliate

I have a few questions to ask Dr. Eriksson to clarify some points made in this excellent paper.

I note with interest that 76 poles have been damaged in the four years that the line has been up, but that none of the damage has been serious enough to warrant pole replacement. To what exstent has the damage been to crossarms – and alternatively to the pole? Has there been damage to the top 1,5 m of the pole above the crossarm, which would indicate a direct strike to a pole? What experience have other operating authorities had with partially or fully unprotected poles – that is, those with a partial or complete down-head?

Dr. Stringfellow has described this test line as having an insulation level of about 500 kV which is significantly higher than the recommended level for 11 to 33 kV lines. This apparently imposes a more severe operating duty on the lightning arrestors compared with less strongly insulated lines and it has been recommended that a co-ordinated B/L of around 200 – 300 kV should be adopted – which view Dr. Eriksson appears to support (P. 11). However, is this not a measure detrimental to line performance, as it implies acceptance of the need for switching to clear a lightning induced fault which may be extinguished naturally on poles with a higher insulation level, sacrificing switching (interruptions) for a softer treatment of arrestors. Dr. Eriksson's comments would be appreciated.

On page 11 (Section 4.2) Dr. Eriksson states that an increase in spark-over level for lightning arrestors would reduce line trips due to arrestor operation on induced surges. This implies that a high proposition of arrestor operations on induced surges lead to arrestor failure and a need to switch the line. If this is what Dr. Eriksson intended to convey, then clearly we should give his recommendation to increase spark-over levels on 11 and even 22 and 33 kV lines very serious consideration.

Another question relates to the attractive radius discussed by Dr. Eriksson on page 8. For what values of H is the expression $Ra^3\ 16{,}3H^{0.61}$ valid?

If we apply this formula to the test line with and without an earthwire it indicates that the incidence of direct strikes is likely to increase by about 10% when the earthwire is added.

The increased radius of attraction would tend to offset an improvement in performance of a line by addition of an earthwire, at a significantly higher cost. I look forward to receiving (in years to come) further information on the effect of shielding this test line which I, like Dr. Eriksson, do not expect to significantly improve the system's performance. In view of the large number of lines in the 11 to 33 kV range which have earthwires, and the very high cost of having an earthwire (in the region of 30% of the cost of an unshielded line), this information will be very useful to system planners and line designers.

I would comment on the data on distribution system faults given at the start of Dr. Eriksson's paper. It has been stated by others that about 85% of lightning arrestors fail through moisture ingress and we must remember that many transformers on rural systems may fail beacause of overloading. Data on actual lightning-related performance is difficult to isolate – especially from other damage suffered in storms. In my paper to the SNEE symposium on lightning earlier this year I called for better operating statistics on distribution line systems. To obtain such information, my firm has agreed to collect and correlate data from several operating authorities. We shall be inviting several of your members to participate in this study, which will not require collection of all operating information on your system but only on one or a few selected lines. If we don't approach one of the authorities represented here today who would, however, like to participate, please don't hesitate to contact us.

Our intention is to collect data which we believe will support the theories developed by Dr. Eriksson and his colleagues in their work on lightning in general and the test line project described to us clearly by Dr. Eriksson today. I would like to thank him, and the organisations supporting this important and relevant research for throwing light on the still imperfectly understood effects of lightning on distribution systems.

Dr. A.J. Eriksson: CSIR

It has long been a target of all the other lightning work to put the ground flash density map to practical use and, in presenting the data in the paper, we have tried to normalise everything in terms of Ground Flash Densities so that people operating systems in different regions of the country can immediately determine the relevant numbers for their regions.

I hope that this work will find its way into the code of practice presently under preparation by the Bureau and I agree completely with your point that we need consensus on an acceptable level of performance. To us in the research field, this still remains a completely dark area. We cannot find utilities or system engineers who can give us a clear guide as to what they regard as an acceptable level of performance and, before one can really optimise design and take some of the decisions that we are suggesting you take, you need to know what performance you would like to have in your system.

Mr. Stromnes has brought up points regarding the arrestor specification and the effect that power follow current multiple strokes will have. The effect of power follow of course is still a matter for the future and we hope in this coming season to give attention to a few of the questions raised on the role of power follow in arrestor duty.

A number of people have, Mr. Martin, brought up this question of the arrestor as well and I think I should deal with these simultaneously now. The definitions I am using in 5 kA and 10 kA at the moment are the nominal I.S.C. type definitions based on the duty cycle rating and I agree with you completely that one cannot make choices on arrestors simply in terms of these numbers, nor can one relate it as simply as I have in the paper to the lightning discharge current.

I was aware of the report you mentioned on the Detroit Edison and Ontario Hydro surveys, and a background part of the test line project has been the collaboration within ESCOM and the various regions of ESCOM to acquire more fault statistics on the performance of the various arrestors. The type of survey you mentioned can be very confusing unless one starts to distinguish between different types of arrestor manufacture and manufacturer and the specifications they were first manufactured against.

As you know, in the United States they have even less consensus than we have, but I agree that arrestors fail for many reasons other than lightning duty. Seal failure has shown up as a problem in other regions of the world as well as in the United States and Canada. It is something we are actively looking into in this country. All I can say at the moment is that in the two years of test line work with arrestors on the line, we have never had any seal failure problems. We removed all arrestors at the end of the season, opened them all up and examined them carefully for moisture ingress and thus far we have not any evidence at all of this, but in the modified specification that the research group and ESCOM are drawing up, we have insisted on a far more stringent seal test requirement and the latest specification has put far less emphasis on the high current impulse referred to by Mr. Stromnes and is placing more emphasis on energy. I do not agree in terms of lightning that one could expect similar performances from large blocks and small blocks. It is clear, if one looks at the energy anticipated in multiple stroke flashes, that the energy capabilities of the so called small block will on occasion fail, as was demonstrated on the one I showed you. If one expresses the operating characteristics of the small block arrestors in terms of kilojule energy capability, then it is easy to show that in the ultimate of lightning statistics one will get failure rates in the order of 3% and this is why we are advocating a higher energy requirement in the modified specification, which is presently being drafted, with a long duration to current tests at low current. It is vitally important though that one has better fault statistics of arrestor performance. Mr. Gaunt has also mentioned that point – I am very happy to hear of the intention of his Company to acquire more statistics as well. ESCOM has taken a leading role in the various regions to acquire better statistics and to correlate according to manufacturers of different equipment and we find this extremely valuable in guiding us to some of the areas which require study. Mr. Stromnes has asked about direct stroke rates of rise. We have direct stroke rates of rise in access of 500 kV per micro second and we would expect statistically to get up to about 2 000 kV per micro second with about a 1% probability of occurance and CIGRE and I.E.C. are also using these data to look at insulator puncture problems.

Mr. Clarke, Mr. Fortmann and Mr. Gaunt refer to the fact that we have not damaged any poles; well, I do not really take any responsibility for that, but it is a fact that of the lightning currents we have measured so far, some have been in excess of 100 kA striking the line directly and this is at the extreme end of the lightning current distribution, so we have had cirtually the most severe lightning occurrences one might reasonably expect to get – certainly the chances of getting lightning currents higher than that are rare, but with the incidents of pole failure you mention, if they are caused by lightning, one should find them at currents below 100 kilo amps. So the information you have given me is a bit of a mystery. We did not select the poles we use; ESCOM provided them and we certainly have not had power follow on the line. That may play a part or I believe it may. I think the clue here lies in the route that the flashover takes and you may have noticed in the diagram that the top of the pole is fitted with a little bracket for an overhead shield wire and this together with the steel cross-arm bracket and the earth cable that we have on the pole encourages the flash-overs to take a path along the surface and not through the pole itself. In a high voltage laboratory where we have done some impulse work, and, as it happens, on wooden poles, we were able to puncture and split poles into braaivleis wood very easily by just not allowing the current to flow along the outside surface of the pole but by forcing it through the inside and I think the pole-top fitting may play an important part here. We do intend to look at this more carefully using the hihg-voltage laboratories rather than a test line and I suspect we may come out with some recommendation about fittings on top of the poles to protect them.

I do not think that fault level has a real role to play on the damage to the pole itself.

Mr. Gaunt asked where the flashovers mainly took place. The most obvious flashover damage to us, was between the cross-arm and the earth-cable although we did have cross-arm damage occasionally and less occasionally damage on the top section of the pole.

Several people asked about attractive range effects. As far as we can determine from data from most regions of the world, that equation can be used for structures up to about 500 metres high, which takes you beyond the distribution range of structures. Mr. Fortmann asked how we determine this. It emerged from our study of lightning effects on structures and the striking distances over which lightning will approach structures. This has been an active project on our research mast at the CSIT for the last 7 or 8 years where we used similar photographic techniques to measure the striking distance effects. We have also looked at the observed direct strike performance of a wide variety of structures round the world and expressed that in terms of an equivalent attractive range and, bringing all that work together, gave us the equation that is used in this report. We were very encouraged to find that the direct stroke performance on the test line agreed well with that equation and that gave us further confidence in the equation. The old equation was based on empirical observations on old lines and earlier line performances overseas and I think the fact that, from our point of view, they got it all wrong is because they were not able to monitor accurately the direct strokes to the line. It is enormously difficult as Mr. Gaunt probably knows, to get accurate fault performance data on systems and it is even more difficult on an operating line to determine how often it is really directly struck. It was only on the test line that we were able to monitor every direct strike and thus we had confidence that we knew exactly how many direct strikes we had had and I think the fact that the equations were too low, lies in the difficulty of monitoring line performances accurately.

Mr. Clarke asked about codes for mounting arrestors as factory fittings. ESCOM have already drawn up a standard for themselves for tank mounting of arrestors and I believe this is now getting to the point of factory fitting. It certainly has the potential of being implemented on a factory fitting basis. In the United States factory fitting is already taking

place. I agreed completely one should avoid the christmas tree effects with a variety of designs. The whole point we are trying to sell here is consistant and co-ordinated insulation level and it is the "christmas trees" that cause the weakening of line structures and really ifluence outage rates, so we would like to see a standard approach to that.

The last point, raised by Mr. Gaunt, was what I meant by trips leading to failure. By trips here I did not mean trips by an arrestor, I meant an arrestor and power follow discharge operation on multiple strokes causing circuit-breaker operation. I think it is reasonable to assume that on a normal operating system one will be using reclosing circuit-breakers and, through having an unnecessarily low arrestor spark over level, you will be causing unnecessary nuisance operations of a circuit-breaker and possible lock-outs if you do it too often. I am not actually talking of failure there, but of trying to minimise the nuisance trips on the line, and operating experience in ESCOM certainly bears this out. The proposal here is that a small rise in the arrestor spark over level could have quite a dramatic improvement in those nuisance trips.

I think, Mr. President that this covers it more or less.

RATIONAL NORMS FOR ELECTRICITY DISTRIBUTION IN RESIDENTIAL TOWNSHIPS

J.K. Von Ahlften – Pr. Eng.

Mr. D.H. Fraser: President

It is now my pleasure to call on our friend and colleague Jules von Ahlften to present his review of the work of the small group that has been deeply involved over many months in an endeavour to produce rational norms for electricity distribution in residential townships. It would be presumptuous of me to attempt to introduce Jules to this gathering or to endeavour to detail his many contributions to the working of the AMEU. In any event that would take too long and I know he is anxious to get started on the members forum. However may I on behalf of all AMEU members express our sincere thanks to you for your untiring efforts on our behalf.

Mnr Jules von Ahlften

1. INTRODUCTION

A brief report was submitted to the 1981 Convention in Durban on the work and progress of the Technical Committee in establishing rational norms for electricity distribution in residential townships. It was felt, however, that a more comprehensive submission giving the reasons for the establishment of rational norms for engineering services and outlining the administration and application of such norms would be of interest to all engineer members of the AMEU.

2. BACKGROUND

In order to make an assessment of the reasons leading to the establishment of retional norms for engineering services, it is necessary to sketch briefly the background which led to the consistitution of the technical committees dealing with township services in general.

Among the terms of reference of the Commission of Enquiry into housing matters, better known as the Fouché Commission, was the investigation into the increase in the cost of serviced land for residential township development.

The Commission concluded that the price of an erf was mainly influenced by market forces based upon supply and demand and that the cost of the engineering services played a subordinate role in determining the final selling price. The Commission however found that all developers complained that the standard of services demanded of them by local authorities was much higher that would have applied had the City or Town Council itself provided the services.

It was, therefore, not surprising that, to ensure that the standards of the internal services specified or provided were as realistic and economic as possible, the Commission recommended that the various provincial administrations and local authorities in co-operation with the CSIR should formulate a code of standards with which local authorities and developeres must comply, taking into account needs which may vary from one region to another. The Commission consequently concluded that it was essential to provide and implement uniform norms for all services as soon as possible.

To enable effect to be given to this finding of the Commission accepted by the Government, the Minister of Community Development requested that the NBRI of the CSIR, in co-operation with other bodies and authorities concerned, should draw up uniform rational and functional norms in respect of all the services and that the top authority responsible for housing matters should take active steps leading to the implementation of these norms in private as well as public township development.

It was further recommended that the necessary ongoing research be undertaken in connection with the technical and economic aspects of township and building services and that the results of such research be effectively applied and, in this connection, that new innovative wiring systems and energy saving should receive high priority.

To assist the Minister in implementing the recommendations of the Fouché Commission, a Housing Matters Advisory Committee under the Chairmanship of the Director General of Community Development and a Housing Policy Council under the Chairmanship of the Minister were set up.

With regard to the uniform standards of services, a Steering Committee to consider rational and uniform norms for township services was subsequently established by the NBRI in consultation with the Director General of Community Development and it was decided that the preparation of the necessary guides should be undertaken by technical working committees constituted of members with the necessary expertise from the various regions of the Republic to cover the following services:–

- Water reticulation
- Sewerage
- Roads, Stormwater and Sidewalks
- Traffic and Transportation

3. TECHNICAL COMMITTEE FOR ELECTRICITY DISTRIBUTION

The NBRI considered the AMEU to be the appropriate body to constitute the technical committee for electricity distribution and requested it to undertake this task.

The Executive Council of the AMEU agreed to this request towards the end of 1978 and the following Technical Committee was constituted as being respresentative of the various regions in the Republic:–

J.K. von Ahlften –	Chairman and the AMEU representative on the Steering Committee
J.A. Loubser –	AMEU Highveld Branch – Vice-Chairman
K.J. Murphy –	AMEU Good Hope Branch
D.R. Hill –	AMEU Natal Branch
J.D. Dawson –	AMEU Cape Eastern Branch
A.H.L. Fortman –	AMEU Highveld Branch (which include the O.F.S. Branch at that stage)
M.R. Padfield –	ESCOM – Western Cape Undertaking (Nominated by ESCOM Management)
J. Prak –	CSIR – Nominated by NEERI
A. Lap –	Technical Representative (Electrical)
J.J.V. Neveling –	NBRI – Co-ordinator for all the Technical Committees

The South African Association of Consulting Engineers (electrical and mechanical division) was invited to comment upon and contribute to the guidelines and the standardised specifications for engineering construction. The G.P.O. was consulted regarding their requirements for the location of underground communication cables in the verges of the revised road reserves for residential townships.

The ESCOM representative was nominated from the Western Cape Undertaking which has the largest percentage of ESCOM's urban consumers and thus had considerable experience in the reticulating of townships.

4. GUIDELINES FOR ELECTRICITY DISTRIBUTION

The Technical Committee held its first meeting in March 1979, has met 17 times since and has produced the final "guidelines" for submission to and approval by the authorities concerned.

To start off the work of the Committees, a questionnaire was sent out by the NBRI to all the major local authorities in the Republic including ESCOM. This was completed and returned by ESCOM and 58 local authorities. The questionnaire was lengthy and covered the whole

technical and financial field of the engineering services involved.

The valuable information gathered from the replies to the questionnaire is respect of electricity distribution, together with the Cape (AMEU) guidelines and the T.P.A. guidelines, which were drawn up following the findings of the Niemand Commission in 1974 was used as the basis for the preparation of the new guidelines.

As part of the whole project, the members of the Technical Committees were given a plan of a typical residential township, code named "Sampleville", and were requested to draw up an estimate of the cost of the internal township services based on 3 different types of township layout.

Plan A was based on a typical layout with 309 erven, Plan E was based on a layout with reduced road reserves giving 383 erven and Plan F provided a combination of residential erven and erven for townhouse type of development giving 443 dwelling units.

The average cost of the services can be tabulated as follows with the electricity service based upon an ADMD of 6 kVA per erf –

Service	Plan A (309 erven)	Plan E (383 erven)	Plan F (443 dwelling units)	Average actual per cent	Average rounded per cent
Water Per cent	R 573 9,93%	R 343 7,75%	R 414 9,69%	9,12%	10%
Sewerage Per cent	R 598 10,35%	R 527 11,80%	R 446 10,44%	10,90%	10%
Electricity Per cent	R 980 16,98%	R 857 19,35%	R 818 19,14%	18,49%	18%
Residential Street Lighting Per cent	R 126 2,18%	R 133 3,00%	R 132 3,08%	2,75%	3%
Roads and Sidewalks Per cent	R2 676 46,35%	R1 796 40,56%	R1 741 40,74%	42,55%	42%
Stormwater Per cent	R 820 14,20%	R 772 17,43%	R 772 16,90%	16,18%	17%
TOTAL	R5 773/ erf	R4 428/ erf	R4 273/ dwelling	100%	100%
SAVINGS Per cent	A over E 23%	A over F 26%	E over F 3,5%	–	–

NB: The above analysis is based on costs obtained in October 1980. Present day costs have probably escalated by some 30%.

The above estimates do not include the costs of the external access supply and trunk mains, nor the costs of the service connections of any of the building services e.g. plumbing, drainage, electrical wiring etc., but are the costs to bring the services to the erf boundary, i.e. the point of supply for the electrical service, ready for connection to the internal house services.

A significant result of this exercise as far as the electrical service is concerned was that the difference in estimates submitted by the municipal members and ESCOM, based on the present standards in their respective regions, did not differ by more than ± 5%, which does indicate that the norms for the electrical services are pretty well up to a uniform standard.

Analysing the costs of electricity distribution, service connections and street lighting, the following interesting average figures were obtained:–

Electricity Distribution	Cost/erf	Percentage
High voltage system	R 310	27%
Low voltage system	R 550	48%
Service connections	R 155	13%
Street lighting – residential only	R 135	12%
TOTAL	R1 150	100%

One of the most significant of the problems identified is that engineering services cost more than necessary when the special layout needs of each service are not co-ordinated in the overall layout planning.

The Fouché Commission's recommendations therefore envisage an overall target of providing an economical residential layout which optimizes the engineering services needed by the occupants and which is acceptable to them as a living environment within their financial means.

The above research into the cost of providing services has clearly shown that road layout plays a key role in the costs of the engineering services. The roads and sidewalks account for the largest capital layout.

The most significant savings are therefore to be obtained in a township layout giving the maximum utilisation of road reserves and erven and co-ordinated design of the engineering services including communication services.

As the guidelines have yet to be approved by the higher authorities, it would not be appropriate to discuss in detail the technical contents of the Guide in this paper, so it is proposed rather to give a resumé of the general approach to the guidelines and their objectives.

The AMEU representatives on the Committee were chosen from the various regrions in the Republic to facilitate obtaining feedback from their regions on any matters needing consultation, and the following basic issues were accepted by the Committee subject to modification in future as more relevant data becomes available:–

4.1 Design ADMD (Per consumer supplied from a given substation)

Three categories of township classification were accepted by all the Committees as follows:–

Category	Type	ADMD (kVA)
A	Higher income group	4 to 8
B	Middle income group	2,5 to 4,0
C	Lower income group	1,5 to 2,5

The above values apply where 100 or more consumers in a group are being considered and are fairly wide for each group. Obviously knowledge and experience in each region will be the determining factor, but the figures are considered to be reasonably representative for the R.S.A. at the present time.

4.2 Limits of voltage drop

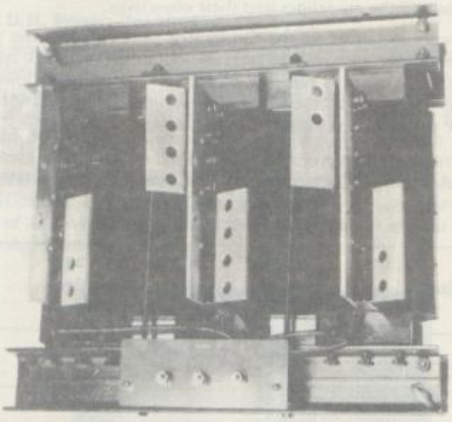
The low voltage system design is based on a maximum calculation voltage drop of 10% at the consumers point of supply made up as follows:–

H.V. distrubution: 2 per cent
Transformer: 2 per cent
L.V. distribution: 6 per cent

4.3 Voltage drop chart

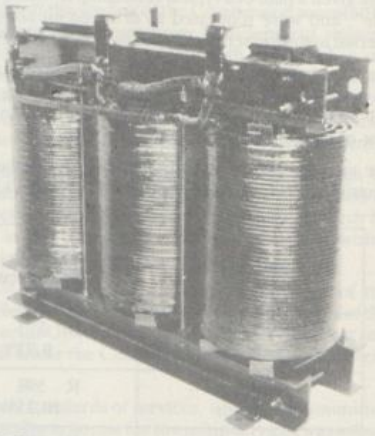
A voltage drop chart, incorporating diversity and unbalance factors, for determining the voltage drops in voltage distributors has been included in the Appendix as well as examples of how to use this chart. It was produced by the Durban Electricity Department and is based on a similar chart approved by the Association of Chief Engineers in the U.K. and contained in their report issued in 1966. The Durban Electricity Department amended the U.K. chart to suit South African requirements and it was checked in a practical manner by each of the Committee members.

