DIE VERENIGING VAN MUNISIPALE ELEKTRISITEITSONDERNEMINGS VAN SUID-AFRIKA

THE ASSOCIATION OF MUNICIPAL ELECTRICITY UNDERTAKINGS OF SOUTH AFRICA

SEWENDE TEGNIESE VERGADERING

MEI 10-11 MAY 10-11 1978

SEVENTH TECHNICAL MEETING

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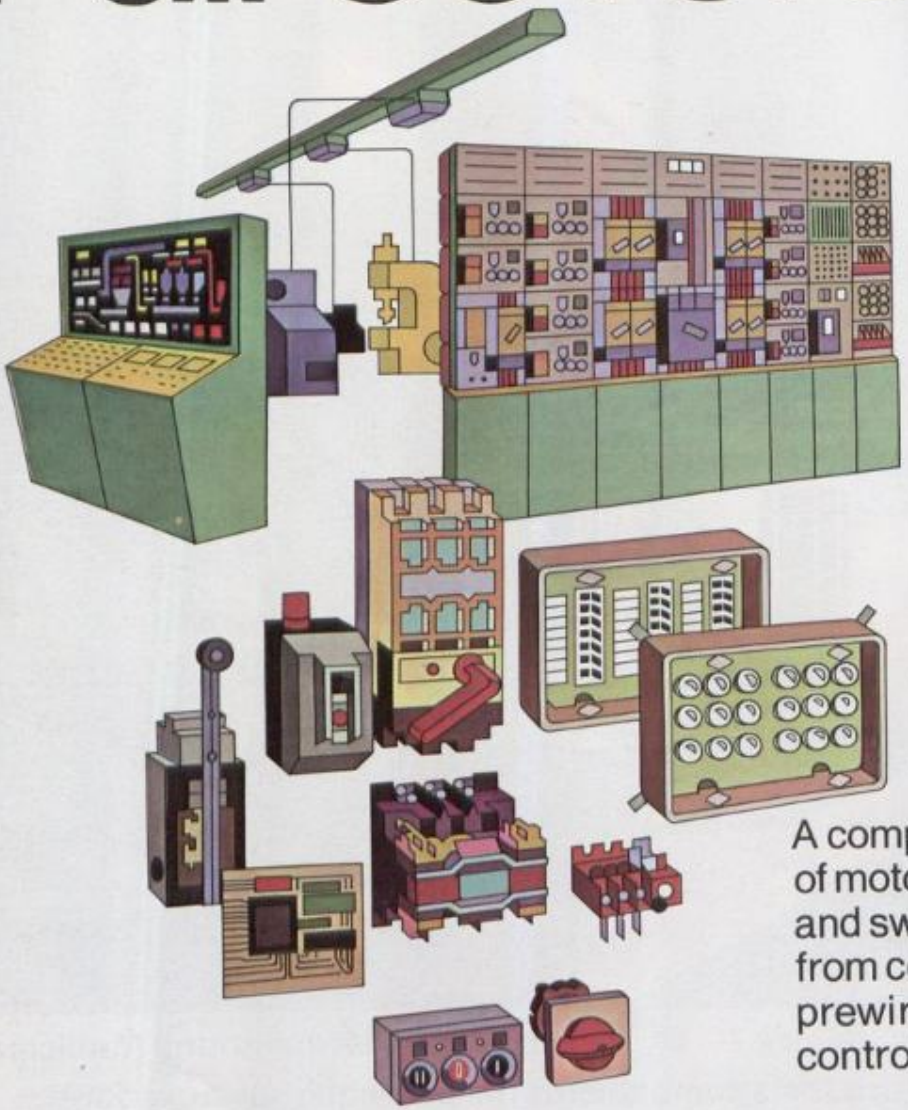

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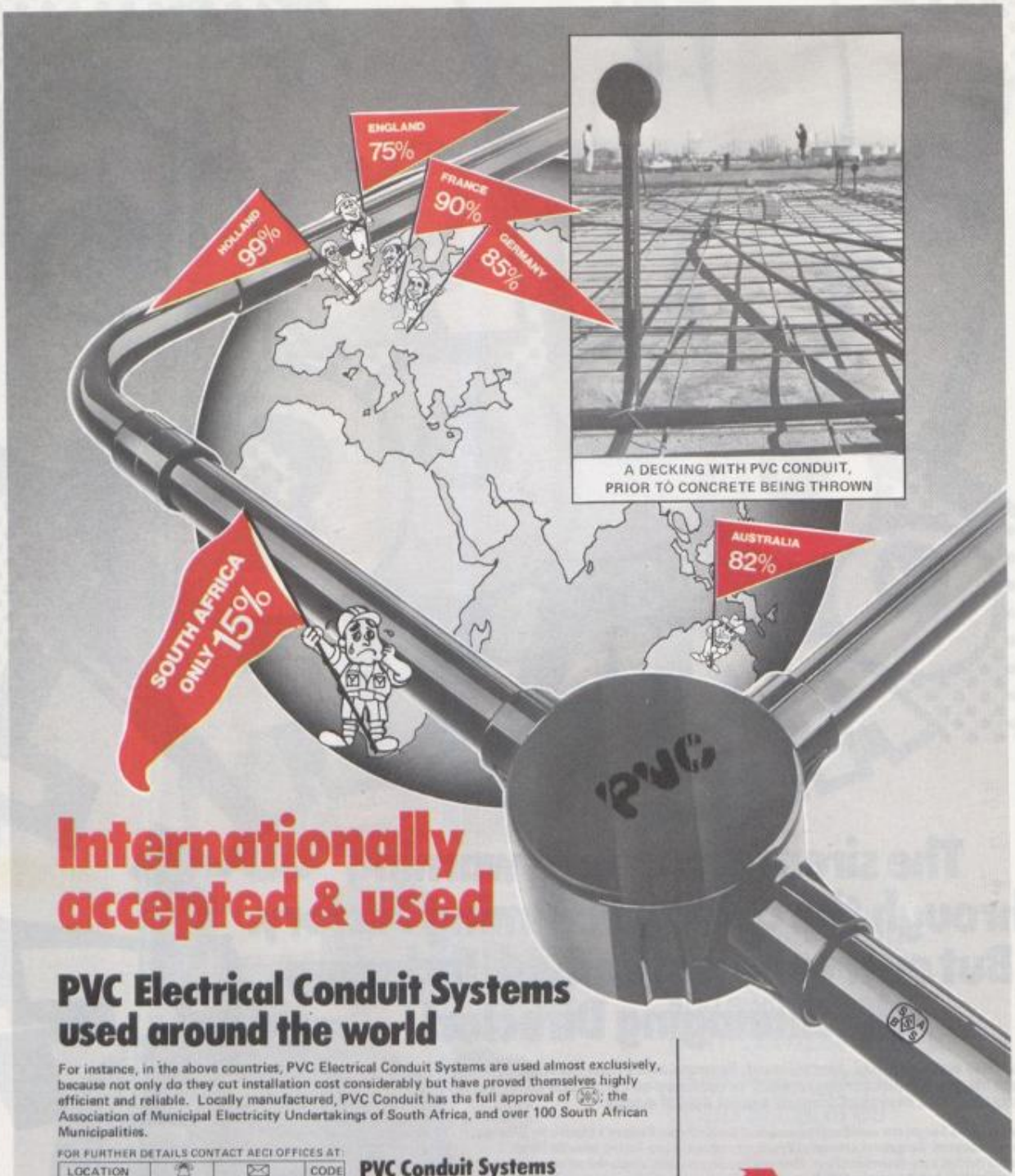

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PROCEEDINGS
7TH TECHNICAL MEETING
10–11 MAY 1978

VERRIGTINGE
7DE TEGNIESE VERGADERING
10–11 MEI 1978

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

TABLE OF ATTENDANCE/TABEL VAN BYWONING

Honorary Members	4	Erelede
Guests	17	Gaste
Engineers	68	Ingenieurs
Associate Members	9	Assosiaatlede
Associates	3	Geassosieerdes
Local Authorities	11	Plaaslike Besture
Organisations	8	Organisasies
Affiliates	90	Geaffilieerdes
Lady Visitors	65	Damesbesoekers
	275	
Apologies	22	Verskonings

MAY - MEI 1978

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PUBLISHERS AND PROPRIETORS
UITGEWERS EN EIENAARS

The Association of Municipal Electricity Undertakings of South Africa
Die Vereniging van Munisipale Elektrisiteitsondernemings van Suid-Afrika

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JOHANNESBURG
Tel:- 838-7711
2001

OFFICIAL OPENING – AMPTELIKE OPENING

Mr K.G. Robson : President

Sy Edelagbare die Burgemeester, raadslid West en mev West, raadslid Neethling, gaste, dames en here.

Dit is vir my 'n besondere plesier om u almal baie hartlik welkom te heet by hierdie Sewende Tegniese Vergadering van die Vereniging van die Munisipale Elektrisiteitsondernemings van Suid-Afrika.

Ek wil graag 'n spesiale woord van verwelkoming oordra aan die Burgemeester en hom van harte bedank dat hy ons vereer met sy teenwoordigheid om die openingsrede te lewer. Graag wil ek ook Ds Heys bedank vir die plegtige skriflesing en gebed.

To have the opportunity to be in this lovely and historic town of Somerset West in May must surely remain one of South Africa's lasting joys. We thank you, Sir, and your Council for having so generously extended the invitation to hold this Technical Meeting here. We are both grateful and honoured.

A view of the delegates attending the technical meeting.

Mr. and Mrs. Horace Eastman, Past President, Honorary Member (87), past Cape Town, city electric engineer, retired in Somerset West.

Mr. Ken Robson – President.

It is for me a special privilege to welcome officially the delegates and their ladies to this meeting. I know the ladies are looking forward to meeting and getting to know the Mayoress, Mrs West. You will be interested to know that the registered attendance is 308.

I am sure that this will be for us an especially memorable time together.

Now it is with very real pleasure that I call on His Worship the Mayor, Councillor A.J. West, to open this Seventh Technical Meeting of the A M E U.

The Mayor of Somerset West, Cllr A.J. West:

Mnr die President, eregaste, dames en here, baie hartlik welkom in die Hottentots-Holland.

We are pleased and proud to host the first A M E U Technical Meeting to be held in the Western Cape.

Somerset West has very firm ties with the A M E U, one of the early Presidents of the A M E U, Mr Horace Eastman, a former Cape Town City Electrical Engineer having retired to Somerset West and, more recently, Mr Ivan Hess, also a former Cape Town City Electrical Engineer. Our previous Town Electrical Engineer, Mr Adams, who is the father of the present Port Elizabeth City Electrical Engineer, is also present here today.

Mr President, this is a fine part of our country in which to live and retire as Mr Eastman, who has turned 87, will confirm. Mr Eastman please stand. Let's give him a cheer.

Somerset West also has very close ties with Escom and we extend a particular welcome to the Escom delegates, who should feel quite at home with all the power station and power line murals by our Mr Kerr adorning the walls of the hall. Possibly you could convince them that lower tariffs would make them even more popular!

Mnr die President, ons leef in die eeu van elektrisiteit en elektronika en daar is vandag byna nie 'n faset van ons lewens wat nie daardeur geraak, bevorder of vergemaklik word nie.

Ons, as Rade en Raadslede maak staat op u kundigheid en kennis en vertrou dat u besprekings tydens dié vergadering die nuttige ekonomiese en doeltreffende gebruik van elektrisiteit in ons ondernemings sal bevorder.