OIL & AIR COOLED TRANSFORMERS — REACTORS CHOKES — WIRE WOUND RESISTORS



BY

OAK



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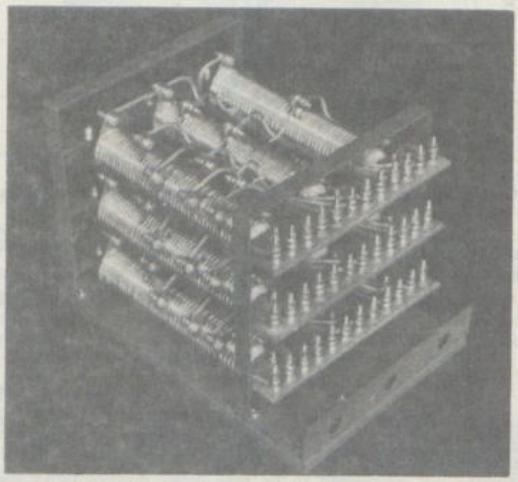

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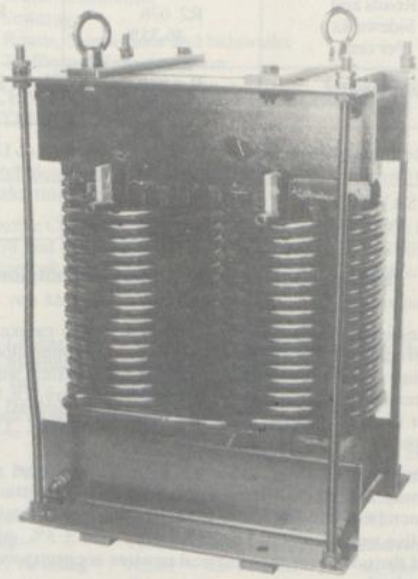
Close Transition Starters.



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The opinion has been expressed by certain Committee members that the use of the chart could result in over-designing. The Committee accepts that this may be so, but in the absence of specific data similar to that offered by the A.C.E., it was decided to accept the chart at this stage.

4.4 Earthing

The guide recommends the use of the AMEU Code of Practice for the Application of Multiple Neutral Earthing to Low Voltage Distribution System, but makes it clear that there are other methods and refers to other Codes such as BSS Code CP.1013.

4.5 Street Lighting

The guide recommends the use of the SABS Code of Practice for Public Lighting, but the Committee has recommended that the SABS produce a further section for street lighting in purely residential areas, as it is felt that the present code standard is too high for this purpose and therefore too expensive.

The Housing Advisory Committee has resolved that the proposed Guidelines for the engineering services should be circulated to a limited but representative number of local authorities for comment. This was to have been in collaboration with the United Municipal Executive and the various Provincial Municipal Associations but because of the urgency of the matter, the documentation was sent direct to the Town Clerks of the following twenty-seven local authorities selected by the United Municipal Executive for this purpose:–

> Johannesburg, Cape Town, Durban, Pretoria, Port Elizabeth, Germiston, Kempton Park, Roodepoort, Sandton, Belville, Uitenhage, Pinetown, Klerksdorp, Pietersburg, Vanderbijlpark, East London, Kimberley, New Castle, Pietermaritzburg, Bloemfontein, Welkom, Sasolburg, Richards Bay, Ladysmith (Natal), Stellenbosch and George.

To further inform the selected local authorities on the broad principles underlying, and the objectives of, the guidelines, discussion sessions were held in the various centres at which a panel consisting of the Chairmen of the five Technical Committees explained technical aspects and answered general queries.

Branch representatives of the Electrical Technical Committee were also present at the sessions held in Durban, Port Elizabeth, Cape Town, Bloemfontein and Pretoria but, regrettably, the attendance and response by the Town and City Electrical Engineers of the above selected local authorities were poor. It would appear that the majority of the Town Clerks to whom the documentation and invitation had been sent either failed to consult with or to pass on the electrical documentation to their respective City and Town Electrical Engineers because of an apparent lack of internal communication.

It is therefore still possible that constructive comments may be forthcoming before the closing date for written comments, i.e. 6 November 1981 from the selected local authorities involved and that a positive response may be reported at the Technical Meeting.

5. PROBLEM IDENTIFICATION

It was recognised that the Technical Committees would mainly concentrate on the technical aspects of the norms but it was inevitable that past difficulties relating to administrative and fiscal policies and practice affecting township development, particularly with regard to the controversial division of financial responsibilities, would be raised. These include:–

- The approval of subdivisions by various bodies other than the Townships Board or Provincial Administrations.
- The varied existing Provincial legislation and interpretation thereof.
- The exact point of division of financial responsibility for the provision of engineering services and time consuming approval procedures for forrowing powers.
- The planning, design and services provision process for the compilation of a final township layout plan.

Recommendations on these matters have been submitted to the Steering Committee. Another technical aspect that came to the fore was the present process of approval of layout plans by the Provincial Administrations and their Township Boards, which does not cater for sufficient weight being attached to the cost effectiveness of such layouts from the engineering service point of view.

There is a need for some form of parallel approval of a services plan by competent persons to prevent layout plans that are expensive to service from becoming a fact before service engineers have been able to assess the cost implications. A recommendation to this effect has been submitted.

Regarding the financial responsibilities, the Fouché Commission's recommendations, which were accepted by the Government, are that the township developers, whether private or local authorities, should be responsible for developing the township fully and for the installation and financing of the internal engineering services. This is a reversal of the earlier recommendations of the Niemand Commission.

In this regard the Technical Committee has recommended that the approach service of access supply to residential townships be clearly defined and that the supply authority should accept financial responsibility for this as opposed to the internal reticulation for which the developer must accept financial responsibility.

The Fouché Commission has further recommended that, to safeguard purchasers from having to pay twice for the same service in cases where the private township developer has already paid for the services in full and recovered the costs in the purchase price of the erven, the local authority taking over responsibility for the services should only be allowed to charge normal tariffs which would exclude any provision for capital expenditure of the internal engineering services.

6. ADMINISTRATION AND APPLICATION OF THE NORMS

The engineering representatives of the Department of Local Government of the four Provinces on the Steering Committee considered the question of an appropriate vehicle for the administration of the norms once established and have submitted the following proposals:–

- There is no need for the rational norms to be promulgated as regulations in the Ordinances exist to apply them.
- Once the rational norms have been approved by the Department of Community Development and published, the Executive Committee of each Province will adopt the document as a base document to be used by the Director of Local Government when laying down conditions for the provision of services for new townships or updating of services in rezoned or redeveloping areas.
- The norms document should be used to govern the design parameters for the services. The physical installation of these services should be carried out in accordance with the relevant SABS 1200 series NSSEC documents which will form part of the norms by reference. It is envisaged that the Townships Boards, in their respective provinces, will either use extracts from the norms document or merely quote by reference the specific clauses required in order to define the level of the services to be installed for a specific township. The norms thus chosen will then become part of the final approved conditions of establishment of the township.
- The procedure at present in use whereby the local authority certifies that the services as installed have been constructed to its satisfaction before the township of any erf can be transferred from the developer should be retained, but the certificateof approval by a professional or a certificataed engineer should include the suggested words: '... the services provided comply with the norms specified in the conditions of establishment of the township'.
- The norms document as published will provide the basic standards for the design and construction of the township services. Should a local authority or developer require to deviate from the norms, application should be made to the Director of Local Government for the proposed deviation. A fully motivated report for the proposed changes should accompany the application.
- Because both the local authority and the developer work to a common known document, the process of negotiation for the services agreement should be facilitated.
- It is recommended that, in order to assist the Townships Board with their deliberations on the provision of services to townships, an engineering staff member from the Department of Local Government should act as co-ordinating engineer on all technical aspects of the layout and provision of services and attend meetings of the Private Townships Board for this purpose.
- The Townships Board is each province should include one member appointed on account of his expert knowledge of the design, construction and operation of township services.
- The principle that the designer of the services should be involved in development of the township layout from the earliest is supported. To achieve this, the layout plan accompanying the township document should indicate the proposed services and a professional or certificated engineer should certify that the design of the layout has been based on the services norms. The services engineers should stay involved in the development of the layout as it alters due to other input factors up to final approval.
- As a result of Government acceptance of the Niemand report,

Provincial Ordinance were revised to include for the relevant recommendations. Decisions have now to be taken by the appropriate authorities as to what measures resulting from the Niemand recommendations should be retracted in order to be replaced by new legislation in accordance with recommendations of the Fouché Commission.

These proposals were accepted by the Steering Committee and submitted to the appropriate higher authorities for consideration. It is most likely that a definite indication can be given at the Technical Meeting of the official decision in this regard.

7. STANDARD FORMS OF SPECIFICATION FOR ENGINEERING CONSTRUCTION

As the adoption of standard forms of specification for construction is a natural and desirable corollary to the concept of norms or guidelines for the design of engineering services, attention has been given to this aspect both in the civil and the electrical engineering fields.

The South African Institution of Civil Engineers and various other bodies involved in the civil engineering field have compiled national standardised specifications for the civil engineering construction (NSSCEC) in collaboration with South African Bureau of Standards. The Technical Committees have therefore joined forces also to apply this process to engineering services in townships including electrical services. The word 'civil' has therefore been dropped from the abbreviation which has now become NSSEC i.e. National Standardised Specification for Engineering Construction.

Good progress has been made with the drawing up of national specifications for the construction of the electrical reticulation of townships, including standardised general conditions of contract which are being prepared by a specialist committee chaired by the electrical and mechanical division of the South African Association of Consulting Engineers, with Messrs. A.H.L. Fortmann and J.A. Loubser as the AMEU representatives on this Committee.

Guides for the drawing up of particular project specifications and the design of systems are also being prepared for incorporation in the national specifications.

8. MAIN OBJECTIVES OF THE RATIONAL NORMS

Turning to the main task of the whole exercise, i.e. the technical norms or guidelines for the installation of engineering services in townships, it has become amply clear that the greatest potential savings in the provision of all township services lie in the new approach to layout planning with particular reference to reduce overall road reserves.

Basically the norms for each service cater for three levels of township development:–

- Lower income group
- Middle income group
- Higher income group

Clearly grey areas may arise and mixed development might occur, but obviously each development will have to be treated on its own merits and needs. It is therefore not intended that the Guidelines should be rigid in their application but flexible. They are therefore primarily intended to contribute towards a sound and economic network design to suit the individual needs and requirements for white, black, coloured and asian housing.

Indications are that the Guidelines will have been officially approved and issued as an official document by the Department of Community Development prior to the Technical Meeting. The majority of the engineer members will then have had an opportunity to study these apart from the engineer members of the selected twenty-seven local authorities to whom the documentation has already been sent.

An expert panel consisting of experienced engineer members of the AMEU who are members of the Technical Committee will be present during the discussion on this paper and there is no doubt that any questions arising from the floor on any technical aspects of the Guidelines will be dealt with adequately and it is hoped that interesting and informative discussion will arise.

The technical committee for traffic and transportation has clearly proved to be the most inportant of all the committees, and its recommendations will no doubt cause the biggest changes in policy and reduction in the overall cost of serviced land.

Mr. Cameron of the NITRR is a member of this technical committee and has, therefore, been invited by the AMEU to address this meeting on the work and recommendations of his Committee. This should prove of special interest to municipal electrical engineers and will make a valuable contribution to this paper and the proceedings of our Technical Meeting.

9. CONCLUSION

In conclusion the following points are relevant:–

- The work on this project was undertaken under the direction of the Housing Matters Advisory Committee under the Chairmanship of Mr. L. Fouché, Director General of the Department of Community Development whose Department financed the project.
- The members of the Technical Committees represented all the main regions of the Republic and were chosen for their specialist knowledge and experience in the field concerned.
- The Steering Committee has passed on the norms documents to the Housing Matters Advisory Committee which will make recommendations on their publication, application and administration.
- A mechanism to update the norms has been recommended and an updating committee under the auspices of the Housing Matters Advisory Committee will be established.

10. REFERENCES

10.1 FOUCHÉ COMMISSION REPORT – CHAPTER V

10.2 NIEMAND COMMISSION REPORT

10.3 T.P.A. GUIDELINES FOR MUNICIPAL SERVICES – PART IV

10.4 CAPE AMEU GUIDELINES FOR ELECTRICITY DISTRIBUTION

10.5 RATIONAL NORMS FOR TOWNSHIP SERVICES – P.R. CRABTREE NBRI – IMIESA JOURNAL JUNE 1981

THE SIGNIFICANCE OF ROAD LAYOUT IN MINIMIZING THE COST OF ENGINEERING SERVICES IN RESIDENTIAL TOWNSHIPS

1. INTRODUCTION

Mr. Von Ahlften has given some background to the effort which the NBRI has recently devoted to the determination of rational norms for engineering services for residential townships. Of greatest significance was the co-operation and collaboration between civil engineers, electrical engineers and town planners, which was aimed at deriving optimal solutions to development problems.

The advantages of co-ordinated development have been amply demonstrated by the development of Mitchells Plain, the coloured New Town on the Cape Flats. In the words of the Cape Town City Engineer *"the design process normally encountered in low-cost* 'or any other' (my words) *housing projects, where planners, land surveyors, engineers and architects work in series, roughly in that order, with comparatively little communication between each stage, allows scant opportunity for one discipline, perceiving a lost opportunity for an economy or a design improvement, to influence the work that has preceeded"* (Brand, 1979).

The procedure which Mr. Von Ahlften has described attempts to recognise this short-coming by suggesting a more interactive process for the planning and design of residential townships. Hopefully, this "co-ordinated development" approach will extend into implementation even in private townships : however, this was beyond the scope of the rational norms exercise.

2. THE COST OF ENGINEERING SERVICES

It has not been possible to set down procedures or norms (standards) which will be universally applicable; nor has it been possible to specify the ideal balance between the requirements of the different services which will minimize total costs. This is because in one case lower costs may be achieved by a **"reduction of standards"**, for example, a decision to provide single track roadways in an area of low car ownership. In another case, savings may be effected by **"designing out"** elements such as stormwater drainage or pedestrian footways. However, for the general case, the "Sampleville" experiment, to which reference has been made by Mr. Von Ahlften, demonstrates that the greatest overall savings are achieved by rationalizing circulation space (road reservations). Traffic circulation (roadways and footways) has the greatest overall space requirement and it was concluded that the circulation requirements of other services can be accommodated, either over- or underground, within the minimum requirements for safe, efficient and economical traffic circulation.

J.W.M. Cameron – M.Sc, M.C.I.T.
Senior Chief Research Officer – CSIR

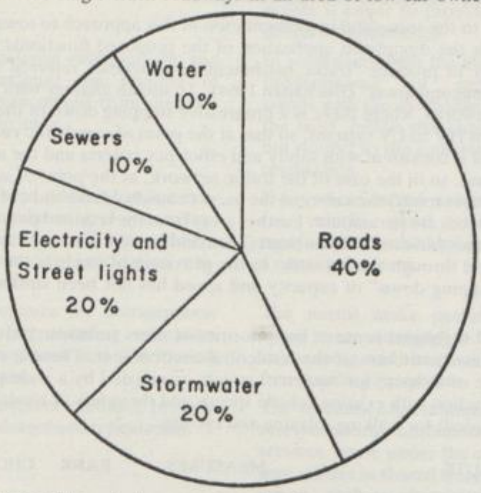


FIGURE 1: The relative cost of engineering services.

The analysis of component costs in the provision of residentail services reveals that on average 40% of the costs are attributable to roads. (Cameron, 1981a.)

The proportionate costs of all services are highlighted in Figure 1 and Table 1 : a 10% cost saving on roads can, therefore, result in overall savings even if there is a consequent increase (of the same order) in the costs of one or more of the other services. For example, in one case the Sampleville experiment produced a 10% overall saving despite cost increases of 24% for street lighting, 3% for electricity, 4% for sewerage and 11% for stormwater. Table 1 contains the cost estimates for Sampleville and in the case of Plan F illustrates how further cost savings may be achieved where "general residential" services requirements are satisfied as part of the initial design process.

No of Cost Estimates	PLAN A 309 erven Mean area/erf 1053 m²		PLAN E 383 erven Mean area/erf 963 m²			PLAN F 326 erven Mean area/erf 963 m²			Average % of Total Cost
						117 d.u Mean area/d.u 365 m²			
	Cost/Erf R	% of total	Cost/Erf R	% of total	% cost Increase/ Decrease	Cost/d.u R	% of total	% cost Increase/ Decrease	
Water (4)	573	9,9	403	7,8	– 30%	414	9,7	– 28%	9,1
Sewerage (5)	598	10,4	619	11,9	+ 4%	446	10,4	– 25%	10,9
Electricity (7)	980	17,0	1007	19,4	+ 3%	818	19,1	– 17%	18,5
Street lighting (3)	126	2,2	156	3,0	+ 24%	132	3,1	+ 5%	2,8
Roads (Tar & Kerbs and Channels) (4)	2676	46,4	2110	40,6	– 21%	1741	40,7	– 35%	42,6
Stormwater (4) (New Method)	820	14,2	907	17,4	+ 11%	722	16,9	– 12%	16,2
Total	5773	100	5202	100	– 10%	4273	100	– 26%	100

TABLE 1 : Sampleville – cost of services (Cameron 1981a.)

3. THE MAGNITUDE OF COST SAVINGS

The significant savings on roads are the result of two main factors.

- Design of local roads (roadway) and local road systems (network) to serve ACCESS TRAFFIC ONLY.
- Application of a FUNCTIONAL TRAFFIC CIRCULATION HIERARCHY which imposes constraints on layout design and result in improved estimation of traffic volume and composition over the "design life" of the facilities.

In the case of the former, the most notable result is that **geometric design standards** are significantly lower than has hitherto been the case. This is because they reflect the fact that "local traffic" is tidal in nature, is slow-moving, and has a relatively low proportion of heavy vehicle movements. The second factor results in a closed system which precludes through traffic, and enables **structural design standards** to be reduced to such an extent that, for residential access roads, no structural design period is applicable. This is because the "cumulative equivalent traffic" is estimated to is estimated to be less than 0,05 x 10^6 E80/lane*.

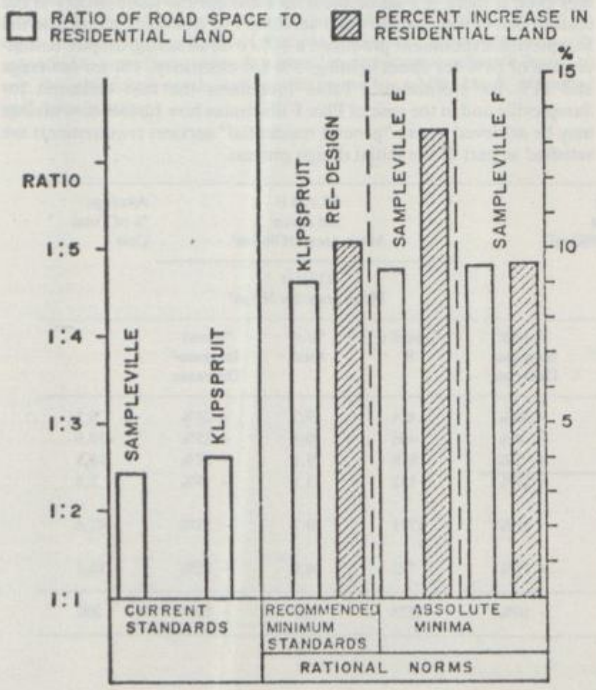
The magnitude of potential cost savings is illustrated in table 2 which compares "old" and "new" standards for the alternative Sampleville layouts. The difference is that the "new", or rational norms layout and standards, cater specifically for bus routes : buses and other heavy vehicles are generally precluded from other local streets. The unit cost savings are attributable to lighter pavement structures AND the total cost savings to the reduction in road space.

OLD STANDARD (All roads of structures suited to bus operation)	OLD STANDARD (Most "likely" roads designed to accommodate bus operation) Other roads	NEW STANDARD Only bus routes designed.
$> 0,2 \times 10^6$ E80/lane	$< 0,2 \times 10^6$ E80/lane	$> 0,2 \times 10^6$ E80/lane
TOTAL COST:		
R340 000	R260 000	R180 000
UNIT COST:		
R5,60 m²	R5,02 m²	R3,74 m²

TABLE 2 : Comparative road costs.

Apart from direct cost savings, the major benefit of the rational norms is that, if applied, they will encourage more efficient and economical use of residential land, making up to 10% more land available for housing development. This improvement in the ratio of road space to residential land is illustrated in figure 2.

* The number of E80's (80 kN single-axle loads) is termed the equivalent traffic; the equivalency factor relating the number of repetitions of a given axle load to the equivalent number of E80's. For example, a single axle load of 45 – 54 kN would have an 80 kN equivalency factor of 0.14 (National Building Research Institute, 1982).



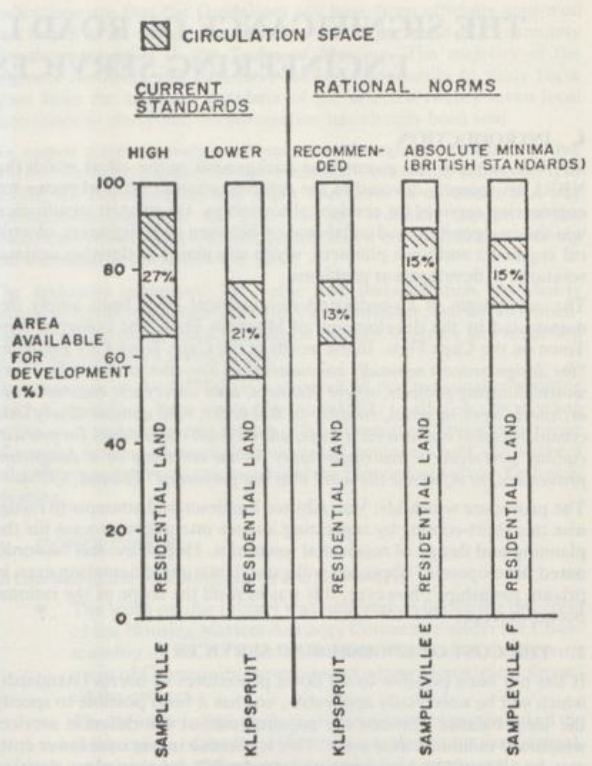


FIGURE 2 : Reduction of circulation space.