Mr President, ladies and gentlemen, may I wish you all a happy stay in Somerset West and the Hottentots Holland and may I express the wish that you will all visit us again now that you know us better.

Mag ek u almal 'n baie gelukkige en aangename verblyf in Somerset-Wes en die Hottentots-Holland toebid en mag die verrigtinge die hoë doelstellings van die Vereniging bevorder.

Mnr die President, dit is met groot genoeë dat ek die Sewende Tegniese Vergadering van die Vereniging van Munisipale Elektrisiteitsondernemings hiermee behoorlik oop verklaar.

Mr President, it now gives me pleasure to declare the Seventh Technical Meeting of the Association of Municipal Electricity Undertakings open.

Mr K.G. Robson : President

Mr Mayor, thank you for your friendly welcome to Somerset West and for having so graciously opened our meeting.

Coming as I do from close-by 1820 Settler country, it was interesting to me to learn that Somerset West was established in that same year of 1820. How strongly do particular times bind peoples together.

To my friend Ken Murphy, my sincere congratulations on the standard of his organisation and his arrangements for the meeting and the social functions. As President, I record my appreciation of the help and co-operation given at all times in his own efficient and charming way during the many months of preparation for this meeting.

May I now ask all the Honorary Members and past Presidents present here today to stand up with Mr Eastmann. I should also like all past members to stand up, and then, lastly, may I ask those newly appointed Town Electrical Engineers attending a Technical Meeting for the first time to rise, so that we may recognize them. We welcome you here to the A M E U and trust that your association with the A M E U will be a long and pleasant one.

Dan wil ons graag ons sekretaris, Mnr Bennie van der Walt en sy vrou, Annatjie, gelukwens met hul verkiesing as Burgemeester en Burgemeesters vrou van Roodepoort. Dit is vir ons 'n besondere prestasie en eer en ons is trots op hulle.

Mnr. Piet Botes, aangewese President.

PIET SMIT

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V.l.n.r.: Rld. Hennie Hugo (Roodepoort), Piet Botes (aangewese President), Gert Human (Stadsklerk van Somerset-Wes), Burgemeester West en Bennie van der Walt (Sekretaris VMEO).

S.H. HAWKESWOOD Pr. Ing., G. Ing., B.Sc (Ing)., L.I.E.I., A.G.I.S.

Mr. K.G. Robson : President

Our first paper is titled "A Demand Controlling Domestic Electricity Tariff" and it gives me great personal pleasure to introduce the author Stan Hawkeswood. I should like to give you a few details of his career. He obtained a B.Sc degree from the Natal University and later obtained his CMIS. He worked for some years for Messrs Merz & McLellan of S.A. on a number of projects and it was at East London, while he was working on a project for ESCOM, that I first met him. He then moved from Merz & McLellan, to become Deputy City Eelectrical Engineer of East London and then, after some years, he moved to Richards Bay as the town electrical engineer and, I may say it publicly, I think he was a tremendous gain for Richards Bay in those early days. He is a member of the working group of the Electrical Energy Conservation Board.

It is my pleasure now to ask Mr Hawkeswood to come forward to present his paper on a Demand Controlling Domestic Electricity Tariff.

'N AANVRAAG-BEHERENDE HUISHOUDELIKE ELEKTRISITEITSTARIEF

SAMEVATTING

Die referaat beskrywe die besluite wat gelei het tot die instelling van 'n aanvraag-beherende elektrisiteitstarief vir huishoudelike verbruikers in Richardsbaai, die werking van die tarief en die resultate van die tarief.

1. DIE BEHOEFTE OM HUISHOUDELIKE ELEKTRISITEITS-AANVRAAG TE BEHEER

Die Richardbaaise Dorpsbestuur het in November 1973 besluit om 'n aanvraag-beherende elektrisiteitstarief vir huishoudelike verbruikers in te stel.

Die oorspronklike redes waarop hierdie besluit gebaseer was, tesame met daaropvolgende ondersteunende redes word hieronder uiteengesit.

1.1 **Billike bydraes tot die aanvraagverwante koste van elektrisiteit**

Soos die meeste plaaslike besture in Suid-Afrika koop Richardsbaai elektrisiteit van die Elektrisiteitsvoorsieningskommissie (EVKOM) teen 'n koste bepaal deur 'n tweedelige tarief bestaande uit 'n maksimum aanvraag- (kVA-) energie- (kWh-) tarief.

Oor die jare het baie plaaslike besture elektrisiteit aan huishoudelike verbruikers verkoop teen 'n prys bepaal deur 'n tweedelige tarief bestaande uit 'n energie- (kWh-) tarief en 'n vaste tarief of 'n kamertarief of bepaal deur 'n eendelige blok-intervaltipe tarief bestaande uit 'n energie- (kWh-) tarief alleenlik – die belangrike oorweging synde dat die aanvraagverwante koste nie verhaal word deur meting of beheer van die aanvraag van individuele verbruikers nie, maar deur raming van die gedeelte van die totale aanvraagverwante koste wat elke verbruiker moet betaal, óf direk óf in verhouding met die getal kamers op die verbruiker se perseel.

In afwagting van sekere tendense, naamlik–

- 'n aansienlike verhoging in Evkom se tariewe, veral die aanvraagtarief (dit het intussen plaasgevind) en
- 'n betekenisvolle vermeerdering in die grootte en getal toestelle geïnstalleer in huishoudelike persele, veral in die middel en hoër inkomstegroepe,

Mr. S.H. Hawkeswood.

A DEMAND CONTROLLING DOMESTIC ELECTRICITY TARIFF

SYNOPSIS

The paper describes the decisions leading up to the introduction of a demand controlling electricity tariff for domestic consumers in Richards Bay, the operation of the tariff and the results of the tariff.