The key to the successful implementation of this approach to township layout, is the disciplined application of the proposed functional road hierarchy to produce "traffic catchments", sometimes referred to as "environmental areas" (Buchanan 1964). To use an analogy with electrical networks, where there is a progressive stepping down of the voltage from HV to LV systems, so that at the point of supply the current delivered is consistent with safety and efficiency criteria and the needs of the user, so in the case of the traffic network, at the point of supply (local access roads) the safety of the users (householders) and environmental needs are paramount. Further away from the terminal points the users' needs (drivers and passengers) demand greater roadway capacity and speed through the network. In the provision of roads in the past, this "stepping down" of capacity and speed has not been sufficiently rigorous.

Table 3* highlights some of the priorities of users (residents) towards road related attributes of the residential environment. There is strong evidence of a desire for "quieter" streets manifested by a widespread dissatisfaction with existing vehicle speeds and the safety of roads (verges included) for walking, playing and cycling.

ATTRIBUTE	MEASURES: Satisfaction (Dissatisfied)	MEASURES: Importance (Very)	RANK	CHOICE
	%	%		%
1. QUIET STREET	35	69	6/24	30
2. NEAR BUS ROUTE	–	58	9,24	23
3. VEHICLE SPEED	46	–	19/21	–
4. SAFETY OF VERGE	45	–	18/21	–

TABLE 3 : Attitudes towards attributes of the residential environment.

The table shows the proportion of residents who are dissatisfied with their immediate road environment, the proportion who consider the first two attributes to be very important, the rank order of importance of the first two attributes and the rank order of satisfaction with the third and fourth and the percentage of respondents who actually selected their dwelling in terms of the first two attributes.

It is therefore important to stress that the potential benefits to the residents and commuters, of the principles and standards contained in the rtional norms inlcude:

1. Improved environmental conditions viz.
   - safety
   - privacy
   - lower noise levels.

* These data are extracted from results of an extensive survey of traffic and road usage in residential townships in four metropolitan areas in South Africa (Cameron 1982).

2. Lower overall costs viz.
   - more economical use of resources (particularly land)
   - cheaper services.

4. RECONCILIATION OF SERVICES REQUIREMENTS

The Sampleville experiment was conducted at an early stage in the investigation into rational norms. At that stage no attempt had been made to reconcile the needs of the different services and as a consequence, the product reflects the priority given to traffic and road needs. Subsequently, an attempt was made to reconcile the needs of all services. The CSIR and the Department of Community Development are currently involved in a "demonstration project", which aims to evaluate the proposed rational norms. The project involves the planning and design of the new Indian township in Pretoria West and the product to date, is a series of layouts which are significantly different to the Sampleville prototype because of this reconciliation process.

Of interest to this meeting will be the specific electricity requirements which have been incorporated in the process of reconciliation. In brief, these are as follows:

REQUIREMENTS	COMMENT
• Minimize the cost of linking cables by ensuring that lateral erf boundaries coincide at frequent intervals.	The curvilinear street form characteristic of the proto-type, which produced awkward shaped erven, has now been modified to produce more regular shaped erven which makes it easier to provide coincidental erf boundaries.
• Minimize cable lengths and maximize the number of erven served from distribution units.	In accordance with the above, the predominance of rectangular stands with the short side fronting the road, fulfills this requirement but subject to the constraint of erf orientation.
• Where possible, utilize rectangular or grid system layouts to facilitate efficient electricity reticulation networks:	Even where curved streets remain (as vehicle speed attenuation measures) erf subdivisions assume a rectangular form.
• Minimize the obtrusiveness of free standing substation equipment and distribution boxes.	The norms make provision for "local street widening" to facilitate landscaping and the placement of free-standing equipment.
• Wherever possible, provide underground reticulation.	The recommended minimum road reserve widths accommodate all services, some under the carriageway, others in shared trenches and others, such as electricity, under the verges.
• Erven should as far as possible be placed on both sides of the road.	This requirement is complementary to those of all other services and is incorporated in the norms.
• Avoid long narrow clusters of erven not linked to any other areas.	See above.
• To reduce electricity runs avoid excessively wide frontages.	See above.
• Electricity distribution should preferably be located in verges of road reserves.	See above.

Unfortunately, however, it was not possible to accommodate all the requirements of each and every service. In the case of electricity distribution, the two main deficiencies relate to culs de sac and curved streets. the norms for electricity distribution stated that:

- *Straight streets are preferable for overhead reticulation. If underground cables are used, changes in road alignment are acceptable. Electricity supply is the most flexible of all the services to be provided and virtually any shape of layout can be reticulated bu always at a higher cost.*
- Culs-de-sac may in some cases substantially increase the cost of the electricity supply system.

The research into traffic behaviour and circulation needs has indicated the need for "quiet" access streets which incorporate speed attenuating features. Culs de sac and curvature provide the necessary attenuation. However, the length of the street section and its width also have an effect on vehicle speed and, accordingly, curvature has only been introduced where straight road sections exceed about 150 m. Provision has been made for servitudes in the heads of culs de sac.

5. CONCLUSION

Provision has been made for regular revision and updating of the rational norms and it is hoped that as implementation progresses, data and information will be generated which will provide a quantitative basis to the process of reconciliation, which will evolve to become a more rigorous optimization procedure. The CSIR has agreed to monitor this implementation to facilitate the process.

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DISCUSSIONS / BESPREKINGS

Mr. Ken Robson: East London

Members and affiliates have been aware of the work being done by the National Building Research Institute's Technical Committee for Electricity Distribution which has functioned under the auspices of the Executive Council of the AMEU and the chairmanship of Mr. J.K. Von Ahlften.

This Committee has been working for over three years and it is timely therefore that the general membership of the AMEU be brought into the picture with regard to the background and objectives of the rational Norms for Electricity Distribution in Residential Townships and the proposals for their application in the four Provinces.

It is a privilege to contribute to the discussion on Mr. Von Ahlften's paper and to record our congratulations on its content. I am grateful also for this opportunity to offer comment on the paper and to ask the speaker some questions.

Electrical engineers have been subjected over many years to criticisms by township developers that the standards and costs of electricity services were inordinately high. Thus it is satisfying to note the speaker's statement that estimates submitted to the Committee from various regions did not differ by more than ± 5%. It would have been useful to have had included in the paper layout drawings of the typical residential township named Sampleville to supplement the table of costs. It is not clear from the cost summary on Page 5 of the paper where the cost of transformation has been allocated in the total cost in 1980 of R1 150 per erf, including service connection, but it is assumed it has been included with the HV system. The estimated cost per erf, including service connection for a township of 73 erven (a much smaller number) designed at the end of 1980 by the East London Undertaking was R1 328 which is 15,5% higher than the speaker's figure. The total cost for this township was made up as follows:

High voltage cables	R17 546,00	
Miniature Substation	10 028,00	28,3%
Low Voltage Cables	48 303,00	50,0%
Street Lighting	10 487,00	10,8%
Service connections	10 585,00	10,9%
TOTAL	R96 949,00	

It would have been helpful to have the details of the design which resulted in a cost of R1 150 per erf.

It is disappointing to find that the approved Guidelines were not issued prior to this Technical Meeting to enable them to be studied with Mr. Von Ahlften's paper.

The statement in the paper that the road layout, its design and road reserve dimensions play a keyrole in the costs of engineering services confirms the opinions of many municipal electrical engineers that overall township costs have been adversely affected in many instances by the road layouts. Understandably therefore the recommendations of the Technical Committee on Township Traffic and Transportation are awaited with keen interest.

A word of sincere congratulation is due to Mr. Cameron for his informative and stimulating presentation which has complemented Mr. Ahlften's paper – Mr. Cameron has been an impressive addition to our panel of authors.

The author has not elaborated on the policy proposals in respect of costs of external access/trunk mains but possibly he is now in a position to give further details.

Also has agreement been reached on the definition that the consumer's point of supply is the point where the electricity service connection crosses the erf boundary?

Notwithstanding the fact that the Technical Committee has received some criticism that the use of the voltage drop chart could result in overdesigning of systems the work of the Durban Electricity Undertaking in producing the chart is to be commended.

The author is requested to indicate what proposals the committee have for monitoring the technical and financial effectiveness of the Guidelines in future developed townships.

The statement is made in the paper that, although the Guidelines recommend the use of the SABS Code of Practice for Public Lighting, the Committee has recommended the inclusion in the SABS Code of a reduced standard of street lighting for residential townships. It would be of interest to know the reaction of the Bureau to this recommendation.

Perhaps Mr. Von Ahlften could elaborate on his statement that there is a need for some form of approval of a service plan by competent persons in parallel with approval by the Townships Board of new township layouts. Who will comprise these "competent persons?"

There must be serious reservations with regard to the recommendation of the Fouchè Commission that, in instances where private developers or local authorities have been responsible for the capital costs of electricity services, consumers in these townships should be charged for electrical energy supplied on a special tariff which excludes capital charges on the capital cost of internal electricity services. Is Mr. Von Ahlften correct in including local authorities? There would appear to be merit in opting for an alternative method to those laid down by the Niemand Commission, namely that private developers provide initially the capital funds on a 50% and 100% refundable basis when say 1/3 and 2/3 respectively of the erven have been built upon and connected.

It is my view that Mr. Von Ahlften should not feel discouraged by the seeming lack of response by city and town electrical engineers to the invitation to attend the five regional discussion sessions. Many of the local authorities listed on Page 7 of the paper had been closely involved with their AMEU Branch representatives on the Technicals Committee throughout the three year period of preparation of the Rational Norms.

Mr. President, Gentlemen the Technical Committee held seventeen meetings and it is fitting that the membership of the AMEU places on record its appreciation to the Department of Community Development, the N.B.R.I., the C.S.I.R., Mr. Von Ahlften and the members of the Technical Committee for their work on our behalf. We salute them.

Mr. V.A. Raynal: Affiliate

I wish to contribute to what has been said this morning about the establishment of Rational Norms for the design of electrical distribution networks in resident townships.

This worthwhile work commenced some 10 years ago under the chairmanship of Mr. W. Barnard assisted by Messrs. Von Ahlften and Jan Loubser. Guidelines were prepared and I gave a paper at the 1975 AMEU Convention in Durban outlining these guidelines and proposing a modern approach to township reticulation.

Because of the ever-increasing shortage of residential property in urban areas in the Republic and the efforts of town planners to make better use of this land, we find ourselves having to provide services in less and less space.

We, as electrical engineers, can make a significant contribution to keeping down costs and providing better and more efficient electricity services in townships by providing opportunities to introduce improvements and innovations in electricity distribution equipment.

I have been disappointed by the response of town electrical engineers in general to the introduction of new ideas and equipment on their distribution systems. How often does one hear that existing methods and types of equipment have been used for many years and, irrespective of economical or other considerations, there is no intention to deviate from these practices. The manufacturing industry in general has made significant progress in introducing new equipment and the S.A.B.S. in specifying and approving it. Similarly the Technical Committee of the AMEU, through the medium of Rational Norms, is seeking to rationalise the design parameters of township reticulation in the national interest.

Yet, if Supply Authorities are not prepared to consider new products and developments, all this effort is wasted.

As indicated by Mr. Von Ahlften, the Rational Norms at present being prepared are only guidelines and will not be mandatory. They are not intended to restrict the choice of methods and equipment available to electrical engineers in this country, but they certainly depend on the active co-operation of all AMEU members for their implementation and success.

In regard to Council reticulation, I gave a paper about seven years ago in Durban and, prior to that, the Niemand Commission had asked that Electrical Engineers take a hard look at trying to cut down the costs of electricity services.

Mr. Barnard, Mr. Loubser and Mr. Von Ahlften were very active in those days and provided them with guidelines.

Since then, over the last decade, I have been rather discouraged at the apparent reluctance in adopting new ideas. We all know that land is becoming scarce and services are becoming more congested; we must all make an effort to try and have services confined in the smallest possible area and this does of course lead to quite a lot of damage through maintenance work on one service affecting another one, and I feel that more has to be done in the way of using new innovations. My experience with local authorities and now with ESCOM as well is that there is strong reluctance among distribution engineers and planning engineers to adpot new methods. One heard yesterday that, in Soweto, paper cables were used because there is quite a high investment in paper cables already, so one can assume that, in an existing township, one should really carry one with a similar type of cable. For new townships, one has a wide variety of new innovations. Manufacturers, the S.A.B.S. and everybody is trying to produce equipment that is simpler to maintain, to install and handle, and that has a longer life, yet so many people are shy to try it out. I am thinking as weel of the smaller street Mr. Cameron showed us. How many subs are very often maxi-subs, while pillars seem to be getting larger. Some thought should be given to trying to eliminate or reduce the amount of street furniture that we have. This is all tied up with the norm because, as Electrical Engineers, we are trying to do our best to provide an excellent service at the minimum price and I would like to make a strong appeal to all Electrical Engineers in the AMEU to take a hard look at how they can rationalise and bring in new ideas and get away from using what has been used for the last 20 or 30 years.

Mr. D.C. Palser: Cape Town

In the schedule in the report the unit costs for street lighting for the three alternate schemes of increasing residential density, namely Schemes A, E and F respectively, are quoted as R126, R133 and R132 respectively, that is, virtually the same in each case. When multiplied by the increasing number of plots in each scheme, however, namely 309, 383 and 443 respectively, the total cost of street lighting in each of the three schemes becomes around R39 000, R51 000 and R59 000 respectively. In other words, the overall cost of street lighting apparently increases as the residential density increases. This is contrary to what one would expect, namely approximately the same total overall cost for the three schemes seeing that they are alternative layouts for the same township, presumably with similar total length of road system in each case. Instead of virtually the same cost per stand for street lighting, as reflected by the schedule, it would therefore have been expected that a decreasing tendency with increasing residential density would have been apparent. Could the panel perhaps comment on this apparent inconsistency?

I note that the recommendations of the Fouché Commission in respect of the installation and financing of engineering services are a reversal of those of the earlier Niemand Commission. My Council's response to the Niemand Commission recommendations in respect of electrical reticulation of residential townships was that it did not favour this work being undertaken by the developer since it was considered that such a system would prove difficult to apply and administer. It was considered that the existing practice whereby the Council undertook at its own cost the electricity reticulation, requiring the owner merely to provide a guaranteed minimum income from the sale of electricity over a five year period, was best. The Provincial Administration subsequently authorised my Council to continue with this practice. It is simple to apply, with all capital costs being recovered via the medium of the electricity tariff.

Regarding the provision of street lighting it would be interesting to know whether it will be incumbent upon local authorities to ensure that

street lighting is provided in all residential townships. At present this is not the case. For example, in the Cape Town area my Council undertakes the installation of street lighting on behalf of the local Divisional Council at its cost. But the Divisional Council does not as a matter of course require street lighting to be installed in all its townships but only in a relatively few selected areas. Could the panel please comment on this aspect?

My final point concerns the definition of "Consumer's Point of Supply". This is quoted in the Guidelines as being "where the electricity supply crosses the erf boundary". The definition also goes on to state that "at this point the consumer's electrical installation is connected to the supply authority's main".

I am not at all happy about this definition. I realise that it is the system adopted by Escom in the Cape and by most, if not all, the Transvaal municipalities. I also accept that it has certain advantages, particularly that all cables can be laid out to the consumers' boundaries at the same time thereby avoiding having repeatedly to come back to site to lay cable from the street kiosk right through to the consumers' premises.

One of the main disadvantages of the proposed system, however, is that laying out all service connection cables early in the township development exposes the cables to vandalism, theft and damage during site and road construction work.

On balance, therefore, I consider it best to lay the service connection cable, as and when required, from the street kiosk through a duct, laid by the consumer, from his boundary into the connection box on his premises.

The point of supply is then an accessible point on the consumer's premises at which statutory voltage checks may readily be made. But where the point of supply is, as proposed, at an inaccessible buried joint on the boundary, it is not possible to determine by measurement whether the voltage at the "consumer's terminals" (as required by Section 24(1)(a) of the Electricity Act) is within statutory limits.

I consider, therefore, that the Guidelines should be amended to permit the adoption of either system, namely the point of supply either at the consumer's boundary or in the connection box on his premises. The panel's comments on this point would also be appreciated.

Mnr. E. de C. Pretorius: Potchefstroom

Mnr. Von Ahlften is vir my die verpersoonliking van die druk besige man wat nog altyd die tyd kan vind vir nog 'n taak. Ek dink die VMEO sal nog eendag 'n standbeeld vir hom moet oprig want selfs 'n erelidmaatskap sal nie kan vergoed vir alles wat hy al vir die VMEO gedoen het nie en in die toekoms nog gaan doen.

Aangesien die riglyne nog nie openbaar gemaak is nie is 'n mens se skietveld uiters beperk. Ek het tog die volgende opmerkings en vrae:

1. **Gediversifiseerde hoogsaanvraag (GHA)**

   Gediversifiseerde hoogsaanvraag moet altyd gekoppel word aan 'n getal verbruikers. Hier verwys ek na die tabel in paragraaf 4.1.

   Dit sal miskien interesseer om te weet watter norme ons in Potchefstroom gebruik vir woongebiede vir Blankes – (ook vir Asiërs); (Potchefstroom het 'n stroombrekertarief):

Getal verbruikers	GHA (kV.A)
3	10
6	8,9
12	7,2
24	6,5
50	6,0
100	5,5
200	5,0
400	4,55
1 000	4,05
2 000	3,7

   Vir hulpbehuisingskemas word 60% van hierdie waardes gebruik.

   Dit lyk dus of ons taamlik in die kol is.

2. **Perke van spanningsval**

   Ek het nog altyd onder die waan verkeer dat die 10%-perk op spanningswisseling een van die belangrikste bydraende faktore is tot die hoë koste van elektrisiteitsverspreiding in woongebiede. Groot was my verbasing toe ek 'n ontwerp gedoen het vir 'n dorpsgebied met ongeveer 300 woonerwe gebaseer op 'n maksimum spanningswisseling van 15% en gevind het dat daar 'n besparing van slegs 2,3% sou wees!

3. **Toelating vir onbalans in driefasige netwerke**

   Ek hoop van harte rasionele norme sal ook in dié verband neergelê word en dat hull op proefondervindelike navorsing gebaseer sal wees. Ons in Potchefstroom het maar 'n skoot in die donker geskied en gebruik die volgende uitbalansfaktore:

Verbruikers	UBF
3	1,8
6	1,7
9	1,6
12	1,5
15	1,4
18	1,3
21	1,2
24	1,1
30	1,05

4. **Straatverligting**

   Dit verheug my om te hoor dat die betrokke komitee van mening is dat die SABS se gebruikskode vir straatverligting in woongebiede se vereistes te hoog is. Ek en my goeie vriend Piet Botes het in die verlede so vele kere dieselfde mening gelug maar ons elke keer vasgeloop teen 'n massameningsverskil.

Jules, ek is seker ek praat namens die hele VMEO as ek sê ons waardeer ook hierdie groot taak wat jy en jou komitee verrig het. Jy bly maar 'n ou staatmaker.

Mr. J.K. Von Ahlften: Springs

Mr. Robson, thank you for your comments, I appreciate these and the Committee will take note of the thanks expressed to them for the hard work undertaken.

One of the first questions asked was whether these costs included the cost of transformation and I think that they are in the figure of R11 150; that cost includes the transformation equipment up to the access supply point. Access supply was not included in the exercise. The access supply is something to be provided by the supplier himself. In the case of property development, the township developer would be responsible for the access supply but otherwise the supplier himself should provide this.

On the question of S.A.B.S. reaction to street lighting, I believe a letter has been submitted to them by the N.B.R.I. I have not had any reaction from them yet, but it would be interesting to have this from them in due course.

Mr. Palser and others raised the point on the consumer's point of supply. This has been argued backwards and forwards by the Committee Members and eventually I got the impression, Mr. Chairman, that this was the closest we could get to satisfying each and every region, but I am afraid I have to agree with Mr. Palser that it is not quite acceptable. It can lead to certain problems, but you want to have a clear definition on the actual point of connection, and I most certainly think we should take this back to the Committee for further investigation.

Mr. Robson asked who the "competent" person is who will approve the service plan. This person is the professional engineer or other engineer who takes responsibility for the design of the installation. Another point raised, also by Mr. Palser I think, was the question of the responsibility for the service; that is if the township developer has paid in full for the services and has subsequently recovered this cost through the selling price then, if the Chouncil takes over that service it should not be entitled to levy basic charges to recover capital costs, or else it would involve the consumer in paying twice for the same service. This was actually what I intended to convey in stating what the Fouché Commission meant by that particular aspect. The point of streetlighting being more expensive with more stands appears to rest on the types of layouts as also shown by Mr. Cameron. If you have more access roads and cul de sacs to accommodate, your street lighting system becomes larger than it would normally be. I think these were the only points raised by Mr. Robson and Mr. Palser. Mr. Raynal, I agree with you full heartedly that we are very slow in adopting new ideas and it will take some time to get us away from the old rut, but your comments are well taken. I have nothing further to add to the comments raised. I think we have had enough discussion on these points, but maybe Mr. Cameron would like to add a final comment on the points raised in connection with his statements.

Mr. J.W.M. Cameron: CSIR

There are just two points I would like to comment on – Mr. Raynal raised the point about a mini-sub in a smaller street. I have included it in the paper of comment about this. Basically the exercise is not only a cost saving exercise. We see this as a total exercise and we realise of course the impact of the reduction in standards or a lowering of standards and not necessarily lower standards, but we realise the impact and the environmental criteria were quite important. We have made provision for local street widening where warrented for landscaping, which will be an important feature in softening the environment and the feeling was that these local street widenings where landscaping was provided could be multipurpose and it would be in that sort of location that your mini-subs would go.

Mr. Palser made some comments about the comparison. I cannot go into great detail, but an attempt was made to hold all things constant within each of the comparative layouts, so all the non-residential components were kept the same, the schools, the parks and that sort of thing, as a proportion. The stands are slightly smaller, but only marginally less than 100 square metres, but again the basis is fully described in the paper.

REPORT : 46TH GENERAL MEETING OF THE INTERNATIONAL ELECTROTECHNICAL COMMISSION : MONTREUX, SWITZERLAND 1981

by Mr. J.D. Dawson

The 46th General Meeting of the International Electrotechnical Commission was held in Montreux, Switzerland from the 15th to the 27th June, 1981.

Some 1 000 delegates from 40 countries attended the meeting and it was an outstanding success. The leader of the South African delegation was Mr. A.A. Middlecote, Deputy Director-General of the South Africa Bureau of Standards, and I considered it a privilege to attend this meeting in his company as he has represented South Africa at the I.E.C. for many years. With his assistance I was made conversant with the procedure of the meetings and was introduced to delegates from all over the world.

This particular meeting coincided with the 75th anniversary of the founding of the I.E.C. and its achievements and successes since its inception were highlighted at numerous functions attended by the delegates.

In the company of Mr. Middlecote I attended meetings of the Committee of Action and the Council and was impressed by the widespread ramifications of the Organisation and the progress being made in the keeping up to date of international standards and the introduction of new standards in the electrical and electronics fields.

Mr. Middlecote was proposed as a Vice-President of the I.E.C. and it is to be regretted that he was not elected to this office. In my opinion he was most deserving of this high honour because of his abilities and his long service in and major contributions to the workings of the I.E.C.

When not attending meetings of the Committee of Action and the Council I was present at meetings of TC 17D (Low Voltage Switchgear and Control Gear Assemblies) but, as this committee has been in existence for a number of years, I found in impossible to make any specific practical contribution to the discussion.

I also attended the inaugural meeting of TC 81 (Lightning Protection of Structures and Buildings) and I am sure it will be most interesting to be a member of this committee in the years to come.

I regret that there were no meetings of TC 64 (Electrical Installations of Buildings) but it was decided by the I.E.C. that meetings of this committee should not be held in conjunction with the General Meeting as it was considered that they would draw too large an attendance of delegates and thus reduce interest in the other committees.

The next General Meeting of the International Electrotechnical Commission is scheduled to be held in Brazil in 1982 and I recommend that the AMEU should continue to be represented at all future meetings.

Finally, I would like to place on record my appreciation to the AMEU for sending me as its representative to the I.E.C. meeting in Switzerland, which I found most informative and which I thoroughly enjoyed.

I wish also to record my thanks to the S.A.B.S. and particularly Mr. Middlecote for all the arrangements made for me in attending the I.E.C. meeting and for the assistance and guidance given to me at the meeting.

ELEKTRISITEITSBEHEER
ALGEMENE RIGLYNE IN VERBAND MET ELEKTRISITEITSVOORSIENING BUITE DIE REGSGEBIEDE VAN STEDELIKE PLAASLIKE OWERHEDE

(a) **TOESTEMMING AAN PLAASLIKE BESTURE**

Die Elektrisiteitsbeheerraad beskou die voorsiening van elektrisiteit in landelike gebiede hoofsaaklik as EVKOM se verantwoordelikheid maar aangesien EVKOM, volgens sy eie mededeling, probleme ondervind om tred te hou met die vele aansoeke om landelike toevoerskemas, het die Raad waardering vir plaaslike owerhede se bereidwilligheid om sodanige skemas in die landelike gebiede rondom hulle eie regsgebiede tot stand te bring. Die Raad sal elke aansoek om toetemming vir die voorsiening van elektrisiteit buite plaaslike besture se regsgebiede op sy meriete oorweeg en sal die belange van die voornemende verbruikers voorop stel. In hierdie verband sal rekening gehou word:

(i) of EVKOM nie miskien self die betrokke gebied meer doeltreffend en ekonomies kan bedien nie;

(ii) of die verlening van die toestemming nie nabygeleë Evkomskemas wat vir die huidige of in die toekoms beplan mag word, ernstig sal benadeel nie;

(iii) of die beoogde skema gerieflik vanaf die betrokke plaaslike owerheid se netwerk bedien kan word sonder dat 'n addisionele voorsieningspunt buite die munisipaliteit se grense deur EVKOM voorsien hoef te word;

(iv) of die beoogde skema binne die vermoë van die betrokke plaaslike owerheid is en nie dalk 'n te wye gebied insluit nie;

(v) met die beoogde tariefstruktuur met inagneming van addisionele koste;

(vi) met die tyd wat sal verloop voordat die krag verskaf sal kan word.

(b) **TERMYN VAN TOESTEMMING**

Die Raad is van mening dat die bepaling in die Elektrisiteitswet, 1958 (Wet 40 van 1958) wat voorsiening maak vir die wysiging van die voorwaardes van 'n toestemming of die terugtrekking van 'n toestemming onder sekere omstandighede (Artikel 40(6)), behoue moet bly. Die Raad wens nietemin plaaslike owerhede te verseker dat hy nie enige toestemming ligtelik sal intrek nie en dat hulle die toestemming wat aan hulle uitgereik is vir alle praktiese doeleindes as permanent kan beskou. Die Raad sal egter in die volgende omstandighede genootsaak wees om, binne die bepalings van die Wet, oorweging aan die terugtrekking van toestemmings te verleen:

(i) As die verbruikers ernstige klagtes sou hê oor die gehalte van die diens wat gelewer word en die klagtes gegrond sou blyk te wees en die betrokke plaaslike owerheid nie bevredigende stappe neem om die probleme wat aanleiding tot die klagtes gegee het, op te los nie.

(ii) As dit absoluut noodsaaklik is dat EVKOM 'n plaaslike owerheid se landelike netwerk moet oorneem ten einde elektrisiteit ekonomies in 'n ander nabygeleë gebied te versprei. In so 'n geval sal daar egter eers met die betrokke plaaslike owerheid oorleg gepleeg word.

(iii) As die toestemming betrekking het op 'n gebied binne die munisipale grense van 'n ander plaaslike owerheid en laasgenoemde sou aansoek doen om terugtrekking van die toestemming ten einde self elektrisiteit in die gebied te voorsien.

(c) **VOORWAARDES GEKOPPEL AAN TOESTEMMINGS**

Behalwe die reeds bestaande standaardvoorwaardes wat aan toestemmings gekoppel word, beoog die Raad ook om die volgende voorwaardes van toepassing te maak:

(i) Die voorsiening van elektrisiteit in die gebied waarop die toestemming betrekking het of aan die individuele verbruikers ten opsigte van wie die toestemming verleen is, moet 'n aanvang neem binne twee jaar vanaf die datum waarop die plaaslike owerheid skriftelik in kennis gestel is dat die toestemming deur die Raad verleen is anders verval die toestemming.

(ii) Die netwerke moet opgerig word en in stand gehou word om te

voldoen aan die vereistes neergelê onder die Wet op Fabrieke, Masjinerie en Bouwerk, 1941 (Wet 22 van 1941) of aan die standaarde soos deur die Raad voorgeskryf.

(d) **TARIEWE**

Wat die tariewe van toepassing op buite-munisipale verbruikers betref, verland die Raad, as 'n plaaslike owerheid wil differensieer tussen die tariewe betaalbaar deur die binne- en die buite-munisipale verbruikers, dat dit gedoen word by wyse van 'n toeslag wat op die buiteverbruikers se rekening gehef word en nie deur die vordering van verskillende basiese tariewe van die twee groepe verbruikers nie.

By die oorweging van aansoeke om die goedkeuring van buite-munisipale elektrisiteitstariewe sal die volgende faktore deur die Raad in ag geneem word:

(i) Die persentasie surplus op die elektrisiteitsrekening wat na die belastingrekening oorgeplaas word.

(ii) Die bevolkingsdigtheid van die buitegebiede;

(iii) Die afstande van die buiteverbruikers;

(iv) Wie vir die netwerke en toerusting betaal het – die plaaslike owerheid of die verbruikers.

(v) Die lynverliese wat plaasvind;

(vi) Die voorsiening wat gemaak word vir die herstel of vervanging van lyne en toerusting. In hierdie verband verlang die Raad dat plaaslike owerhede voorsiening van hierdie aard maak om te voorkom dat groot kapitaalinvesterings van die verbruikers gevorder word wanneer uitgediende lyne of toetusting vervang moet word.

Die Raad verkies ook dat plaaslike owerhede en nie die verbruikers nie in alle gevalle die onderhoud van die lyne moet behartig.

MEMBERS' FORUM / LEDE FORUM

Messrs. Jules von Ahlften and Dave Soens
Questionmasters at Members' Forum

Mr. D.H. Fraser: President

Gentlemen it is now my pleasure to hand you over to our two question masters who will conduct the Members' Forum until the close of the meeting. Mr. Dave Soons who is a Director of SCL Marketing Services (Pty) Limited which he founded in February this year is well known to the members of the AMEU. This is his first appearance on the Forum Panel but he has a ready wit and lots of experience to equip him for the task. We are delighted to have your assistance Dave and look forward to the full participation of the Affiliates in this session. Thank you Jules for once again taking on the job of quizmaster – now we are in your hands.

TARIFF INCREASE ANNOUNCEMENTS BY ESCOM

Mr. Murphy of Somerset West said that Escom had recently publicly announced that its tariff in the Western Cape would increase by 15%. In fact however the increase turned out to be more like 20% and this could cause municipalities some embarrassment when drawing up Estimates of Revenue and Expenditure.

It was suggested that Escom should be called upon to quote more realistic figures when announcing tariff increases.

GOOD HOPE BRANCH

AANGEKONDIGDE TARIEF VERHOGINGS DEUR EVKOM

Mnr., Murphy van Somerset-Wes sê Evkom het onlangs amptelik 'n 15% verhoging in hulle tarief in die Wes-Kaap aangekondig. In werklikheid was die verhoging in die omgewing van 20% en dit kan 'n verleentheid skep vir plaaslike owerhede met die opstel van jaarlikse begrotings.

Dit word voorgestel dat Evkom versoek word om meer realistiese syfers te kwoteer wanneer tariefverhogings aangekondig word.

GOEIE HOOP TAK

Mnr. P.J. Botes: Roodepoort

Meneer die Vraesteller, teen die einde van verlede jaar het ek een van die bekende bankinstellings se kort oorsig oor die bedrywighede van Evkom gesien. Hulle het 'n finansiële studie gemaak en 'n kort oorsig uitgegee en hulle het dit daar gestel dat hulle voel dat Evkom behoort teen 1 Januarie 1982 'n verhoging van minstens 25% op hulle tariewe in te stel en dat die tariewe dan nog baie goedkoper sal wees as oorsee. Soos u weet was die verhoging met aanvang 1 Januarie 1982 heelwat laer en ek het gewonder waaroor en wat gaan nou aan, maar nou het ons pas verneem van 'n nuwe verhoging met ingang 1 Julie. Hierdie nuuswaardigheid van Evkom gee ons heelwat probleme in verskeie vorms.

1. Dit is gewoonlik uit die bloute.
2. Dit vind plaas om 'n ongeleë tyd soos byvoorbeeld tydens tegniese vergaderings en kongresse, en
3. Dit geen ons munisipale ingenieurs min tyd om ons tariewe by te werk en heelwat verlies aan inkomste gaan dus verlore.

Weliswaar het verskeie munisipaliteite outomatiese aanpassingsformules, maar selfs dit lewer probleme op. Ons sal graag tenminste drie maande tyd wil hê vir so 'n kennisgewing van tariefverhoging. Die tariefwysiging van 'n Stadsraad, en ek wil graag net so kortliks dit verduidelik sodat miskien Evkom en ander dit kan verstaan wat ons probleme is, behels 'n studie van die inkomste en uitgawe syfers en 'n verslag van die ingenieur aan die Raad. Hierdie prosedure neem tenminste een volle maand voordat 'n besluit geneem word. Daarna moet die beoogde

verandering in die tarief geadverteer word en tenminste drie maande tyd gegee word vir enige iemand wat wil kommentaar lewer. Wanneer daar enige objeksies is, moet weer kommentaar daaroor gelewer word en moontlik eers weer aan die Stadsraad voorgelê word. Daarna moet die beoogde wysigings aan die Provinsiale Administrasie gestuur word wat hulle tyd neem oor die aangeleentheid. Teen daardie tyd kan maklik ses na nege maande verloop terwyl ons in hierdie geval net twee maande kennis gekry het. Gewoonlik soos ook gister word net oor die nuus gesê dat die verhoging van tussen 5,8% tot 7,5% is, maar 'n mens weet nie presies wat die persentasie verhoging in jou deel van die wêreld is nie. Munisipaliteite met 'n lae lasfaktor moet 'n hoë toeslag oordra op die verbruikers om die bykome uitgawe in aankoop van 'n stroom te delf.

Mr. Question-master, may I ask the convener of the Escom sub-committee or the Executive, once again to appeal to Escom to keep this in mind. I would ask for better liaison. One matter that comes to mind is that immediately before publicizing the increase, the convener of the Escom sub-committee should be notified on the exact increase for each area so that he will have notice of what it is and transmit it to anybody who wants this information. In this way members will be quickly and reliably informed of the increase. One finds that various regions of Escom take their time in advising the Municipalities on the exact increase. After a notice of tariff increase appears in the press, it may take two to three months before a region advises the Municipality by letter as to what the exact increase is. Secondly, as we have to live with tariff increases, could we have better personal contact between this committee and Escom? I think that regular meetings of this nature would be of mutual benefit. Mr. Question-master may I now, for the benefit of all the new Engineers who are attending the AMEU Technical Meeting for the first time, introduce to them Mr. Stoffie Stofberg of Escom, a seasoned convention attendant, a past-master in passing the buck and in oral argument and who must not, I repeat must not, be blamed for Escom increases. Although there is no obligation on him to do so on this occasion, I am sure that he might like to say a few words.

Mr. T. Stoffberg: Escom

I have been charged with three separate tasks.

Firstly, I have to confirm the bad news which you have already read in the press and heard from Mr. Botes.

Secondly, I have to tell some worse news, which we have not released to the press.

Die besonderhede van die tariefaanpassings wat met ingang Julie 1982 sal geld is soos volg:

Thirdly, at the end of all that, I am charged to bring you Escom's greetings and *good* wishes.

The bad news you already know. The fact is that an unusual Escom tariff increase will be implemented with effect from 1st July 1982.

The July 1982 increase is unusual in several respects. Firstly it is a modest increase for Escom – about 6.6% only!

Secondly it is imposed in mid year, and with somewhat less than the customary 3 months notice to AMEU members.

The July 1982 tariff increase is unusual in that it is caused by the unreliability of the Cabora Bassa supply.

It is because of this that Escom was able to state in its press release that it has the support of the Government in raising the tariffs during mid-year 1982.

After the bad news, I am also authorised and required to share with you, the worse news:

There will certainly be the usual tariff increase in January 1983. The July 1982 increase should be seen as one above the regular annual increase which you are all expecting in January 1983.

In die Pers praat ons nou baie oor die Cabora Bassa-probleme, maar afgesien van Cabora Bassa het ons nou met 'n hele reeks ander nuwe probleme te kampe.

Oor die afgelope ses maande het rentekoerse die hoogte ingeskiet. Met die depresiasie van die Rand is valuta termyndekkings vir buitelandse verpligtings ook heelwat hoër.

Vergeleke met verlede jaar is daar groot nuwe bedryfskoste en kapitaalbedryf vir sekuriteitsmaatreëls.

Bo en behalwe die hoë inflasiekoers wat voort duur, het ons hierdie jaar die verhoging in die algemene verkoopbelasting en veral ook die verhoogde bo-belasting op invoergoedere.

Die *slegter* nuus, mnr. die President, is dat ek u moet voorberei vir nog 'n tariefverhoging in Januarie 1983.

Ten spyte van die spesiale tariefverhoging van Julie 1982, sal die daaropvolgende tariefverhoging in Januarie 1983 waarskynlik nie laer wees as die tariefverhoging wat Evkom in Januarie 1982 ingestel het nie.

Mr. President, this brings me to the last of my tasks. On behalf of the Chairman of Escom I bring to the AMEU, Escom's greetings and warm good wishes.

Onderneming	Huidige tarief toeslag of korting	Tarief toeslag of korting vanaf 1/7/82	Effektiewe verhoging
Rand & OVS	9% toeslag	16% toeslag	6,4%
Natal	20% toeslag	29% toeslag	7,5%
Oos-Transvaal	9% toeslag	17% toeslag	7,3%
Wes-Kaapland	14% korting	9% korting	5,8%
Noord-Kaapland	16% korting	11% korting	6,0%
Oranje Rivier	14% korting	9% korting	5,8%
Grens	16% korting	11% korting	6,0%
GEMIDDELDE VERHOGING			6,6%

Mr. K.J. Murphy: Somerset West

The question as posed is straightforward and requires no further amplification. I would however hasten to add that we have no reason to believe that Escom attempted to deliberately mislead us.

A statement, when necessary, that the actual percentage increase would depend on the consumer's load factor will make it easier for us to justify tariff increases to our consumers.

The problem of tampering with meters seems to be growing and is not confined to the poorer residential areas. What steps can be taken to deal with this problem?

Die probleem van peutering met meters neem blykbaar toe en is nie slegs beperk tot die laer inkomste woongebiede nie. Watter maatreëls kan geneem word om dit te verhoed?

Mr. D.C. Palser: Cape Town

In recent years there appears to have been a marked increase in the incidence of cases involving fraudulent tampering with meters. Apparently this is a world-wide problem, no doubt attributable to rapidly increasing costs and inflation generally as well as a progressive and regrettable decline in moral standards in the western world.

I believe the problem is particularly serious in Great Britain and the United States where literature can readily be purchased on how to tamper fraudulently with meters. Only two years ago, for instance, a landlord in London was jailed for three years for defrauding the local electricity board of around R135 000!

To the best of my knowledge things are not as bad in Cape Town! Nevertheless, with a total of around 190 000 consumers, the detected incidence of meter tampering has increased rapidly over the past five years from about 6 cases a year to its present level of about 120 a year. Relatively speaking, this incidence might not appear high but it is surely only the tip of the iceberg.

It is also extremely difficult to obtain a prosecution. Out of more than 200 cases reported to the police over the past five years only 13 have actually reached the courts. In one case a conviction was obtained for bypassing the meter and resulted in a fine of R200 (or 100 days) of which R150 (or 75 days) was suspended. This case required a two day atten-

dance in court. In the second case the accused was found not guilty through lack of sufficient evidence. This particular case lasted four days spread over a period of three months and required the attendance of eight members of the electricity department's staff.

Arising out of representations made by my Council to the Chief Magistrate of Cape Town in regard to the difficulty experienced in obtaining prosecutions for contraventions of municipal by-laws, the Attorney General recently delegated to certain named legal officials of the Council the power to act as public prosecutors in such cases. Since these officials clearly have a more detailed knowledge of local by-laws and a greater interest in obtaining a conviction, it is anticipated that it might now be possible to achieve more convictions than has hitherto been the case.

A variety of methods of defrauding the municipality are practised, some of them displaying considerable ingenuity. A method now prevalent in Cape Town is the removal of the terminal cover and disconnection of the voltage-circuit test-link. The link is left open for progressively longer periods each month resulting in a steady decline in consumption that is difficult to detect through routine checks, such as computer variance print outs.

In other cases voltage-coils have been disconnected internally, holes drilled in covers and foreign objects introduced and dial pointers moved back. Another method practised is to slacken-off the rotor bottom suspension assembly thereby allowing the disc to rest on the brake magnet. As well as tampering with meters to decrease the recorded consumption, meters are also frequently by-passed.

In an attempt to counter these various fraudulent practices a number of methods have been adopted or are being considered. These include moving internal meters to less accessible external positions such as commmon kerbside metering kiosks, silver soldering potential link screws, by-passing potential links internally, installing parallel secret unidentifiable check meters, changing metering kiosk locks and adopting more effective methods of sealing meters.

A promising develpment that is currently being investigated is the replacement of the conventional lead seal with a more secure stranded spring steel wire with crimped copper seals. Also being investigated is the use of special adhesive tape on meter covers and terminal strips that breaks up on removal. A third possibility being explored is the redesign of meter and circuit breaker terminal strips and covers to prevent bypassing. Finally, special meter cover screws are available that can be tightened but not unscrewed. To remove, the screw is tightened until it shears at a special designed point and a small screw driver is then employed to remove the stub fromm the rear by means of a slot in the end of the screw. Another method employs plastic plugs pressed in over the meter cover screws that cannot be removed without destroying them. An attempt has been made to assess the magnitude of the problem by studying the trend of distribution losses over the past 50 years. Although no increasing trend has yet been detected there is no doubt that this problem of theft of electricity is on the increase.

It would accordingly be interesting to learn of the experience of other municipalities, not only in regard to any fraudulent methods adopted and the incidence of detection, but also the success or otherwise in securing prosecutions, and what practical steps, if any, can reasonably be taken to combat this problem and improve the rate of successful prosecutions.

Mnr. N. Botha: Bloemfontein

Die probleem waarna Mnr. Fortmann verwys, is aan die orde van die dag en glo ek sal ons nooit voldoende maatreëls kan tref om dit te verhoed nie, maar ek is seker dat daar wel sekere optredes gevolg kan word om peutering tot 'n minimum te beperk.

In Bloemfontein het ons die afgelope jare 'n redelike mate van sukses gehad met vervolgings, natuurlik ook ons mislukkings, maar in die algemeen sou ek sê het verbeterings met strawwe so hoog soos R400 wat opgelê is, 'n demper op peutering met elektrisiteitsmeters gehad.

Mnr. die vraesteller, ek wil graag noem dat daar reeds 'n uitgewysde saak in die verband bestaan. Dit is 'n saak wat gedurende Junie-Julie 1963 in die Transvaalse Hooggeregshof beslis was. Die belangrikste aspek van genoemde saak is dat omstandigheidgetuienis wel aanvaar word.