1. THE NEED TO CONTROL DOMESTIC ELECTRICITY DEMAND

In November 1973, the Richards Bay Town Board resolved to introduce a demand controlling electricity tariff for domestic consumers.

The original reasons on which this decision was based, together with subsequent reasons which support the decision, are set out below–

1.1 **Equitable contributions towards the demand related costs of electricity**

In common with most local authorities in South Africa, Richards Bay purchases electricity from the Electricity Supply Commission (ESCOM) at a cost determined by a two-part tariff comprising a maximum demand (kVA) charge and an energy (kWh) charge.

Over the years, many local authorities have sold electricity to domestic consumers at a price determined by a two-part tariff comprising an energy (kWh) charge and a fixed charge or a room charge or determined by a one-part block-interval type tariff comprising an energy (kWh) charge only – the important consideration being that the demand related costs are not recovered by measuring or controlling the demand of individual consumers but by estimating the share of the total demand related costs each consumer must pay, either directly or in proportion to the number of rooms of the consumer's premises.

In anticipation of certain trends, namely–

- A substantial increase in Escom's tariff, especially the demand tariff (this has subsequently taken place) and
- A significant increase in the capacity and number of appliances installed in domestic premises, especially those of the middle and upper income groups,

was een van die vernaamste redes om af te wyk van die konvensionele tariefstelsel hierbo beskrywe en 'n tarief in te stel wat maksimum aanvraag òf meet òf beheer, om te streef na 'n situasie **waar die spaarsamige verbruiker nie die koste van die verkwistende verbruiker van elektrisiteit subsideer nie.**

In die 1977/1978-boekjaar is die relatiewe waardes van die vernaamste bedrae van die Elektrisiteitshandelsrekening van die Richardbaaise Dorpsbestuur soos volg geraam:

Verkoop van elektrisiteit			100%
min Aankoop van elektrisiteit			
Maksimum aanvraag (kVA)	49%		
Energie (kWh)	32%	81%	
Administrasiekoste		1%	
Onderhoudskoste		3%	
Leningskoste		9%	
Kapitaalontwikkelingsfonds		3%	97%
Netto surplus			3%

Aangesien aanvraagverwante koste omtrent 50% - 60% van die totale koste van elektrisiteit in Richardsbaai uitmaak, is die mening dat daar goeie redes bestaan vir 'n tarief wat, sover dit prakties moontlik is, verseker dat alle verbruikers bydra tot hierdie koste in verhouding met hulle individuele aanvraag vir elektrisiteit.

*(*Nota: Die 1977/1978-begroting word beskou as 'n akkurater weergawe van die huidige koste van elektrisiteit aangesien dit die groot Evkom-verhogings van 1976/1977 insluit.)*

1.2 Besparings vir verbruikers

Omtrent 50% van die huidige totale koste van elektrisiteit is betaalbaar aan Evkom as aanvraagvorderings. Van die oorblywende koste, saamgestel uit items soos energievorderings betaalbaar aan Evkom, administrasiekoste ens. is daar min ruimte vir enige noemenswaardige besparings in die prys wat verbruikers vir elektrisiteit betaal.

Aangesien totale stelselaanvraag tot 'n mate beheerbaar is, en aangesien 'n relatiewe klein persentasie verandering in totale betaalbare aanvraagvorderings 'n betekenisvolle effek op die prys van elektrisiteit kan hê, was 'n vername rede vir die keuse van 'n tarief wat aanvraag meet of beheer, om die verbruikers in staat te stel om elektrisiteitkoste te verlaag en oor die lang termyn die koers van verhogings in elektrisiteitkoste te verlaag.

1.3 Verlaging van netwerkkoste

In 'n groeipunt soos Richardsbaai is al die netwerke opgerig oor 'n relatiewe kort periode teen die hoë koste wat in hierdie dekade geheers het.

Die gevolge van hierdie tipe van ontwikkeling is dat die infrastruktuurleningskoste wat uit tariewe verhaal word hoog is en dat die verspreidingsnetwerkkoste wat verhaal word uit die verkoop van grond eweneens hoog is.

Met betrekking tot hierdie en toekomstige hoë netwerkkoste, is daar twee belangrike redes vir die keuse van 'n tarief wat aanvraag meet of beheer.

- Deur deurlopend die aanvraag van verbruikers te meet, word waardevolle statistieke verkry, nie net van die individuele aanvraag van verbruikers op een tydstip nie, maar ook van die individuele aanvraag van verbruikers oor 'n lang periode wat veranderings in verbruikpatrone mag uitwys. Op hulle beurt word hierdie statistieke gekorreleer met lasregistrasies op verskillende dele van die netwerke om ontwerpparameters te verkry, d.i. die N.D.M.A. per perseel vir die verskillende groottes gedeeltes van die netwerke kan geskat word van die maandelikse lesings van die individuele aanvrae.

- 'n Effektiewe aanvraagmetende of -beherende tarief het 'n beperkende invloed op die gemiddelde aanvraag van verbruikers wat die netwerkontwerper in staat stel om te ontwerp binne kleiner toleransies. In die geval van bestaande netwerke sal die beperking van aanvraag waarskynlik die toekomstige nodigheid om die kapasiteit van die netwerke te verhoog, verminder indien nie uitskakel nie.

Tipiese relatiewe waardes van die koste om 'n 200-erf-woongebied te

one of the main reasons for deviating from the conventional tariffs described above and for opting for a tariff which either measures or controls maximum demand, was to aim for a situation where the **prudent consumer does not subsidise the electricity costs of the extravagant consumer of electricity.**

In the *1977/1978 Financial Year, the relative values of the major amounts of the Electricity Trading Account of Richards Bay Town Board have been estimated to be as follows–

Sales of Electricity			100%
less Purchases of Electricity			
Maximum Demand (kVA)	49%		
Energy (kWh)	32%	81%	
Administration Costs		1%	
Maintenance Costs		3%	
Loan Charges		9%	
Capital Development Fund		3%	97%
Net Surplus			3%

Since demand related costs equal about 50% - 60% of the total price paid for electricity in Richards Bay, there are considered to be strong grounds for a tariff which, as far as is reasonably practical, ensures that all consumers contribute towards their share of these costs in proportion to their individual demands for electricity.