Ek wil graag die volgende aan die hand doen waar peutering met elektrisiteitsmeters ondervind word ongeag of dit nou die gewone self-aanskakeling is deur seëls te breek of andersins peutering in die sin van brugstukke, gaatjies boor of wat ook al:

(i) U moet sorg dat die Senior Staatsaanklaer ten volle ingelig is en die basiese werking van elektrisiteitsmeters verstaan, indien moontlik neem hom na u meterkamer en wys hom alles;

(ii) Probeer om dieselfde staatsaanklaer vir hierdie tipe sake te verkry;

(iii) Sorg dat ten minste twee of drie getuies die betrokke perseel besoek, (indien moontlik twee maal) en homself vergewis van die omstandighede en lesings;

(iv) Beëdigde verklarings word van amptenare verkry en tesame met bewysstukke en 'n klagstaat word dan 'n kriminele klag teen die persoon gelê;

Wanneer die saak verhoor word en skuldig bevinding verkry is, moet sorg gedra word dat die pers dit rapporteer.

Mnr. E. de C. Pretorius: Potchefstroom

In Potchefstroom word die maskeerplaat van die meterkabinet met 'n standaard meterkabinethangslot gesluit. (Wanneer 'n verbruiker se toevoer afgeskakel word, word die stroombreker in die meterkabinet afgeskakel en die deksel van die meterkabinet met dieselfde slot gesluit.

Mr. V.A. Raynal: Affiliate

Speaking from my past experience in the Johannesburg Electricity Department, I wish to describe a practice that has been introduced recently to combat the theft of electricity. This appears to have had the desired effect in minimising loss. The procedure is as follows:

(a) A consumer in arrears is cut-off by the City Treasurer's staff who switch off and seal the MCB on the meter board;

(b) If at a later inspection the supply is found to have been illegally switched on, the City Treasurer requests the Electricity Department to cut-off the consumer effectively.

(c) If subsequent to (b) above the service connection is illegally reconnected, the consumer is given 7 day's notice of termination of the electricity supply contract with the Council. The service connection is then physically removed and the consumer is required to apply and pay for a new service connection, pay for all arrears and enter into a new supply contract with the Council.

Mr. H. Frankle: Affiliate

A number of effective security features are available which are designed to discourage unauthorised entry into the meter and to provide safeguards against other well known methods of misuse.

(1) **The extended terminal** cover has been available for many years and this completely encloses the connections when the incoming cables enter from the rear.

(2) **Tamperproof** screws for the front cover and terminal cover are now available. These are designed so that they can be tightened but not undone. They can only be removed by overtightening which fractures the screw shaft across a specially reduced section. The remaining stub can then be removed from the rear when the meter has been removed from its mounting. However, it would not be practical for meters to leave the factory with these screws fitted as most large supply authorities do their own testing before issuing to Consumers' premises. A solution could be for the supply authority to carry its own stocks of these special screws which it could fit after test and before sealing and issuing the meter.

(3) An internal potential connection inside the meter housing instead of the traditional swing type link in the terminal compartment can now be provided, but this arrangement requires the use orf multiple secondary voltage transformers when the need for a separate connection to the meter voltage terminal is eliminated. These transformers can if required be used externally in conjunction with existing test benches.

Mr. W. Barnard: Johannesburg

Mr. Question-master, I think I must just update Mr. Raynal and it might be of interest to the other members if I tell you that the actions referred to by Mr. Raynal are taking place not only in Johannesburg but also in the Transvaal Province. Our problem in the past has been that where the power supply has been cut off and been illegally restored or where the meter has been tampered with, it has been virtually impossible to prove who the guilty party is. Our legal people are now working on an amendment to the Transvaal Provincial Ordinance which has so far been accepted by the Director of Local Government in the Transvaal. In terms of this, if any consumer who has been cut off and claims the power has been restored without his knowledge or that somebody has tampered with the meter by breaking the seal or otherwise, he will be considered to be the guilty party unless he notifies the Supply Authority of the incident within 24 hours.

OWNERSHIP OF SERVICE EQUIPMENT

Mr. Algera has encountered the problem of consumers who claim ownership of the service equipment for which they have paid a connection fee in terms of the Standard Electricity By-laws (Transvaal). What is the opinion of AMEU members in this regard?

Mnr. J.D. Algera: Rustenburg

Artikel 44 van die Elektrisiteitsvoorsieningsverordeninge van die Stadsraad van Rustenburg, afgekondig in Provinsiale Koerant No. 4100 van 27 Augustus 1980, lees as volg:

"Materiaal, apparaat en toerusting wat deur die Raad vir elektriese aansluitings verbruik word, **bly die eiendom van die Raad** en moet deur die Raad onderhou word"; ens.

Verder lees artikel 20(2) en (3) van die Standaardelektrisiteitsverordeninge van die Provinsie Transvaal, afgekondig in 'n Buitengwone Offisiële Koerant van 24 November 1971, Administrateurskennisgewing 1627 as volg:

"(2) 'n Verbruikersaansluiting word op die eienaar se onkoste geïnstalleer en die koste daarvan, soos deur die Raad bepaal, moet aan die Raad betaal word voordat toevoer gemagtig word.
(3) Elke gedeelte van die verbruikersaansluiting bly die eiendom van die Raad".

Artikel 42(1) en (2) van die Standaardelektrisiteitsverordeninge van Kaapland, afgekondig onder Provinsiale Kennisgewing Nr. 3977 van 13 Januarie 1978 lees as volg:

"(1) Die verbruiker dra die voorgeskrewe koste van die diensaansluiting, met inbegrip van die diensbeveiliging toestelle, tussen die toevoerpunt op die hooftoevoerleiding en die punt van aansluiting by sy bedradingsinstallasie.
(2) Ten spyte daarvan dat die verbruiker die koste gedra het van die werk wat deur die voorsieningsowerheid uitgevoer is, berus eiendomsreg op die diensaansluiting, wat deur die voorsieningsowerheid aangelê of opgerig is, by die voorsieningsowerheid wat verantwoordelik is vir die onderhoud van sodanige diensaansluiting. Die verbruiker is nie geregtig op enige vergoeding van die voorsieningsowerheid ten opsigte van sodanige diensaansluiting nie".

Gemeenregtelik is die persoon wat vir 'n artikel betaal, ook die besitter van sodanige artikel. Word sy eiendomsreg deur bogenoemde verordeninge nietig verklaar sover dit die verbruikersaansluiting aangaan en gaan dit oor op die Raad?

Gevalle het voorgekom waar 'n persoon sy diensaansluiting laat verander van byvoorbeeld enkelfase na driefase. Dit is blykbaar die aanvaarde gebruik om so 'n persoon krediet toe te staan vir herbruikbare materiaal van sy vorige verbruikersaansluiting. Word die verordeninge nie verontagsaam in so 'n geval nie omdat eiendomsreg daardeur erken word?

Sou die verordeninge die toets deurstaan indien 'n hofsaak oor eiendomsreg van 'n verbruiker se toerusting/aansluiting besleg word?

EIENAARSKAP VAN DIENSTOERUSTING

Mnr. Algera ondervind die probleem dat verbruikers eienaarskap van toerusting van 'n diensaansluiting eis waarvan 'n aansluitingsfooi volgens die Standaard Elektrisiteits-verordeninge betaal is. Wat is die sienswyse van VMEO lede in die verband?

Mnr. A.H.L. Fortmann: Boksburg

Mnr. die vraesteller, eintlik het ek gemeen mnr. Algera het 'n ander probleem gehad en ek het toe na die standaard elektrisiteitsverordeninge gekyk en dieselfde artikel wat hy aanhaal, is wel daar en ek het nie eintlik besef dat hy 'n ander probleem het as dié nie, want die elektrisiteitsverordeninge sê uitdruklik vir Transvasal en vir die Kaap ook dat die diensaansluiting die eiendom van die Raad bly en dit is eintlik al wat ek wou gesê het.

Mnr. E. de C. Pretorius: Potchefstroom

Mnr. die vraesteller, die antwoorde wat ek voorberei het, is presies dieselfde wat Mnr. Fortmann gesê het, maar ek wil iets anders noem, dat ons het hierdie probleem voorsien en artikel 20.2 van die standaardverordeninge wat soos volg lei:

"'n Verbruikersaansluiting word op die eienaar se onkoste geïnstalleer en die kost daarvan soos deur die Raad bepaal. Daardie sinsnedes het ons vervang met die volgende en die heffing daarvoor soos die tarief nou groei en ek dink dit sal die probleem oplos"

Mr. V.A. Raynal: Affiliate

Mr. Question-master, speak if I may for the Johannesburg Council, the practice in Johannesburg was initially that the consumer had no claim to equipment in the service connection. Subsequently this attitude was relaxed to the extent that, if the consumer made application in writing to the Electricity Department, this would be reported to Council with the recommendation that the consumer be allowed to take over the equipment at the price it would cost the Council to recover it.

Mnr. N. Botha: Bloemfontein

Die probleem wat Mnr. Algera ondervind, word blykbaar van tyd tot tyd van die suide tot die noorde ondervind en glo ek kan hoofsaaklik toegeskryf word aan onkunde aan die kant van elektrisiteitsverbruikers, alhoewel dit sekerlik nie verregaande vir 'n elektrisiteitsverbruiker is om te wil argumenteer dat sodra hy vir dienstoerusting betaal dit sy eiendom is nie.

In Bloemfontein probeer ons sover as moontlik die woord "dienstoerusting" te vermy en word deurgaans slegs na 'n diens verwys. Met 'n diens word onder andere die dienstoerusting bedoel, maar dit sluit ook baie meer in soos byvoorbeeld die instandhouding daarvan en alle gepaardgaande risiko's.

Ek dink meneer die vraesteller, deur slegs na 'n diens te verwys 'n mate van sukses verseker kan word en dan dink ek ook dit is wenslik dat alle munisipale owerhede die betrokke aspek duidelik in hulle onderskeie verordeninge behoort te omskryf.

NEW REGULATIONS FOR ELECTRICAL INSTALLATIONS

The Highveld Branch has requested a discussion on the application of these new regulations since implementation from 1 March 1982.

Mnr. E. de C. Pretorius: Potchefstroom

Die nuwe regulasies is regulasies nr. C175 tot C191 wat verskyn in Deel VIII van die regulasies onder die Wet op Fabrieke, Masjinerie en Bouwerk, 1941 (Wet 22 van 1941). Hierdie regulasies is nou twee maande van krag; miskien is die tydsverloop nog te kort om werklike leemtes daarin, indien enige, te identifiseer.

Die Hoofinspekteur van Fabrieke, mnr. A.A. Weich, het groot moeite gedoen om die regulasies persoonlik aan die onderskeie takke van die VMEO te verduidelik en vrae voortspruitend daaruit te beantwoord. Ek en mnr. Von Ahlften het hom op sy ronde vergesel en ek kan net met lof praat van die manier waarop mnr. Weich hom van sy taak gekwyt het.

Vandag se bespreking moet asseblief nie 'n herhaling wees van vrae of standpunte wat reeds op genoemde seminare gestel is nie; u moet u asseblief toespits op werklike probleme wat sedert 1 Maart 1982 met die toepassing van die regulasies opgeduik het. Ek is seker mnr. Weich, wat ons vereer met sy teenwoordigheid by hierdie tegniese vergadering, met genoeë op u bydraes sal reageer.

NUWE REGULASIES VIR ELEKTRIESE INSTALLASIES

Die Hoëveld Tak versoek 'n bespreking met die toepassing van die nuwe regulasies sedert implementering vanaf 1 Maart 1982.

Mnr. Von Ahlften, wat voorsitter is van die betrokke **ad hoc**-komitee van die VMEO, het 'n opsomming gemaak – ek weet nie waar vind hy die tyd om dié dinge te doen nie! – van sake waaroor uitsluitsel of leiding gegee is by genoemde seminare. Hierdie dokument sal eers more aan die vergadering van die Uitv. Raad van VMEO voorgelê word vir bekragtiging voordat dit aan lede beskikbaar gestel word.

Om die bal aan die rol te sit, noem ek drie probleme wat onder my aandag gekom het: aldrie het te doen met die registrasie van kontrakteurs, nl.

1. Ek het geweier om 'n voornemende kontrakteur woonagtig in Potchefstroom te registreer omdat hy self nie 'n installasie-elektrisiën is of een in sy voltydse diens het nie maar sy aansoek om registrasie in 'n ander dorp was suksesvol.

   Ek persoonlik is op my hoede om 'n voornemende kontrakteur te registreer wat nie in sy tuisdorp geregistreer is nie.

   Hierdie voorval sterk my nog meer in my sienswyse dat die registrasie van kontrakteurs deur 'n sentrale liggaam gehanteer behoort

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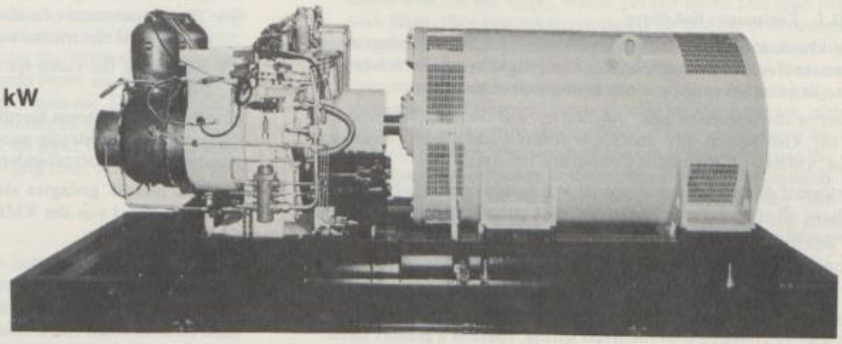

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te word. (Die EKV steun ook hierdie gedagte en ek stel formeel voor dat die VMEO aandag daaraan skenk.)

2. 'n Voornemende Kontrakteur met 'n vaste adres in dorp A het 'n telefoon onder sy naam gelys in dorp B maar nie in dorp A nie. Ek het geweier om hom te registreer maar ek het 'n vermoede ek beweeg op dun ys! Wat sê die Forum?
3. Op die goedgekeurde vorm van aansoek om registrasie as kontrakteur en die lisensievorm verskyn onderskeidelik die uitdrukkings "vaste besigheidsadres" en "besigheidsadres". Beide uitdrukkings strook nie met regulasie C179 nie waarin slegs die uitdrukking "vaste adres" voorkom.

Die volgende is 'n enkele praktiese toepassing, nl. van die voorbehoudsbepaling in regulasie 176(1): In Potchefstroom word dit nie verwag dat ons van die aanvang van installeerwerk verwittig word indien dit (a) die wysiging of herstel van 'n bestaande elektriese installasie behels nie; (b) dit toevoegings tot 'n bestaande installasie is en die geraamde las van die installasie as gevolg van die toevoegings nie met meer as 20% van die bestaande geraamde las, maar hoogstens 10 kW, vermeerder word nie.

Mr. G. Weich: Chief Inspector

Mr. Question-master, I would like to comment on what Mr. Pretorius of Potchefstroom said about the contractor having been registered by one of his neighbours in contravention of the regulations. I would like the name of the neighbour en ek sal hom regsien.

On the question of permit-holders mentioned by Mr. McDonald, it has come to my notice during the proceedings here, that there are certain suppliers who are taking the issuing of permits to ridiculous lengths. I have the names of the few of them already. They will hear from the Department in due course. I would like them to mend their ways quickly because we shall be watching them.

COOKING APPLIANCES

Should it not be made Standard practice throughout the R.S.A. that other than built in cooking appliances be supplied through a stove connector only and not from the fixed wiring, for safer maintenance and replacement by consumers.

Mnr. A.H.L. Fortmann: Boksburg

Die wenslikheid, al dan nie, om nie-ingeboude kooktoestelle slegs deur middel van stoofverbinderstopkontakte met krag te voorsien, is iets wat die meeste van ons seker al deur ons gedagtes laat gaan het.

About two or three months ago, this matter was discussed informally between Mr. Gus Weich, Mr. Jules von Ahlften and myself, when we met for an AMEU-ECA Liaison Committee meeting.

At this informal discussion, we agreed that it would probably be a good thing to have all stoves, or at least those that are not built-in, supplied through special cooker plugs only.

There would be distinct advantages in having special stove plugs fitted, of which the following are probably the most important:

(a) The ease of moving a stove from its position for cleaning purposes. With a stove connected to the fixed wiring, there is a greater likelihood of damage to the flexible tubing, wiring and earth connection when a stove is moved.
(b) The replacement of a stove by its owner would be far simpler – no installation electrician would be required.
(c) Removing the stove for maintenance purposes would be far simpler.

Hoe voel lede omtrent hierdie gedagtes, en behoort die SABS nie versoek te word om hierdie aangeleentheid, met die oog op die verpligte standaarddtipe stoofverbinderstopkontakte, te ondersoek nie?

As lede hierdie gedagtes steun, beveel ek formeel aan dat die Uitvoerende Raad van die VMEO 'n versoek in hierdie verband aan die SABS rig.

Mr. J.V. Grant: SABS

I think Mr. Fortmann means that a fixed stove (probably domestic) must be connected to the fixed wiring permanently but that a stationary (i.e. movable) stove **must** be connected by means of a plug and socket-outlet arrangement, such as a "stove connector".

KOOKTOESTELLE

Behoort dit nie standaard praktyk in die R.S.A te wees dat nie-ingeboude kooktoestelle slegs deur middel van stoofverbinder krag ontvang en nie vanaf die vaste bedrading vir veiliger instandhouding en vervanging deur verbruikers.

This matter was discussed by the Wiring Code: Main Committee some years ago but it was decided that making stove-connectors compulsory was impracticable for the following reasons:

1. Domestic service connections may be one-or-three phase. The stove may therefore have to be connected across one, two or three phases for balancing the load. In order that any stove may be connected to any installation, it is therefore necessary to –
   (a) wire every stove to the plug in a three-phase mode;
   (b) wire the phase contacts of the socket to the installation onto three-phase or onto one phase with the three contacts bridged;
   (c) use a plug and socket arrangement that has pins rated for, say, 16A each for phase pins and 48A for the neutral pin (this is necessary for the single-phase mode);
   (d) use a plug and socket having an efficient earth connection (sliding surface contacts or the use of the housing screw-on ring were not considered efficient and permanent).
2. A new design of plug and socket, with a specification, is needed (5 pins).
3. The existing "Cape cooker plug" would have to be discontinued and, in fact replaced, within a reasonable period.
4. Old installations would have to be fitted with the new sockets over a period.

Mnr. J.A. Loubser: Benoni

Mnr. die vraesteller, ek wil eintlik net mnr. Fortmann hartlik ondersteun met sy voorstel. Ek kan nie sien dat die probleme wat mnr. Grant vir ons genoem het, onoorkomelik is nie, maar vir my nog belangriker as dit, is die feit dat die Departement van Gemeenskapsbou onlangs byvoorbeeld 'n skrywe aan die Stadsraad gerig het waarin hy gesê het dat in die toekoms gaan stowe nie meer voorsien word as deel van die vaste installasie van 'n huis nie. Dit beteken dat baie persone wat daar gaan intrek, ou mense en arm mense, wat in elk geval nie 'n groot inkomste het nie, sal moet betaal vir die konnekteer van sodanige stoof. So ek wil regtig mnr. Fortmann ondersteun met sy voorstel.

Mr. D.H. Fraser: President

Mr. Question-master, I personally am convinced by Mr. Grant's remarks, particularly when you consider the magnitude of the difficulty in respect of existing installations. I think in Durban we have about 180 000 existing consumers and to contemplate these being made to comply with new standard arrangements in respect of stove connections is quite mind-boggling. You could well have a situation where somebody whose stove was wired with a plug would expect to be able to move into other premises and just be able to plug in, but find that the installation wasn't suitable. So really I think the difficulties are quite tremendous especially when you consider the length of time during which the existing practice has been in force and the relatively few problems experienced with the permanently wired stove arrangement. There just doesn't seem to be much virtue in considering a change in respect of movement of the stove even if it is a plug in type. Generally speaking, the stove would have to be moved to get at the plug connection, so the question of disturbing the flexible leads would probably still arise. So my vote would go to Mr. Grant's views on the matter.

Mr. A.H.L. Fortmann: Boksburg

Mr. Question-master, allow me to clarify what I meant in my appeal just now. The question of making plugs compulsory is certainly not intended to apply to existing installations but only on all new stoves that are manufactured in future. Then it would also become compulsory in all new houses that are being built. If a person then moves a stove from an older house to a new one, he would obviously have to have a plug fitted to the stove.

Mr. G. Brümmer: Stellenbosch

Mr. Question-master, we have for many years used the plug system in Stellenbosch. Originally it was a four-pin plug and more recently it has been replaced by a three-pin plug. Now, of course, we have a mixture of the two. It is actually a safety measure because we have found that, in the Cape, where people move and take their stoves with them, they just cut the connections and the next occupant of the house or flat then makes a very inexpert job of connecting the new stove and doesn't bother to get an electrician and that can be very dangerous. So, where we have the condition of taking the appliance with you, the "plug-in" method is by far the superior, although we have difficulties with three-phase connections where we have the four-pin plug and the single-phase connection. We use the 45 amp 3 pin plug. The difficulty is there, but I think it is certainly better to have the three-pin plug changed to a four-pin plug than to allow people to cut off their connections when they take the stove away. I think this will not prove to be of great difficulty in the Cape. This has been our experience.

Mr. D.C. Palser: Cape Town

Mr. Question-master, we have about 150 000 domestic consumers. We have been using the so-called Cape cooker plug for many, many

years now and I can assure Mr. Grant that we have no trouble with it at all, not that I am aware of.

Mr. D. Haig-Smith: Queenstown

Mr. Question-master, if you go back in AMEU records, you will find that the cooker plug which is now being used was introduced at the request of the AMEU. Discussion went on for quite a few years about the cooker plug before it finally received the approval of the AMEU.