*(*Note: The 1977/1978 Estimates are considered to provide a more accurate picture of present day electricity costs since they incorporate the very large Escom increases brought into effect in 1976/1977.)*

1.2 Savings for consumers

Approximately 50% of the total cost of electricity is payable to Escom as demand charges at present. Of the remaining cost, made up of items such as energy charges payable to Escom, administration costs etc, there is little scope for making any significant savings in the price paid by the consumers for electricity.

Since total system demand is to a degree controllable and since a relatively small percentage change in total demand charges payable can have a significant effect on the price of electricity, an important reason for opting for a demand measuring or controlling tariff was to afford consumers the opportunity of reducing electricity costs and in the long term reducing the rate of increase of electricity costs.

1.3 Reductions in network costs

In a growth point such as Richards Bay, all the networks have been constructed over a relatively short period at the high costs which have obtained in this decade.

The consequences of this type of development are that the infrastructure loan charges which are recovered via the tariffs are high and that the reticulation costs recovered via the sale of serviced land are equally high.

With regard to these and future high network costs, there are two important reasons for opting for a demand measuring or controlling tariff.

- By continuously monitoring the demand of consumers, valuable statistics are produced, not only of the individual demands of consumers at one time but of the individual demands of consumers over a long period which may highlight changes in consumption patterns. In turn these statistics are correllated with the load recordings of different parts of the networks to provide networks design parameters i.e. the ADMD per dwelling for the different sized sections of the networks can be estimated from the monthly readings of the individual demands.

- An effective demand measuring or controlling tariff has a restrictive effect on the average demand of consumers and the network designer is afforded the opportunity of designing his networks within much closer tolerances. In the case of existing networks, restrictions of the demand will probably reduce, if not eliminate, the future need to increase the capacity of the networks.

Some typical relative values of the costs of reticulating a 200 plot

benet vir verskillende waardes van die N.D.M.A. vir 15 - 25 installasies word hieronder uiteengesit–

N.D.M.A. (kVA)	Relatiewe koste
6	110% - 115%
5	105% - 107½%
4	100%
3	92½% - 95%

In Richardsbaai word N.D.M.A.-ontwerpwaardes van 4 kVA per huishoudelike installasie vir die laagspanningnetwerke wat 15 - 25 installasies voorsien, en 2 kVA per huishoudelike installasie vir die hoogspanningnetwerke en transformators wat dorpsgebiede van 200 - 400 erwe voorsien, gebruik. Voorsiening word gemaak in die ontwerp vir die toekomstige installering van addisionele toerusting vir verhoogde las as dit benodig sou word.

Klaarblyklik kan groot besparings gemaak word, nie alleen in dorpsgebiedkapitaalkoste nie, maar ook in die aanwending van materiale soos koper en aluminium (grondstowwe wat opgebruik word), deur netwerke te ontwerp en te bou gebaseer op 'n N.D.M.A. wat redelik akkuraat is.

1.4 **Besparing van aanvraag in die nasionale belang**

Behalwe die versoek van die Minister van Ekonomiese Sake is baie geskryf en gesê oor hierdie onderwerp by konferensies, simposiums, in die pers en oor radio- en televisieprogramme. Sonder om in besonderhede in te gaan, is daar weinig ruimte vir twyfel dat die kapitaalkoste geassosieer met die opwekking, transmissie en verspreiding van elektriese krag sal aanhou styg in die toekoms.

Ongetwyfeld sal oorwegings rakende kapitaaluitgawe op elektrisiteitopwekking en -verspreiding in die toekoms meer krities beskou word, wat kan lei tot 'n meer kritiese oorweging van die nodigheid van uitbreidings van die opwekking en verspreiding van krag.

'n Belangrike rede vir die keuse van 'n tarief wat aanvraag meet of beheer, is die daarstelling van 'n meganisme waardeur sterker beperkings of aanmoedigings om aanvraag in toom te hou of te verminder, ingestel kan word, sou sulke beperkings of aanmoedigings in die toekoms nodig word.

Met die oog op die behoefte om energie te bespaar, is 'n noodsaaklike vereiste van enige aanvraagmetende of -beherende tarief dat 'n vermindering in aanvraag **nie** 'n verhoogde energieverbruik tot gevolg sal hê nie. Die tarief moet 'n vermindering in beide aanvraag en energieverbruik aanmoedig.

2. 'N ONDERSOEK VAN VERSKILLENDE METODES OM ENKELFASIGE HUISHOUDELIKE VERBRUIKERS SE AANVRAAG TE MEET OF TE BEHEER

'n Aantal verskillende metodes van beheer of meting van die aanvraag van enkelfasige huishoudelike verbruikers deur kommersieel beskikbare toerusting is ondersoek.

2.1 **Vergelyking van metodes**

'n Beskrywing van die werking van die verskillende metodes van beheer of meting van die aanvraag van enkelfasige verbruikers, en die meriete van die verskillende metodes, soos gesien deur die skrywer, is soos volg:-

(a) kVA of ampère-aanvraagmeting

Met hierdie metode word 'n aparte Ampère-aanvraagmeter bykomend tot die kWh-meter **of** 'n saamgestelde kVA/kWh-meter by elke verbruiker geïnstalleer.

Met twee meters is die prys van hierdie metode redelik en het dit die voordeel dat die tarief nie alleen aanpas by die Evkom-tarief nie, maar maklik gewysig kan word om by omstandighede te pas.