Mr. V.A.H. McDonald: Affiliate

Mr. Question-master, I know that the particular cooker plug that has been used in the Cape, where they do not have much lightning, for so long was used in Pretoria at one time, but I can assure you that it did not work very well except as a lightning arrestor! They just blew up, so we have to look at something new. Mr. Question-master I would like to support Mr. Fortmann because you know stoves today are moved from one home to another, they are disconnected, taken out for repair and new stoves may be bought in their place. The stove is delivered by the supplier and we all know what happens then. In many instances the delivery truck driver has been given a quick five minute lesson and then left to connect the stove. I would support Mr. Fortmann.

MR. J.V. Grant: SABS

Mr. Question-master, I don't want to fight with the AMEU but unfortunately, technically, I can't say too much about the Cape cooker plug, but it has been sent to us for test. I would just warn you that Mr. McDonald has a point and if you want the present plug that is on the market to be propagated, I think you should ask for it to be tested by us and we will do this with pleasure. You will be surprised at the results!

The insulation resistance is really not good enough, but I didn't bring that up myself, Mr. McDonald did. The Main-Committee did discuss this matter at great length and I don't want to labour the point. If you wish to bring it up of course that is the prerogative of the AMEU, but the Main-Committee on which the AMEU is and always has been very well represented, said "no" some time ago. Thank you.

Mr. P.J. Botes: Roodepoort

Mr. Question-master, this is really a problem and I want to support Mr. Fortmann as well. The point is that the Department of Community Development for sub-economic houses won't allow unqualified installation of a stove. So it seems necessary to have a suitable stove termination on the wiring installation. I don't know what the legal aspects are. If a wiring installation is left without suitable circuit terminations – e.g. a stove socket outlet – and it is then tested as in fact it must be to clear the wiring contractor, any one can come later and connect up any kind of stove in any manner – safe or unsafe!

So it is very important that we examine the question of the stove plug carefully because it will almost certainly become standard practice at a future date.

Mr. J. Smit: SABS

Mr. Question-master, unfortunately I have to leave now but following on to what Mr. Grant has said, I would like to point out that in the present wiring regulations stoves, geysers, instantaneous waterheaters and light fittings are not covered anywhere. Now we seem to be making a fuss about a plug on its own. That is just a thought Mr. President. I think there are more things for us to worry about at this stage than a stove plug.

Mr. G. Weich: Chief Inspector

Correction please. It is true that stoves and hot water cylinders are outside the new wiring relations, but not the connection of those appliances. The plug would simplify that very much. The plug would eliminate all the illegal wiring that is done by householders, shopkeepers, etc. I am afraid I must correct the Bureau, they should read the regulations more carefully.

PIETERMARITZBURG ARMATURE WINDERS VERSUS PIETERMARITZBURG CITY COUNCIL

The abovementioned case has far reaching implications as far as the electricity supply industry concerned.

Mr. E.G. Davies: Pietermaritzburg

A report of low-voltage was received by the department, which immediately dispatched an electrician to the plaintiff's premises. At that stage the largest item of electrical equipment was an oven which was being repaired. The consumer stated that the oven, then under repair, had been the cause of the low-voltage and that it was not caused by any Council electrical equipment. Nevertheless the electrician took voltage readings on all three phases and confirmed that there was no low-voltage.

It was not possible at that stage to load the system because the oven was out of order. Some days later a report was received that the same plaintiff was experiencing low-voltage which had damaged some equipment. An inspection ws made and it was ascertained that a neutral link on the incoming supply cable had burnt contacts, which burning could only be seen when the link was removed. The firm claimed approximately R2 000 from the Council.

In terms of the by-laws, the Council is precluded from paying such claims unless it was due to negligence by the Council. In this instance Council considered thát it had not been negligent.

After approximately a year the case came to the Supreme Court in Pietermaritzburg, the plaintiff's argument being that there is an absolute liability in terms of Section 50 of the Electricity Act (No. 40 of 1958) which goes thus:

(1) "In any proceedings against an undertaker arising out of damage or injury caused by induction or electrolysis or otherwise by means of electricity generated or transmitted by or escaping from the plant or machinery of any undertaker, it shall *not be necessary for the plaintiff to prove that the damage or injury was caused by the negligence of the defendant, and damages may be recovered notwithstanding the absence of such proof.*

(2) In any such proceedings it shall be a defence that the damage or injury was due to the wilful act or to the negligence of the person injured or of some person not in the employ of the defendant or of some person operating the plant or machinery of the defendant without his consent."

The case was heard on 13th November, 1980 and lasted a day and a half. Much stress was laid on the actual wording of the Act and whether the word "otherwise" referred to something similar to induction or electrolysis. Numerous cases were quoted. The main case set forth to uphold the opinion of the Council was that of Botes versus Potchefstroom Municipality and Another 1941 T.P.D. 149. The judgment in the case under consideration consists of 13 pages but, contrary to previous cases in the Transvaal, went against the Council so that in Natal there now appears to be an absolute liability imposed on the supply authority in such cases.

The position at the moment is that a prominent Advocate in Durban disagrees with the judgment and suggest that it be taken to appeal and this will be done in due course. I would suggest that if the appeal were to fail the matter wil have to be taken up with the Electricity Control Board because, in my opinion, there are so many instances where Council or other undertakings for that matter could be sued as to make the supply of electricity almost untenable.

PIETERMARITZBURG ARMATURE WINDERS IN DIE SAAK TEEN DIE STADSRAAD VAN PIETERMARITZBURG

Bovermelde saak het wye implikasies in die elektriese voorsieningsnywerheid.

Mr. D.C. Palser: Cape Town

My Council also has an electricity supply by-law which states that the Council shall not be liable for any loss or damage arising from inter alia, an incident similar to that outlined. In such cases the Council will not entertain any claims. But in view of what has just been said it is clear that there is an absolute liability because of the superior legislation of the Electricity Act. The legal dispute, however, apparently centres on what is meant by the phrase "or otherwise" in Section 50 of the Electricity Act.

One way out of this dilemma is to take out a public liability insurance policy covering all such types of claim. My Council has such a policy. In terms of this policy the insurer is liable for all sums which the Council becomes legally liable to pay for compensation in respect of bodily injury or illness to any person, fatal or otherwise, and damage to property, whether due to negligence of the Council's employees or not. The premium currently being paid is slightly in excess of R100 000 per annum, the limits of liability being R100 000 for any one claimant and R400 000 for any one accident. This policy will lapse shortly and my Council is now considering covering this risk by means of self-insurance in future.

I would therefore suggest that insurance is one answer to this problem, be it by means of a conventional public liability policy or self insurance.

Progress report on the influence of instant type water heaters on the maximum demand of a block of flats.

Vorderingsverslag oor die invloed van kits-waterverwarmers op die maksimum aanvraag van 'n woonstelgebou.

Mr. D.S. van der Merwe: Witbank

1. The object is to investigate the effect of instant type water heaters as opposed to storage heaters and other types with respect to kWh consumption, demand diversity and how results may influence an existing tariff structure.
2. Instant type water heating is referred to as an instant type heater replacing a conventional storage heater as the main hot water source of an installation. It seems practice to install in addition a small mini-type throughput geyser at kitchen sinks and at other draw off points where the volume of hot water required is small.

   On the instant type heating system under test the yield of hot water measured was 12 litres/min at 60°C and at pressures varying between 600 and 800 kPa, the measured kW demand of the unit was 24.

   The units are installed midway between two bathrooms with a smaller 3 kW instant (push through) type at the kitchen wash-up. From observation, domestic instant heating units yielding **less than 10 L/min** of hot water and used as the main source of hot water supply, are of limited use.

   Four different modes of heating systems were installed in four separate blocks of flats being:

   SYSTEM A:

   A conventional 4 kW 120 litre storage heater in each of twelve living units and one 4 kW storage heater in a service block common to all of the twelve living units.

   SYSTEM B:

   One 24 kW instant heater for bath and washrooms aided by a 3 kW mini-geyser in kitchens, all installed in each of eight living units. A 1 x 4 kW conventional storage heater installed in a common service block, as in system A.

   SYSTEM C:

   One single 24 kW 1 000 litre central heater installed common to eight living units and a 1 x 4 kW storage heater in a service block, as in system A.

   SYSTEM D:

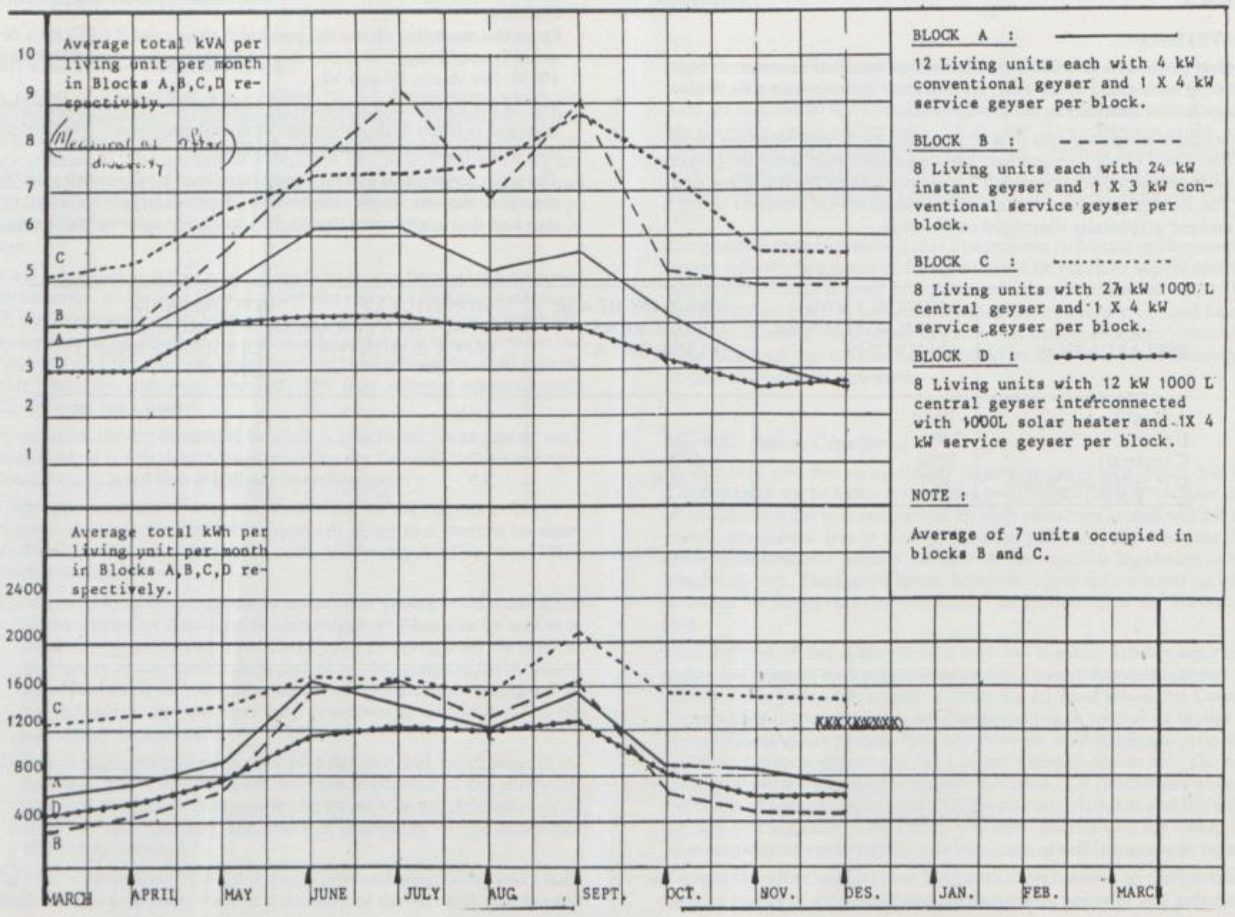
   One single 12 kW 1 000 L central heater installed common to eight living units aided by a 1 000 L solar heater. As before a 1 x 4 kW storage heater installed in the service block.
3. Separate measurements of water heating loads only were not possible. Total block demand and kWh measurements were thus taken and compared with separate kWh measurements of each living unit. The average results so obtained are tabulated on attached Sheet I and are graphically illustrated on Sheet II.

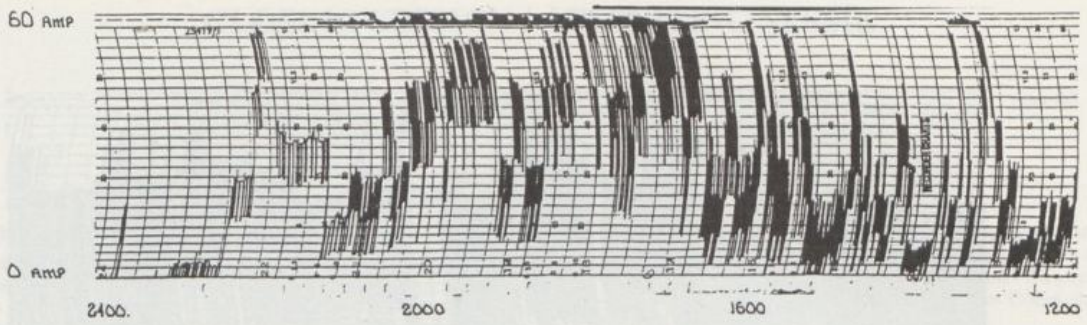
OBSERVATION:

1. To the Consumer against whom a basic monthly charge and straight kWh tariff is levied, the instant heater, by virtue of its low heat losses during summer months, has something to offer by way of kWh savings. During winter months however the kWh consumption rises above that of the conventional storage heater. The average monthly kWh consumption over 10 months are lower. In comparison with the conventional heater, the kW demand resulting from instant heaters over the test period of 10 months indicates a monthly average increase of 6.16 kW less 4,54 kW = 35,6% per living unit. (see curves A and B on Sheet II and table below).
2. The connection load-to-demand ratio of installations equipped with conventional hot water appliances approximates 3.7 whilst that of 24 kW "instant equipped" installations approximates a ratio of 6. This suggests that a single 7 to 9 kW instant type appliance may be permissable without grave danger of exceeding demands obtained with conventional geysers. The consumer will retain kWh economy if he is prepared to put up with the inconvenience of a lower rate yield of hot water. The supplier on the other hand will be faced with low load factors and loss of revenue on kWhs.
3. The result obtained from the central heating system is disappointing. On the installation under test (Block "C") the heating unit is installed 25 metres from the nearest hot water outlet and 50 metres from the most remote outlet.
   The compairitively high demand and consequent high kWh consumption is indicative of severe heat losses along the route.
4. Heat losses of the same order for the same reason occur on the solar assisted central heater and cancel to some degree the bonanza which could be had from solar energy. In the installation under test a kWh saving and lower demand, despite losses, is prevalent. The low powered element (12 kW) on a bulk reservoir (1 000 L) together with solar benefits explains the behaviour of curves "D".
5. When restoring power after an interruption, the instant geyser has little effect on M.D.
6. It was difficult to ascertain if the maximum demand established by all forms of heating coincided with the maximum demand registered by ESCOM.
   From the recording charts the possibility does exist if ESCOM's demand is established, as is the case in Witbank, between 18h30 and 19h30. See sheets III and VI.
7. The 24 kW instant unit under test is designed for 3 phase delta operation and is fitted with a pressure operated membrane which limits power input under low pressure conditions.
8. The most economical unit, consumption wise, is the central solar assisted installation. Its success however depends largely on layout design and thorough – very thorough – insulation against heat losses.

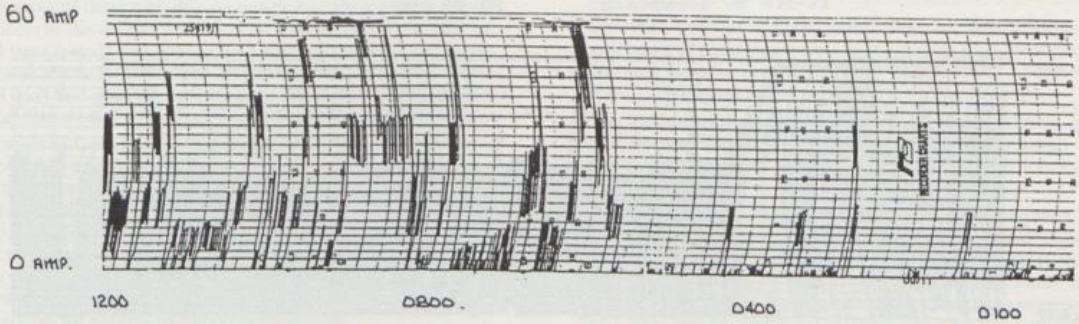
INSTALLATION	MONTHLY kWh AVERAGED OVER 10 MONTHS	kWh % INCREASE OR DECREASE BASED ON "A"	MONTHLY kW DEMAND AVERAGED OVER 10 MONTHS	kW DEMAND % INCREASE OR DECREASE BASED ON "A"
A (conv)	1060	–	4.54	–
B (Inst)	931	– 12%	6.16	+ 35.6%
C (central)	1568	+ 47%	6.7	+ 47.5%
D (Central and Solar)	877	– 17.26%	3.5	– 22.9%

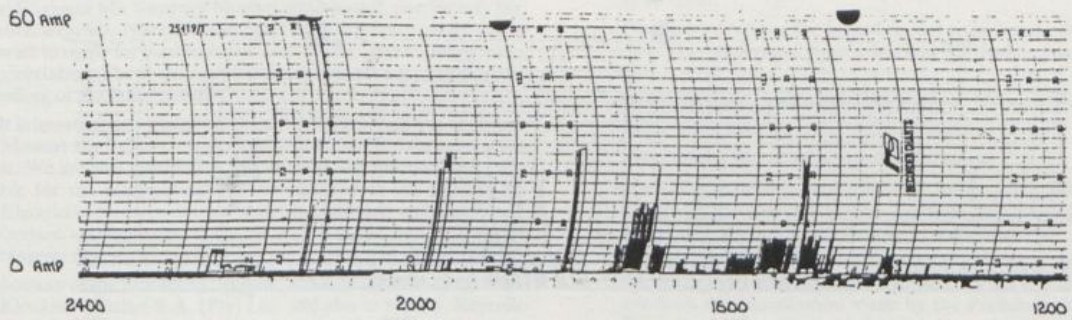
	TOTAL kWh FOR COMPLETE BLOCK INCLUSIVE OF SERVICE GEYSER				TOTAL kVA/hr FOR COMPLETE BLOCK INCLUSIVE OF SERVICE GEYSER				AVERAGE (FROM ACTUAL READINGS) kWh PER LIVING UNIT PER MONTH				AVERAGE kVA PER LIVING UNIT PER MONTH				kWh PER PERSON PER MONTH				kVA PER PERSON PER MONTH			
	BLOCK				BLOCK				BLOCK				BLOCK				BLOCK				BLOCK							
DATE	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D				
March 81	7270	2391	8895	3716	40	28	36	23,6	605,6	316	1270	464	3,6	4	5,1	3,4	197	126	296	154	1,08	1,5	1,2	1				
April	8800	3101	9611	4755	45,6	28,4	37,6	24,4	733,3	443	1373	594	3,8	4	5,4	3	238	163	320	198	1,23	1,5	1,25	1				
May	11003	4642	9938	6288	59,2	40	46	32,8	916,9	663	1419	786	4,9	5,7	6,6	4,1	297	244	331	267	1,6	2,1	1,53	1,36				
June	20126	10907	11824	9428	74,2	53,6	52	33,6	1677,2	1558	1689	1178	6,2	7,65	7,4	4,2	544	574	394	392	2	2,8	1,73	1,4				
July	17975	11660	11789	9746	74,2	65,6	52	33,6	1478	1665	1684	1218	6,2	9,27	7,4	4,2	486	614	392	406	2	3,45	1,73	1,4				
August	14718	9546	11025	9646	63,2	48,8	53,6	31,2	1232	1363	1575	1205	5,2	6,9	7,65	3,9	399	502	367	401	1,7	2,56	1,77	1,3				
September	18939	11733	15205	9953	67,2	64	61,6	31,2	1578	1676	2172	1244	5,6	9,1	8,8	3,9	511	617	506	414	1,7	3,36	2,0	1,3				
October	10315	5377	10708	5642	50,4	41,6	52,8	25,6	859,5	672	1528	806	4,2	5,2	7,5	3,2	278	283	356	235	1,36	2,2	1,75	1				
November	9928	3843	10528	4880	37,6	39,2	39,2	20,8	827,5	480,3	1504	610	3,1	4,9	5,6	2,6	268	202	350	203	1,01	2,06	1,3	0,866				
December	8395	3827	10285	5345	32	39,2	39,2	21,6	699,5	478,3	1469	668	2,6	4,9	5,6	2,7	226	201	342	222	0,86	2,06	1,3	0,9				



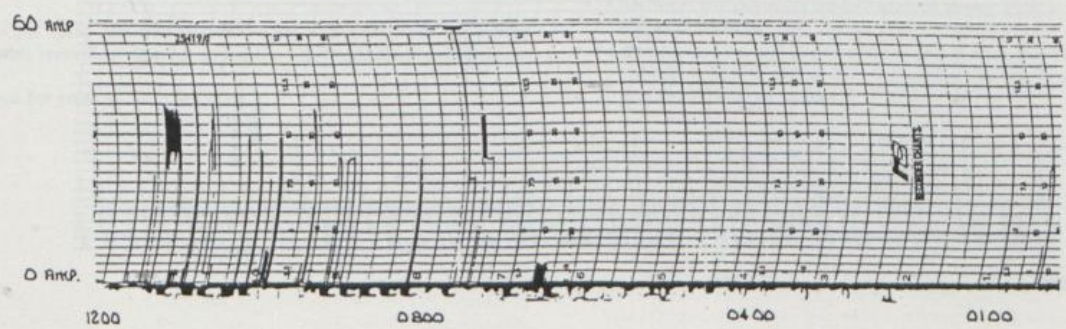


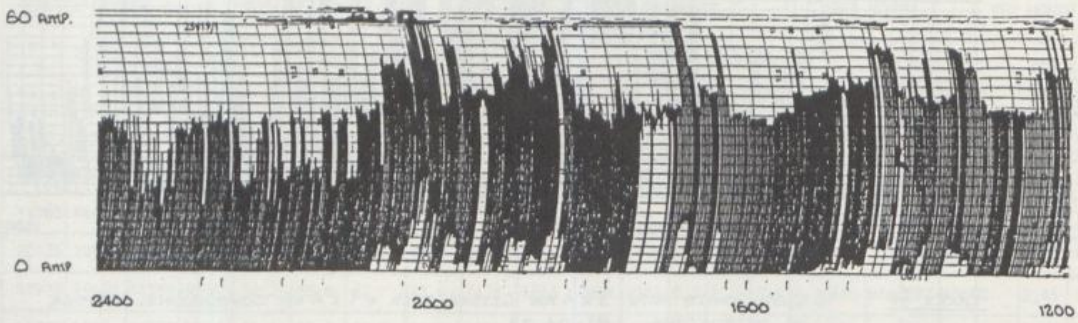
BLOCK A 12 LIVING UNITS WITH 1 x 4 KW GEYSER EACH + 1 x 4 KW CONVENSIONAL GEYSER IN OUTBUILDING. 81-04-24.