Alle verbruikers word billik behandel. Hierdie is 'n non-tydselektiewe metode omdat 'n goed ontwerpte tarief 'n vermindering in aanvraag oor die hele vier-en-twintig-uur-periode aanmoedig en nie net gedurende spesifieke tye gedurende die dag nie d.i. dit moedig 'n beter lasfaktor aan.

Die belangrikste nadele volgens die mening van die skrywer is dat die meters maandeliks gelees en herset moet word, die meterlesings is onderhewig aan bedrog, en praktiese probleme bestaan in Richardsbaai om akkommodasie vir die ekstra kVA-

township for different values of the ADMD for 15 - 25 installations are set out below–

ADMD (kVA)	Relative Cost
6	110% - 115%
5	105% - 107½%
4	100%
3	92½% - 95%

In Richards Bay, ADMD design figures of 4 kVA per domestic installation for the low voltage reticulation networks feeding 15 - 25 installations and 2 kVA per domestic installation for the high voltage reticulation and transformers feeding townships of 200 - 400 plots, are used. Provision is made in the design to install additional equipment in the future to cater for increased loads, should this become necessary.

Obviously, big savings, not only in township capital costs but in the utilisation of materials such as copper and aluminium (natural resources which are being depleted) can be achieved by designing and constructing networks based on an ADMD which is reasonably accurately determined.

1.4 **Demand savings in the national interest**

In addition to the request made by the Minister of Economic Affairs, much has been written and spoken about this subject at conferences, symposiums, in the press and on radio and television programmes. Without going into detail, there is little room for doubt that the capital costs involved in generating, transmitting and distributing electrical power will continue to increase in the future.

Undoubtedly, decisions to incur capital expenditure on electricity power production and distribution will be more critically examined in the future, which in turn could result in a more critical appraisal of the needs to expand power production and distribution.

An important reason for opting for a tariff which either measures or controls demand is to provide the mechanism whereby stronger restrictions or incentives to contain or reduce demand may be applied, should such restrictions or incentives become necessary in the future.

In view of the need to conserve energy, an essential requirement of any demand measuring or controlling tariff is that a reduction in demand should not be accompanied by an increase in energy consumption i.e. the tariff should encourage both demand and energy saving.

2. AN INVESTIGATION INTO SOME DIFFERENT METHODS OF MEASURING OR CONTROLLING SINGLE PHASE DOMESTIC ELECTRICITY DEMAND

A number of different methods of controlling or measuring single phase domestic electricity demand, using commercially available equipment, have been investigated.

2.1 **Comparison of Methods**

A description of the operation of the different methods of measuring or controlling demand of single phase consumers and the merits of the different methods, as viewed by the author, are as follows–

(a) **kVA or Ampere Demand Metering**

With this method, a separate ampere demand meter in addition to the kWh meter **or** a combined kVA/kWh meter is installed at each consumer's premises.

Using two meters, this method is reasonably priced and has the advantages that the tariff used not only relates directly to the Escom tariff but can be easily changed to suit circumstances.

All consumers are treated equitably. This is a non time-selective method in that a well designed tariff encourages a reduction in demand over the full twenty-four hour period and not at specific times during the day i.e. it encourages an improved load factor.

The main disadvantages, in the opinion of the author, are that the meters must be read and reset once a month, the meter readings are subject to fraud and practical difficulties exist in Richards Bay in providing accommodation for the additional

meter te voorsien. Hierdie laaste nadeel val weg as 'n gekombineerde kVA/kWh-meter gebruik word, maar die koste van hierdie meter is hoog.

(b) **Outomatiese Lasvermindering**

'n Sein wat in die kragnetwerk ingespuit word, isoleer die verbruiker se warmwatertoestel gedurende kruintye volgens hierdie metode.

Hierdie is 'n tyd-selektiewe metode omdat die waterverhittingslas geïsoleer word gedurende kruintye om die kruinlas te verminder. Die toerusting kan ook gebruik word om munisipale, kommersiële en industriële pompe of verhitting te isoleer gedurende kruintye en kan ook ander munisipale funksies verrig soos die beheer van straatverligting. Nog 'n voordeel is dat 'n betekenisvolle las geïsoleer kan word gedurende gedeeltelike verlies van verspreidingsnetwerke.

Aangesien die verbruiker se las saamgestel is uit 'n aantal toestelle soos 'n stoof, warmwatertoestel, lugversorgers, ruimteverwarmers, ketels ens. is dit die mening dat daar 'n aantal nadele aan hierdie metode verbonde is, naamlik–

(i) As vragvermindering beperk word tot warmwatertoestelle alleen, word verbruikers nie aangespoor om hulle ander toestelle oordeelkundig te gebruik nie; hoë aanvrae kan nog voorkom en die verkwistende verbruiker word nie verhoed om voordeel te trek uit die spaarsamige verbruiker nie. Ook kan die toekomstige vervanging van elektriese verhitting deur sonverhitting hierdie metode oneffektief maak.

(ii) Sonder om die verbruiker se gebruik van sy toestelle aansienlik te beperk, is die aantal toestelle wat deur hierdie metode beheer kan word beperk. 'n Belangrike nadeel word gesien in die nodige toesig om te verseker dat daar nie met die beheerde stroombane gepeuter word nie.

(c) **Tydtariefafmeting**

Met hierdie metode word tydtariefmeters geïnstalleer of konvensionele enkelregister-kWh-meters word omgeskakel na tydtariefmeters.

Tydtariefmeters het twee registers – die een register meet kWh deurlopend en die ander register meet kruin-kWh. Die tweede register word in werking gestel deur 'n solonoïde in die meter, wat deur 'n aparte tydskakelaar of deur 'n rimpelbeheerrelê beheer word.

Die kruin-kWh-register word gedurende die kruintyd in werking gestel deur middel van die tydskakelaar of die rimpelbeheerrelê. 'n Hoër tarief word gehef vir kruin-kWh of 'n laer tarief vir nie-kruintye.

Hierdie is 'n tyd-selektiewe metode wat, met 'n gepaste tarief, verbruikers aanspoor om hulle elektrisiteitverbruik gedurende kruintye te verminder of alternatiewelik water en kamers buite kruintye te verhit.

Na die mening van die skrywer is die vernaamste nadeel van hierdie metode die hoë aanvanklike koste van meettoerusting, praktiese probleme om in Richardsbaai akkommodasie vir die ekstra rimpelrelê of tydskakelaar te voorsien, en die operasionele nadeel dat die verbruik van energie, en nie die aanvraag nie, gemeet en dus beheer word gedurende kruintye.

(d) **Lastariefafmeting**

Met hierdie metode word lastariefmeters geïnstalleer of konvensionele enkelregister-kWh-meters word verander om as lastariefmeters te werk. Lastariefmeters het twee registers – die een register meet kWh deurlopend en die ander meet oormaateenhede.

Hierdie tweede register word in werking gestel sodra 'n vooraf-gestelde aanvraag oorskry word. Die meters kan gestel word om oormaateenhede te begin registreer by aanvrae tussen 3 kW en 16 kW in 1-kW-stappe.

Die tarief wat gebruik word met hierdie metode kan bestaan uit 'n vaste heffing vir elke instelling van kW plus 'n kWh- en 'n oormaat-kWh-tarief, of 'n enkele vaste heffing vir 'n enkele instelling, sê 4 kW, plus 'n kWh- en 'n oormaat-kWh-tarief. Die aan-

kVA meter. This last disadvantage falls away if a combined kVA/kWh meter is used, but the cost of this meter is high.

(b) **Automatic Load Shedding**

A signal injected into the supply mains isolates the consumer's water heaters during peak periods with this method.

This is a time-selective method in that the total water heating load is isolated during system peak periods to reduce the peak loads. The signal injection system can also be used to isolate municipal, commercial and industrial pumping or heating loads during system peak periods and perform other municipal functions such as switching streetlights on and off. Another advantage is that a significant load can be shed during times of partial failure of supply equipment.

Since the consumer's load is produced by a number of appliances i.e. cooker, water heater, air-conditioners, space heaters, kettles etc, there are considered to be a number of disadvantages of this method, namely–

(i) If load shedding is restricted to water heaters only, consumers are not induced to use their other appliances conservatively, high demands can still result and extravagant users are not stopped from benefitting at the expense of the prudent users. Also the possible replacement of electric heating with solar heating in the future may render this method ineffectual.

(ii) Without severely restricting the consumer's use of his appliances, the number of appliances which can be controlled by this method is limited. A major disadvantage is seen to be the "policing" function necessary to ensure that the circuits which fall under the load shedding umbrella are not tampered with.

(c) **Time Rate Metering**

With this method, time rate meters are installed or conventional single register kWh meters are altered to operate as time rate meters.

Time rate meters have two registers – the one register measuring kWhs continuously and the other register measuring peak kWhs. The second register is brought into operation by energising a solenoid in the meter. The solenoid is energised either by a separate time clock or by means of a ripple control relay.

At peak hours, the peak kWh register is brought into operation either by means of the pre-set time clock or by means of a signal injected into the supply mains which operates the ripple relay. A higher tariff rate is charged for peak kWhs or a lower rate for off-peak hours.

This is a time-selective method which, with a suitable tariff, induces consumers to reduce their electricity consumption at peak hours or alternatively induces consumers to heat water or rooms at off-peak hours.

In the opinion of the author, the main disadvantages of this method are the relatively high initial cost of metering equipment, practical difficulties in providing accommodation in Richards Bay for the additional ripple relay or time clock and the operational disadvantage that the consumption of energy and not the demand is measured and hence controlled during peak hours.

(b) **Load Rate Metering**

With this method, load rate meters are installed or conventional single register kWh meters are altered to operate as load rate meters. Load rate meters have two registers – the one register measuring kWhs continuously and the other measuring excess kWhs.

This second register is brought into operation when a preset demand is exceeded. The meters may be set to start measuring excess kWhs at any load between 3 kW and 16 kW in 1kW steps.

The tariff used with this method can either impose a fixed charge for each pre-set kW step plus a kWh and an excess kWh charge or one fixed charge for one setting, say 4 kW, plus a kWh and an excess kWh charge. The recommended charge for excess kWhs

beveelde tarief vir oormaat kWh is omtrent 6 maal die tarief vir gewone kWh.

Hierdie is 'n non-tydselektiewe metode omdat dit 'n vermindering in aanvraag oor die hele 24-uur-periode aanmoedig, d.i. dit bevorder 'n beter lasfaktor. Alle verbruikers word billik behandel en met hierdie metode betaal verbruikers vir aanvraag net terwyl die aanvraag bestaan. Die tarief kan maklik aangepas word om by omstandighede te pas.

(e) **Tariefstroombrekerbeheer**

Met hierdie metode betaal die verbruiker 'n vaste maandelikse heffing ooreenkomstig 'n neergelegde skedule vir die verskillende groottes stroombrekers geïnstalleer – hoe hoër die ampèreaanslag van die stroombeker, hoe hoër die heffing. Hierdie is ook 'n non-tydselektiewe metode omdat dit 'n beter lasfaktor aanmoedig en het die groot voordeel van baie lae koste.