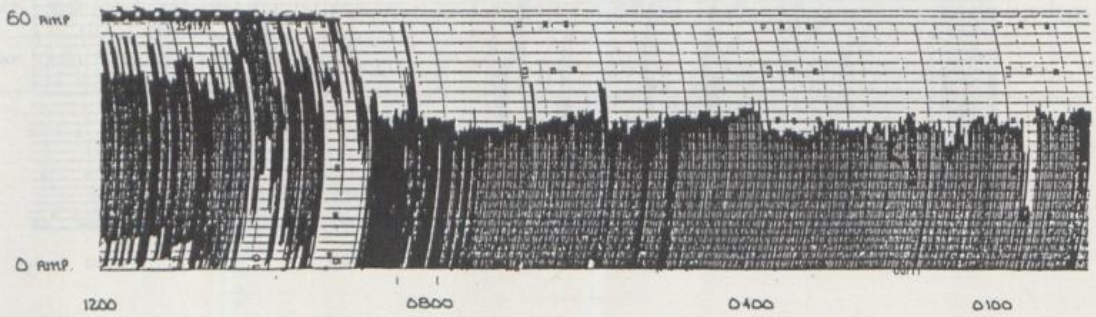


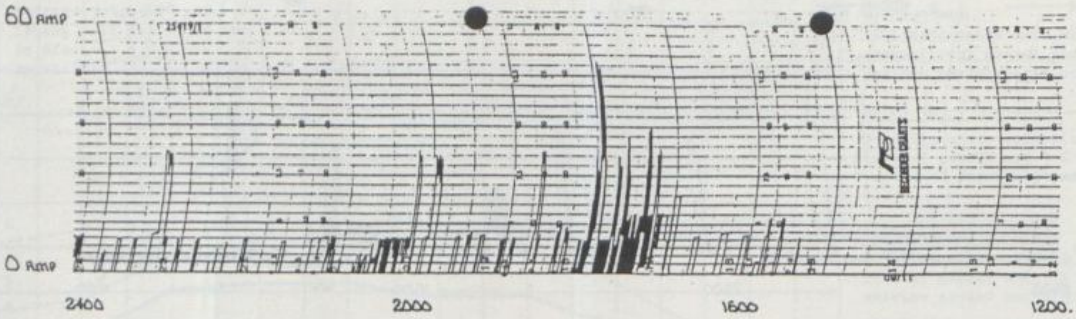
BLOCK B 8 LIVING UNITS WITH 24 KW INSTANT GEYSERS FOR BATHROOMS + 1 x 3 KW MINEE GEYSERS AT WASH-UP + 1 x 4 KW CONVENSIONAL GEYSER IN OUTBUILDING. 81-03-31.



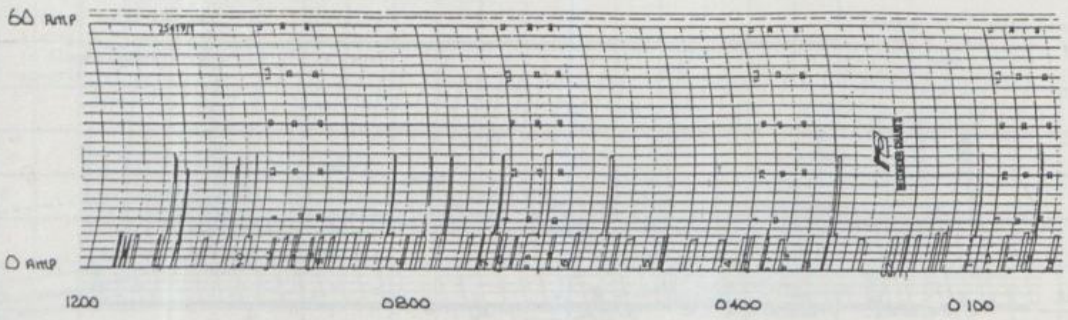


BLOCK C. 27 KW 1000 LITRE 3 ϕ GEYSER SERVING 8 LIVING UNITS + 1 x 4 KW CONVENSIONAL GEYSER IN OUTBUILDING. 81-04-18.





BLOCK D 12 KW x 1000 LITRE GEYSER AIDED BY 1000 LITRE SOLAR HEATER SERVING 8 LIVING UNITS + 1 x 4 KW CONVENSIONAL GEYSER IN OUTBUILDING. 81-04-22.



CLOSING SESSION / AFLSUITING SESSIE

Mr. D.H. Fraser: President

Now ladies and gentlemen we come to the end of the formal proceedings of this 9th AMEU Technical Meeting which, I am sure you will agree, has been rewarding in every way. It has been said before but bears repeating that perhaps the greatest value of meetings of this nature is the opportunity which it provides of informal exchange of views, and the deepening of friendships and relationships outside the conference hall. Their closing therefore is usually tinged with sadness as it means parting from friends.

Perhaps there are some present this afternoon who will be retiring or leaving municipal service before the next Convention and it is fitting that we take leave of them with due recognition of their efforts. May I ask my members in this category to stand for a moment. Gentlemen, on behalf of all your friends and colleagues I wish you well for the future and thank you for your contributions to the AMEU and to the municipal service. I trust that you will continue your association with us as Past Members and that we will see lots of you at future AMEU functions.

The organisation of Conventions and meetings of this nature entails a great deal of hard work by many people and when everything goes smoothly as it has done during the past two days it is not always apparent what goes on behind the scenes. It is therefore right and proper that we should publicly record our thanks and indebtedness to those who have contributed to the success of this Technical Meeting. Firstly, to His Worship the Mayor, Clr. Heunis and his Council for inviting us to this delightful town and for the warmth of their hospitality and involvement in the proceedings we express our deep appreciation.

To the Mayoress we extend thanks for her hospitality to the ladies and her gracious participation in the various items on the programme.

Thanks also to the Town Clerk, Mr. Carel du Plessis whose valued support and assistance with the arrangements is much appreciated.

Undoubtedly the heaviest burden has been shouldered by the Town Electrical Engineer Mr. Sweeney Mostert and his staff, particularly Mr. Dale Liebenberg, Mr. Hank Luckhoff and Mr. Cliff Spiro, and I would like them all to come forward to receive an AMEU tie as a small token of our appreciation. They have certainly made my task easy by their efficient handling of the many details.

The most interesting and imaginative Ladies Programme was arranged by Mrs. Mostert who is to be congratulated and thanked for her valued assistance. We are also indebted to Mr. Sherriff, the caretaker who was responsible for the arrangements in the hall and to the staff of the George Electricity Department for their co-operation and assistance, Mrs. Robertson and her helpers deserve special credit for the beautiful floral arrangements.

To the sponsors of the luncheons, Messrs. Power Engineers (Pty) Ltd., Messrs. Klockner Moeller S.A. (Pty) Ltd. and also to Messrs. Reyrolle Parsons (Pty) Ltd. in anticipation of their hospitality this evening, our very grateful thanks. We record our appreciation to Messrs. Thorn Lighting for the provision of folders and also to Sanlam for pens and note pads. The ladies, by all reports, had a most interesting visit to the S.A. Women's Army College and were entertained to a most enjoyable luncheon. It is not known how many were recruited into the army. Our thanks to the authorities responsible and also the SAASVELD for the ladies' other visit. Special thanks tothe firm of Consulting Engineers that sponsored the Ladies other Luncheon. They must remain anonomous.

Messrs. Cliff Spiro and Brian Barton were responsible for the public address and recording. Mr. Loots for the registration and information service.
Thank you for your valuable service.

To the charming ladies, Mrs. Els, Mrs. Coleman and Miss Pool who catered for our needs at the registration and information desks, we are especially grateful. Also Estelle Swart and Nantes Zwiegelaar for assistance with folders and administration and Miss Esterhuizen for typing services.

The morning and afternoon teas were kindly sponsored by Messrs. GEC Power, Hubert Davies, Industrial Machinery Suppliers, Aberdare Cables and Scottish Cables, and provided by Womens' Agricultural Association and Hawthorndene Hotel who handled the catering. We record our appreciation to them, and thanks for the high quality Scottish Cables-keyrings. The bus drivers fulfilled a very important function and thanks are also due to Table Top for assistance with transport.

Diversion to those addicted to inflicting punishment on the indefensible golf ball will be made possible tomorrow through the support of Messrs. North & Robertson, GEC Power, GEC Cables, Aberdare Cables and Valley Construction and I thank you on their behalf.

The authors of the papers, Dr. A. Eriksson and Messrs. Seymore, von Ahlften and Wedderburn played a most important part for which we thank them, together with our Quizmasters, Dave Soons and Jules von Ahlften.

To representatives of other organizations, including the COTT, CSIR, S.A. Transport Services, SABS, Dept. of Manpower, Communication Division Posts and Telegraphs, Provincial Administrations of the Cape and Orange Free State, Institute of Municipal Engineers, Lesotho Electricity Corporation, Transkei Electricity Supply Commission, Republic of Ciskei and University of Stellenbosch who have attended this meeting, thank you for your presence and contributions.

My personal thanks to the President Elect, Wessel Barnard, for his co-operation and support and to our Secretary Bennie van der Walt and his wife Annatjie for all their efforts to ensure the success of this meeting. To my wife, Val, my thanks for your unfailing help and encouragement at all times.

Finally to all of you for attending and contributing in so many ways to make this conference memorable and worthwhile, my sincere appreciation.

Before closing I understand Mr. Wessel Barnard wishes to say a few words.

Mnr. Wessel Barnard: Aangewese President

Mnr. die President, dames en here, ek is seker u sal almal met my saamstem dat hierdie Negende Tegniese Vergadering nog een van ons hoogs suksesvolle en waardevolle vergaderings was.

Without detracting from the substantial and highly competent contributions made by others already mentioned by the President, one must not overlook the contribution made by the President, Mr. Denis Fraser. Denis has again guided and directed the proceedings both the technical session and social functions in his usual competent, well planned, friendly manner. His has made no unsightful contribution and on your behalf I would like to thank him for this one, to congratulate him on a highly successful Technical Meeting.

Mr. D.H. Fraser

Thank you Wessel for your kind words.

That concludes the formal proceedings but we gather again this evening at 19h30 for the final social function in the Civic Centre as guests of Reyrolle Parsons and George Town Council.
I wish you all a safe journey home and declare this 9th Technical Meeting of the AMEU closed. Ek verklaar hierdie 9de Tegniese Vergadering van die VMEO as gesluit.

KWALITEITPRODUKTE IN 'N MEDEDINGENDE WÊRELD

deur
A.A. Middlecote, B.Sc (ELEK.ING) PR. ING.
Adjunk-direkteur-generaal, SABS

QUALITY PRODUCTS IN A COMPETITIVE WORLD

by
A.A. Middlecote, B.Sc (ELEC.ING) PR. ENG.
Deputy Director General, SABS

Die behoefte aan voortgesette ekonomiese groei in veral die hoogs geïndustrialiseerde lande, het die aandag gefokus op die behoefte daaraan om internasionale handel te vergemaklik en te bevorder. Die volgehoue pogings om handelsversperrings uit te skakel, het gelei tot belangrike onderhandelinge soos dié in verband met die Algemene Ooreenkoms insake Tariewe en Handel (AOTH) in Genève, en die internasionale handel is besig om vinnig toe te neem. Net wat elektriese ingenieursprodukte betref, het die wêreldhandel sedert 1960 sowat 14 maal groter geword, d.w.s. van ongeveer 5 000 miljoen dollar tot 70 000 miljoen dollar toegeneem.

Hierdie vergemakliking van die internasionale handel het vereis dat tegniese handelsversperrings voorkom moes word en dat diskriminerende toepassing van produkstandaarde, produktoetse en produksertifiseringskemas ontmoedig moes word.

In the agtergrond by alle handelsversperrings, hetsy tarief- of nie-tariefversperrings, standaarde of regeringsregulasies, bly daar egter steeds die kewssie van die verhouding tussen koper en verkoper. As die produk nie reg is nie, word dit nie verkoop nie, of minstens nie teen 'n wins verkoop nie. Namate ons 'n wêreld betree waarin die handel in toenemende mate vryer word en daar gevolglik 'n toename is in die druk wat internasionale mededinging meebring, sal daar ongetwyfeld steeds meer aandag geskenk moet word aan kwaliteit as een van die vernaamste maniere om markte te verkry, of dit nou op nasionale of internasionale vlak is.

Hierbenewens maak die jongste neigings wat aanspreeklikheid en moontlike eise teen fabrikante betref en wat in sommige lande skrikwekkende afmetings aanneem, dit ook nodig dat elke moontlike stap gedoen word om kwaliteitsprodukte in die volle sin van die woord te verseker – of dit nou na die regte inhoud in 'n houer verwys; of na 'n korrek geëtiketteerde houer; of dat die houer nie oopgemaak kan word deur 'n kind wat nie kan lees nie.

En daarom lees ons nou oral van kwaliteit, kwaliteitskontrole, kwaliteitsversekering en kwaliteitsbestuur. Hierdie terme kan verwar word en moontlik sal dit die beste wees om die terme duideliker te omskryf voordat daar ingegaan word op die wyse waarop finale kwaliteit die beste in 'n produk verseker kan word.

KWALITEIT

Kwaliteit is 'n begrip wat moeilik vasgevat kan word, veral wanneer 'n onskrywing daarvoor gesoek word. Vanuit die oogpunt van standaardisasie en kwaliteitsbestuur is die volgende waarskynlik die beste omskrywing:

Die totaliteit van die kenmerke en eienskappe van 'n produk of diens wat in verband staan met die vermoë daarvan om 'n bepaalde behoefte te bevredig.

Die bepaalde behoefte word grootliks deur marknavorsing en produktoetse vasgestel. Oor die algemeen word die vereistes om 'n bepaalde behoefte te bevredig in 'n spesifikasie of standaard uitgedruk, hetsy nasionaal of internasionaal. Dit word dan die wesenlike en gesonde basis om die nodige kwaliteitsvlakke daar te stel. Daar na sodanige standaarde te verwys, kan 'n koper aan 'n leweransier 'n aanduiding gee van watter kwaliteite in sy produk nodig is. Die ontwerper self kan egter ook 'n bydrae tot kwaliteit lewer, veral met betrekking tot gesofistikeerde produkte. As gevolg hiervan sluit kwaliteitsversekeringsvereistes dikwels die terugvoer en hersiening van ontwerpkontrole in.

In die Republiek is die Sud-Afrikaanse Buro vir Standaarde grotendeels

The need for continued economic growth in the highly industrialized countries in particular, has concentrated attention on the need for facilitating and promoting international trade. The continued efforts to remove trade barriers has resulted in major negotiations such as those in the General Agreement on Tariffs and Trade (GATT) in Geneva, and international trade is increasing rapidly. In electrical engineering products alone the world trade has increased by about 14 times since 1960, i.e. from about 5 000 million dollars to 70 000 million dollars.

This facilitation of international trade has called for the prevention of technical barriers to trade and the discouragement of discriminatory application of product standards, product testing and product certification schemes.

However, behind all trade barriers, whether tariff or non-tariff, whether standards or government regulations, remains the question of buyer/seller relationships. If the product is not right, it will not be sold or at least it will not be sold at a profit. There is no doubt that as we move into a world with progressively free trade with resulting increase in international competitive pressures, more and more attention will need to be paid to quality as a prime means of securing business, whether in the national of the international sphere.

In addition, latest trends concerning liability and possible claims against manufacturers that are assuming alarming proportions in some countries, also call for every step to be taken to ensure product quality in the full sense of the word – whether this refers to the right contents in a container; or a correctly labelled container; or that the container cannot be opened by an infant unable to read.

And so now er read extensively regarding Quality, Quality Control, Quality Assurance and Quality Management. All these terms can be confused and perhaps it would be best to define these terms more clearly before studying how ultimate quality can best be assured in a product.

QUALITY

Quality is an elusive concept not least from the point of view of definition. From the point of view of standardization and quality management the following is possibly the best definition:–

The totality of features and characteristics of a product or service that bear on its ability to satisfy a given need.

The given need is established largely by market research and product testing. In the main the requirements to satisfy the given need are expressed in a specification or standard, whether national or international. These then become the essential and sound bases for establishing the necessary levels of quality. By reference to such standards a purchaser may indicate to a supplier what qualities are necessary in his product. However, there is a contribution to quality by the designer himself, particularly in sophisticated products. It is for this reason that quality assurance requirements often include design control feedback and review.

In the Republic, the South African Bureau of Standards is responsible largely for the production of specifications and standards as the bases for quality products but it also promotes good design through its Design Institute. Continuous monitoring of the resultant products in the market, particularly through the agency of the standardization mark scheme, and also participation in international standardization activities ensures continuous review of the specification or standard so that these are indeed bases for quality.

vir die opstel van spesifikasies en standaarde as die basis vir kwaliteitprodukte verantwoordelik, maar die Buro moedig ook goeie ontwerp deur sy Ontwerpinstituut aan. Voortdurende monitering van die resulterende produkte op die mark, veral deur middel van die standaardmerkskema, asook deelname aan internasionale standaardiseringswerksaamhede, verseker deurlopende hersiening van die spesifiekasie of standaarde, met die gevolg dat dit werklik basisse vir kwaliteit is.

Daar kan gevolglik gesê word dat 'n koper die kwaliteit van 'n produk kan toets en evalueer deur verwysing na standaarde. Die volgende probleem van so 'n koper is egter om seker te maak dat die kwaliteit enbetroubaarheid van die besendings produkte wat vervolgens deur die leweransier gelewer word, deurgaans op dieselfde vlak is as dié van die monster wat getoets en geëvalueer is. Dit het gelei tot 'n behoefte aan wat bekend geword het as kwaliteitskontrole wat nou, uit 'n baie nederige oorsprong, in baie gevalle 'n gesofistikeerde vorm van kontrole geword het.

KWALITEITSKONTROLE

Die vroegste kwaliteitskontrole op 'n produk was waarskynlik dié van mev Ples wat, nadat sy aan haar eggenoot haar spesifikasie vir 'n dierepels gegee het, onbevredigende pelse afgekeur het totdat een 'wat geskik was vir die doel' afgelewer is. Dit geskied d.m.v. finale ondersoek en toets en vereis in gevalle van groot besendings statistiese monsterneming om potensiële buitensporig hoë toets- en ondersoekkoste te besnoei.

Hierdie stelsel het egter met die koms van moderne produksiemetodes en die gebruik van minder geskoolde arbeid wat dikwels kwaliteitsgewys deur produksiebonusse beïnvloed is, onekonomies geword. Baie produkte is na finale ondersoek afgekeur, wat 'n groot verlies beteken het. So is daar gaandeweg al vroeër in die produksielyn met ondersoek en toetse begin sodat gebrekkige materiaal en komponente verwyder of gekontroleer kon word voordat die eindproduk saamgestel word. Meer gesofistikeerde toets- en kontrole-uitrusting is gebruik om kontrole te verbeter en die vervaardiging van onbevredigende onderdele te voorkom. Daar is ook van kontrolekaarte gebruik gemaak. Uiteindelik is aanvaar dat kwaliteit nie deur inspeksie aan 'n produk gegee kan word nie en is kwaliteitskontrole in 'n groot mate gesentreer om pogings om almal te motiveer om kwaliteit in 'n produk in te bou en dit die eerste maal reg te doen – dus bykans terug na die jaloerse benadering van die gildewerkers van die Middeleeue. Dit is grootliks hierdie aspek wat verantwoordelik is vir die sukses van die kwaliteitskontrolekringe wat in Japan gebruik word en nou in Westerse lande aanvaar begin word.

Kwaliteitskontrole kan dus in eenvoudige taal omskryf word as

Die bedryfstegnieke en werksaamhede wat die kwaliteit van 'n produk en diens wat bepaalde behoeftes bevredig, rugsteun; dit sluit die gebruik van sodanige tegnieke en werksaamhede in.

Dit het egter duidelik geword dat kwaliteitskontrole verder strek as bloot die fabriek of monteeraanleg – dit sluit in werklikheid ook ontwerp, bemarking en vervoer in. En so het die begrip van algehele kwaliteitskontrole of kwaliteitsversekering, soos dit nou bekend staan, ontstaan.

KWALITEITSVERSEKERING

Fig. 1 sit diagrammaties een moontlike begrip van algehele kwaliteitskontrole of kwaliteitsversekering uiteen. Dit gee die baie gebiede aan wat betrokke is by die versekering van kwaliteit, bv. marknavoring, spesifikasie en standaarde, ontwerp, produkingenieurswese, aankope, vervaardiging, produksieondersoek en toers, verpakking en vervoer, en aanwysings.

Bogenoemde is waarskynlik die rede waarom kwaliteitsversekering omskryf word as

Die georganiseerde evaluering van kwaliteitskontrole met inbegrip van planne en stelsels wat daarop gemik is om versekering van en vertroue in die kwaliteit van die produk te voorsien. Dit dek die behoorlike spesifisering van wat verlang word, met terugvoer afkomstig van marknavorsing; ontwerp van die produk of diens om aan die vereistes te voldoen; produksie of installering om aan die volle vereistes en oogmerk van die spesifikasie te voldoen; en nagaan van gebruik vir die hersiening van die spesifikasie. Doeltreffende benutting van hierdie tegnologieë en werksaamhede is 'n noodsaaklike element in die ekonomiese kontrole van kwaliteit.

Hierdie somtotaal van komponente wat kwaliteit vergestalt, lei tot 'n logieser benadering tot vraagstukke in verband met kwaliteit. Indien mislukkings op die gebied voorkom, kan die versoeking ontstaan om probleme te probeer oplos deur die lynkwaliteitskontrole teen groot onkoste te verskerp, terwyl mislukkings wesenlik tog nie verminder word nie. Die werklike probleem kan 'n ontwerp- of spesifikasiewakheid of -tekortkoming wees.

Ten einde doeltreffende implementering van die beginsels hierbo genoem moontlik te maak, word bestuur vereis, net soos ander werk-

Thus one could say that any purchaser could test and evaluate the quality of a product by using standards as a reference. However, his next problem is to ensure that the consignments of products subsequently delivered by the supplier will be of consistent quality and reliability to the level of the sample tested and evaluated. This required what became known as quality control which from very humble origins has now, in many cases, become a sophisticated control.

QUALITY CONTROL

Possibly the earliest quality control on a product was by Mrs Ples who, having given her husband her specification for an animal fur, rejected unsatisfactory ones until one 'suitable for the purpose' was delivered. This is by final inspection and testing, and in cases of large consignments required statistical sampling to reduce what would become inordinately high cost of testing and inspection.

However, with modern production methods and use of less skilled labour, often affected quality-wise by production bonuses, this system became uneconomic. Many products were rejected after final inspection and represented a large loss. And so the inspection and testing were successively transferred lower down the production line so that faulty materials and components could be eliminated or controlled before being assembled into the final product. More sophisticated test and control equipment were restored to improve control and prevent manufacture of unsatisfactory parts. Control charts were resorted to. Finally, it was accepted that quality could not be inspected into a product, and a large amount of quality control was centred round motivating everyone to build quality into the product and do the work properly the first time. Back almost to the jealous approach of the Guild workers of the Middle Ages. It is this component which is largely responsible for the success of the Quality Control Circles used in Japan and now finding favour in Western countries.

In simple language, Quality Control could thus be defined as

The operational techniques and the activities which sustain a quality of product or service that will satisfy given needs; also the use of such techniques and activities.

However, it became apparent that control of quality went beyond the factory or assembly plant alone – it really includes design, marketing, transport. And so the concept of Total Quality Control or as it has now become known, Quality Assurance, was born.

QUALITY ASSURANCE

Fig. 1 gives diagrammatically one possible concept of Total Quality Assurance. It indicates the many areas involved in ensuring quality, such as Market Research, Specification and Standards, Design, Product Engineering, Buying, Manufacturing, Production Inspection and Testing, Packaging and Transportation; and Instruction.

This has possibly suggested that Quality Assurance be defined as

The organized evaluation of quality control including plans and systems aiming at providing assurance of and confidence in the quality of the product. It covers the proper specification of what is wanted, with feedback from market research; design of the product or service to meet the requirements; production or installation to meet the full requirements and intent of the specification; and review of usage for revision of specification. Effective utilization of these technologies and activities is an essential element in the economic control of quality.

This totality of components making up quality makes the general approach to quality problems more logical. If there are failures in the field, one might be tempted to solve this by tightening up the line quality control at great expense and yet not significantly reduce the failures. The real answer could be a design or specification weakness or shortcoming.

Now for all this to be effectively implemented requires management, just as other activities of an organization require management, and this has resulted in the concept of Quality Management.

saamhede van 'n organisasie bestuur vereis, en dit het gelei tot die begrip kwaliteitsbestuur.

KWALITEITSBESTUUR

Om doeltreffend te wees, is dit nodig dat kwaliteitsversekering, soos in die geval van ander belangrike aspekte van bestuur, aan 'n erkende en toegewyde bestuursdepartement opgedra moet word. Dit vereis inderdaad toewyding van bestuurskant.

DIE VERPLIGTINGE VAN DIE SABS

Om die uitdagings van kwaliteit in die moderne wêreld te aanvaar, het die SABS die volgende verantwoordelikhede op hom geneem:

1) Die formuleting van kwaliteitspesifikasie en -standaarde vir produkte en toetsmetodes.
2) Voorsiening van toetsfasiliteite.
3) Advies en leiding met betrekking tot monsternemingsmetodes en die toepassing van kwaliteitskontrole.
4) Die formulering van 'n gebruikskode vir kwaliteitsbestuurstelsels – SABS 0157
5) Administrasie van 'n standaardmerkskema.

GEBRUIKSKODE VIR KWALITEITSBESTUURSTELSELS

Terwyl mense wat bedrewe is in die besondere tegnologie van 'n produk bykans instinkmatig kwaliteitsvermoë in 'n fabriek kan aanvoel, sit die gebruikskode vir kwaliteitsbestuurstelsels die raamwerk uiteen waarop 'n gesonde kwalteitsbestuurstelsel gebou kan word. Dit gee 'n globale uiteensetting wat wesenlik vereis word.

Omdat kwaliteitsbestuur in 'n betekenisvolle mate afhang van die aard van die produk of diens wat vereis word, word die onderwerp in die breë kategorieë in die kode gehandel.
Die drie dele is:–

DEEL 1 – *Kwaliteitstelsel vir ontwerp, vervaardiging en installering*

Dit maak voorsiening vir gesofistikeerde produkte of dienste wat ontwerp, ontwikkel en vervaardig word in streng gekontroleerde toestande waar die leweransier vir ontwerp, ontwikkeling, vervaardiging en installering, en veldtoetse verantwoordelik kan wees. Dit dui ook op die behoefte aan hoë betroubaarheid in die produk, want faling daarvan kan ernstige gevolge hê.

DEEL 2 – *Kwaliteitstelsel vir vervaardiging en installering*

Hierdie deel het betrekking op die vervaardiging van 'n produk waarvan die ontwerp reeds gevestig is en as bevredigend aanvaar kan word. Dit vereis nie dieselfde mate van ontwerpkontrole as wat die geval in deel 1 is nie, maar daar moet in alle stadiums van die vervaardigingsiklus deur ondersoek bepaal word of daar aan die vereistes voldoen word. Dit impliseer effens minder klem op betroubaarheid omdat faling van hierdie produk nie sulke ernstige gevolge sal hê as wat die geval sal wees met produkte wat in deel 1 gedek word nie.

DEEL 3 – *Kwaliteitstelsel vir finale ondersoek*

Dit geld vir produkte waarvan bevredigendheid genoegsaam deur 'ondersoek en toets van die finale artikel' bepaal kan word. Die impliseer dat faling van die produk nie ernstige gevolge sal hê nie.

In die kode self word die aandag by die volgende as 'n basis vir goeie kwaliteitsbestuur bepaal:

VEREISTES VIR KWALITEIT

a) *Gedokumenteerde verklaring oor kwaliteitstelsel* – doelstellings, beleidsrigtings, organisasie, ens. van kwaliteitsbestuur
b) *Organisasie* – personeel aan wie verantwoordelikheid vir kwaliteit opgedra is
c) *Hersiening van kwaliteitstelsel* – verklaar en onderneem
d) *Beplanning* om in koper se vereistes te voorsien
e) *Werksaanwysings* – ontwikkeling en handhawing van duidelik en volledige gedokumenteerde aanwysings
f) *Korrektiewe stappe* – ontleiding van defekte, deurlopende prosesbeheer om korrektiewe optrede te bepaal en te verseker dat dit toegepas word
g) *Ontwerpkontrole* – waar nodig, 'n stelsel vir die ontleding van ontwerpterugvoer en die algemene hersiening van ontwerp om deurlopende kwaliteit te verseker
h) *Kontrole van dokumentasie* wat betrokke is
i) *Kontrole van ondersoek-, meet- en toetsuitrusting*
j) *Kontrole van aangekoope materieel*
k) *Kontrole van vervaardiging*
l) *Monsterneming, ondersoek en toets van klaar produk*
m) *Kontrole van materieel wat nie voldoen nie*
n) *Beskerming en bewaring van produkkwaliteit* deur bevredigendehantering, bewaring, verpakking en aflewering.

Die finale kwaliteitsbestuurstelsel wat met inagneming van bogenoemde punte ontwikkel, word gewoonlik in 'n kwaliteitshandleiding uiteengesit. Dit is 'n dokument wat die bestuur se aanvaarding van die begin-

QUALITY MANAGEMENT

To be effective it is necessary to quality assurance to be handled by a recognized department of management, just as is the case with other important facets of management. This really calls for a dedicated quality declaration policy on the part of management.

THE OBLIGATIONS OF THE SABS

To meet the challenge of quality in the modern world, the SABS has accepted the following responsibilities:

1) Formulation of specifications and standards of quality for products and test methods
2) Provision of testing facilities
3) Advice and guidance regarding sampling methods and quality control applications
4) Formulation of a Code of Practice for Quality Management Systems – SABS 0157
5) Operation of a standardization scheme.

CODE OF PRACTICE FOR QUALITY MANAGEMENT SYSTEMS

While persons versed in the particular technology of a product can almost instinctively sense quality capability in a factory, the Code of Practice for Quality Management Systems sets out the framework around which a sound quality management system can be built. It expresses very broadly what is essentially required.

The code itself accepts three broad divisions of quality management since this depends significantly on the nature of the product or service required.
The three parts are:

PART 1 – *Quality system for design, manufacture and installation*

This caters of sophisticated products or services which are designed, developed and manufactured under closely controlled conditions where the supplier may be responsible for design, development, manufacture and installation and field trials. This also implied the need for high reliability in the product, the failure of which could have serious consequences.

PART 2 – *Quality system for manufacture and installation*

This refers to manufacture of a product where the design is already established and can be accepted as satisfactory. This does not require the same degree of design control as set out in Part 1, but compliance with the requirements has to be adequately determined by inspection performed throughout all stages of the manufacturing cycle. This implies slightly less accent on reliability since failure of the product would not have the serious consequences that failure of products covered by Part 1 would have.

PART 3 – *Quality system for final inspection*

This applies to products whose acceptability can be adequately determined by 'inspection and testing of the final article'. This implied that failure of the product would not have serious consequences.

In the code itself, attention is centred on the following as a basis for good Quality management.

REQUIREMENTS FOR QUALITY

a) Documented statement on Quality System – Quality management objectives, policies, organization, etc.
b) *Organization* – personnel delegated with quality responsibility
c) *Review of Quality System* – declared and undertaken
d) *Planning* to meet purchasers' requirements
e) *Work instructions* – developments and maintenance of clear and complete documented instructions
f) *Corrective Action* – analysis of defects, continuous monitoring of process to establish corrective actions with assurance that these are applied
g) *Design Control* – where necessary a system to analyse design feedback and generally review design to ensure continued quality
h) *Control of codumentation* involved
i) *Control of inspection, measuring and testing equipment*
j) *Control of purchased materiel*
k) *Control of manufacture*
l) *Completed product sampling inspection and testing*
m) *Control of non-conforming materiel*
n) *Protection and preservation of product quality* through satisfactory handling, storage, packaging and delivery

The final system of Quality Management evolved by consideration of the abovementioned points is usually set out in a Quality Manual. This is a document expressing management's acceptance of the principle of quality management and includes guidelines on the quality policy to be followed in the organization. The authority and responsibilities for

sel van kwaliteitsbestuur uitdruk en sluit riglyne in oor die kwaliteitsbeleid wat in die organisasie gevolg moet word. Die gesag en verantwoordelikheid vir die uitvoering van elke aspek van die kwaliteitsversekeringsprogram moet aangegee word.

Die Suid-Afrikaanse Buro vir Standaarde werk feitlik die afgelope twintig jaar al volgens dié riglyne deurdat hy in die spesifieke voorwaardes by die permit wat aan 'n fabrikant uitgereik word ingevolge waarvan hy die standaardmerk op sy produk kan gebruik, die gebruik van 'n tipe handleiding vereis. Dié voorwaardes word ter wille van eenvormigheid in ooreenstemming met SABS 0157 gebring.

TOEPASSING VAN GEBRUIKSKODE VIR KWALITEITSBESTUUR

Die gebruikskode word deur 'n koper of 'n derde party gebruik as basis vir die beoordeling van die kwaliteitsvermoë van 'n fabrikant.

Op nasionale en internationale gebied is daar vandag die verskynsel dat kopers leweransiers beoordeel voordat 'n bestelling geplaas word. Hulle wil vasstel of die leweransier oor die nodige organisasie, bestuurstruktuur, finansiële steun, produksievermoë, fasiliteite, en veral die korrekte benaderingswyse beskik om aan die vereistes te voldoen.

Baie kopers kan dieselfde leweransier beoordeel – ongelukkig soms volgens verskillende maatstawwe, standaarde of gebruikskodes. Die SABS se gebruikskode, SABS 0157, Kwaliteitsbestuurstelsels, is ontwerp om die veelvuldigheid vereistes wat tot verwarring in die vervaardigingsbedryf kan lei, te voorkom.

In alle gevalle moet daar besef word dat dit by die beoordeling van 'n kwaliteitsbestuurstelsel slegs om die bestuur en konsekwentheid van produksie gaan. Die evaluering van produkte self is steeds nodig en so ook die verifiëring van die daaropvolgende produksie.

SABS-STANDAARDMERKE

Daar moet op gelet word dat 'n produk waarop die SABS-merk aangebring is, 'n kwaliteitsproduk is omdat die merk verseker dat –

a) die produk volgens 'n bevredigende spesifikasie vervaardig word;
b) die kwaliteitsbestuur van die fabriek volgens SABS 0157 beoordeel is en daar gevind is dat dit bevredigend is;
c) gereelde verifiëring in die fabriek en in die veld uitgevoer word.

KWALITEITSBESTUUR

Ten einde kennis te neem van beginsels wat as riglyne kan dien, is dit nodig om die suksesvolle toepassing van kwaliteitsbestuur in Japan te bestudeer – selfs al vind dit meer aansluiting by die Oosterse denkwyse as by dié van die Weste. Interessante punte is –

a) *Kwaliteitskontrolekringe.* In die Japanse nywerheidswese word vergaderings tussen lede van die verskillende werkersvlakke, middelbestuur en topbestuur gereeld gehou om die verbetering van kwaliteit te bespreek.

b) *Nie-spesialisering.* In Japan word geneem dat kwaliteitsbestuurpersoneel nie moet oorspesialiseer nie. Hulle moet wel goed onderlê wees in kwaliteitsbestuur, maar ook in algemene tegnologie sodat hulle kan instaan vir ander departementele amptenare, soos in produksie, voorraadaanskaffing, beplanning, ens. Dit wil voorkom asof bogenoemde 'n bydrae tot samewerking lewer.

Laastens moet gesonde verstand ook gebruik word by die interpretasie van vereistes. Terwyl die kode van lui dae '... meting tot nasionale standaarde herlei moet kan word' geld dit nie in gevalle waar metings benaderd of binne bv. net 10% is nie. Ook moet dokumentasie net dié wees wat van wesenlike belang is vir die bereiking van ware kwaliteit en moet dit beslis nie teen-produktief wees nie.

carrying out each of the elements of the quality assurance program are to be declared.

The South African Bureau of Standards has worked virtually for the past twenty years along these lines in that it has required a type of manual in the specific conditions accompanying the permit issued to a manufacturer to apply the standardization mark to his product.

It is now lining up these with SABS 0157 for the sake of uniformity.

APPLICATION OF CODE OF PRACTICE FOR QUALITY MANAGEMENT

The Code of Practice is used as a basis for assessment by a purchaser or third party of the quality capability of a manufacturer.

We see today in the national and international field purchasers assessing suppliers before they are prepared to place an order. They want to find out whether the supplier has the necessary organization, management structure, financial backing, production capability, facilities and above all, the attitude of mind to meet these requirements.

There could be many purchasers assessing the same supplier – unfortunately sometimes to different criteria, standards or codes of practice. The SABS Code of Practice SABS 0157 *Quality Management Systems* is designed to prevent such multiplicity of requirements which could confuse the manufacturing industry.

In all cases, it must also be appreciated that quality management system assessment only commits itself as regards management and consistence of production. Evaluation of the products itself is still necessar as is audit of the subsequent production.

SABS STANDARDIZATION MARKS

It should be noted that a product bearing the SABS mark is complete quality since it ensures that

a) the product is manufactured to a satisfactory specification;
b) the quality management of the factory has been assessed and found satisfactory in terms of SABS 0157;
c) regular audits in the factory and in the field are carried out.

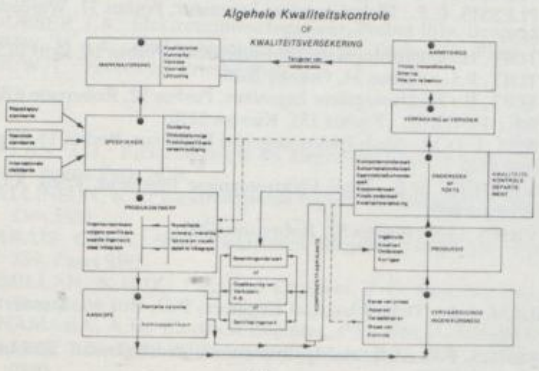
QUALITY MANAGEMENT

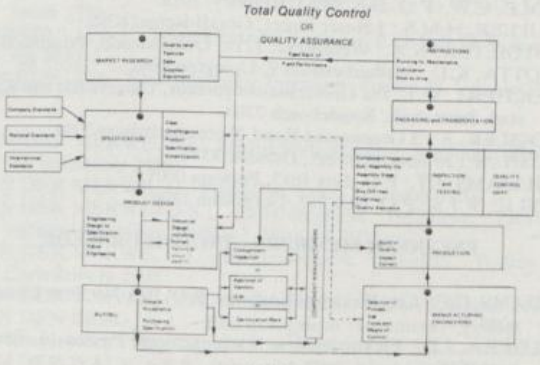
One must study the successful application of Quality Management in Japan to learn guiding principles – even though these may be more suited to the oriental mind than to the western mind. Interesting points are:–

a) *Quality Control Circles.* In Japanese industry there are regular meetings between members of the different strata of workers, middle management and top management to discuss improvement of Quality.

b) *Non-specialization.* In Japan it is felt that undue specialization should not be attached to quality management personnel. They should be well versed in quality management but equally so in general technology so as to be interchangeable with other departmental officials such as in production, stores acquisition, planning, etc. This appears to help as regards co-operation.

Finally, there must be common sense as regards interpretation of requirements. While the code might say that '... measurements must be traceable to the national standard' this does not apply where measurements are approximate or within say only 10%. Also documentation must only be that intrinsically necessary for real quality achievement and certainly not counter-productive.





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B

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S

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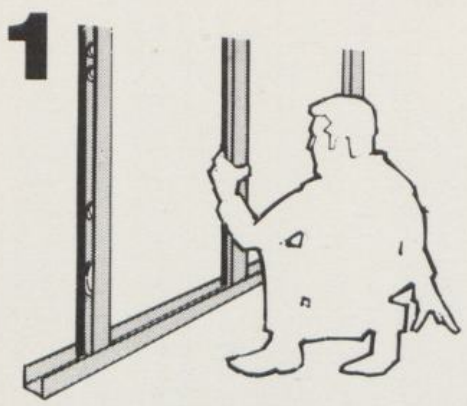

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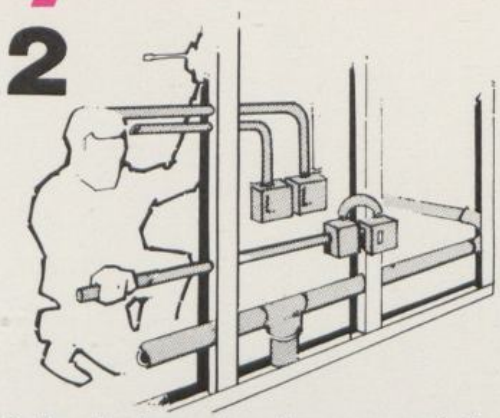

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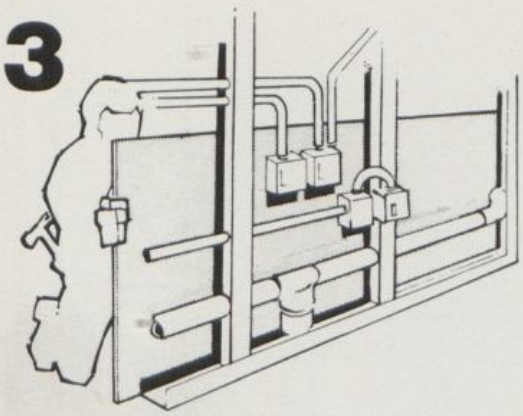

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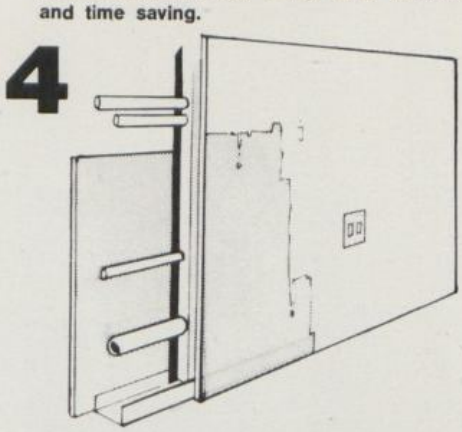

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