Die grootste nadeel van hierdie metode, na die mening van die skrywer, is dat verbruikers 'n stroombrekergrootte kies om by hulle kruinlas te pas. Te alle ander tye kan hulle aanvraag dus toeneem tot hierdie waarde, en gevolglik kan die doelstelling van die tarief, naamlik om aanvraag te beheer, in 'n groot mate verydel word. Dit is die mening dat hierdie metode 'n onredelike beperking op die verbruiker se gebruik van elektrisiteit stel omdat hy verhoed word om ten volle van sy toestelle gebruik te maak by daardie geleenthede wat in elke huisbewoner se lewe opduik byvoorbeeld die aankoms van onverwagte gaste of die hou van 'n partytjie.

2.2 **Koste van benodigde toerusting**

Tabelle 1 en 2 toon die benodigde toerusting en die geraamde koste daarvan, gebaseer op pryse en arbeidskoste wat in 1977 in Richardsbaai geheers het, van die verskillende metodes. Die relatiewe waardes in 1977 is omtrent dieselfde as dié van 1973, toe die vergelyking oorspronklik gemaak is.

Tabel 1 : Nuwe Installasies

Metode	kVA- of ampère-aanvraag-afmeting		Outomatiese lasvermindering	Tydtarief-afmeting		Lastarief afmeting	Tariefstroombreker-beheer
Toerusting	(R)		(R)	(R)		(R)	(R)
	Apart	Gekombineer		Tydskakelaar	Rimpelrelé		
kWh-meter	24	–	24	–	–	24
Ampère-aanvraagmeter	36	–	–	–	–	–	–
kVA/kWh-meter	–	130	–	–	–	–	–
Seininspuittoerusting per verbruiker (gebaseer op 5000 verbruikers)	–	–	5	–	5	–	–
Rimpelrelê by verbruiker se installasie	–	–	70	–	70	–	–
Tydtariefmeter	–	–	–	50	50	–	–
Tydskakelaar	–	–	–	40	–	–	–
Lastariefmeter	–	–	–	–	–	74	–
Tariefstroombreker	–	–	–	–	–	–	2
Addisionele akkommodasie benodig by meterkabinet	15	–	–	15	15	–	–
Installasie van toerusting by verbruiker se perseel	7	7	7	7	7	7	7
Aansluiting by verbruiker se warmwatertoestel	–	–	verbruiker se koste	–	–	–	–
TOTAAL	82	137	106	112	147	81	33

Nota: In Richardsbaai is elektrisiteitmeters in grensgemonteerde kiosks.

Tabel 2 : Gewysigde bestaande installasie

'n Aantal konvensionele enkelfasige meters is oorspronklik vervang deur lastariefmeters in Richardsbaai. Aangesien verdere ondersoek bewys het dat konvensionele enkelfasige meters omgeskakel kan word na tyd- of lastariefmeters, illustreer hierdie tabel die

is about 6 times the charge for ordinary kWhs.

This is a non time-selective method in that it encourages a reduction in demand over the full twenty-four hours period i.e. it encourages an improved load factor. All consumers are treated equitably and with this method, consumers are only charged for maximum demand when they incur the demand. The tariff charge can be easily adjusted to suit circumstances.

(e) **Tariff Circuit Breaker Control**

With this method, the consumer pays a monthly fixed charge in accordance with a laid down schedule of charges for the different sizes of tariff circuit breakers installed – the higher the ampere rating of the circuit breaker, the higher the charge.

This is also a non time-selective method i.e. it encourages an improved load factor and has the principle advantage of very low cost.

The main disadvantage of this method, in the opinion of the author, is that consumers tend to opt for a rating of circuit breaker to cater for their peak loads. In turn this means that at all other times, they can impose a demand up to this maximum – the result of which is that the object for which the tariff is designed i.e. controlling maximum demand, may to a large extent be defeated. This method is considered to place an unreasonable restriction on the consumers use of electricity in that he is prevented from making full use of his appliances for those occasions which crop up in every householders life e.g. the arrival of unexpected guests or the holding of a party.

2.2 **Cost of Equipment required**

Table 1 and 2 detail the equipment required and the estimated cost thereof, based on the prices and labour rates ruling in 1977 in Richards Bay, for these different methods. The relative values in 1977 are approximately the same as those obtained in 1973, when the comparison was originally made.

Table 1 : New Installations

Method	kVA or Ampere Demand Metering		Automatic load shedding	Time Rate Metering		Load Rate Metering	Tariff circuit Breaker Control
Equipment	(R)		(R)	(R)		(R)	(R)
	Separate	Combined		Time Clock	Ripple Relay		
kWh Meter	24	–	24	–	–	–	24
Ampere demand Meter	36	–	–	–	–	–	–
Combined kVA demand kWh Meter	–	130	–	–	–	–	–
Signal inject. equipment per consumer (based on 5 000 consumers)	–	–	5	–	5	–	–
Load Shedding (Ripple) Relay at customer's premises	–	–	70	–	70	–	–
Time Rate Meter	–	–	–	50	50	–	–
Time Clock	–	–	–	40	–	–	–
Load Rate Meter	–	–	–	–	–	74	–
Time/Load Rate Meter	–	–	–	–	–	–	–
Tariff Circuit Breaker	–	–	–	–	–	–	2
Additional Accommodation required at meter cubicle	15	–	Consumer cost	15	15	–	–
Installation of equipment at customer's premises	7	7	7	7	7		7
Connections to consumer's hot water heater	–	–	Consumer cost	–	–	–	–
TOTAL	R82	R137	R106	R112	R147	R81	R33

Note: In Richards Bay, electricity meters are located in boundary mounted cubicles.

Table 2 : Existing Installation Altered

A number of conventional single phase meters were originally replaced with load-rate meters in Richards Bay. Since further investigation has proved that conventional single phase meters can be converted to time- or load-rate meters, this schedule illustrates the

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vergelykende koste van die verskillende metodes waar 'n bestaande installasie gewysig word.

Metode	kVA- of ampère-aanvraag-afmeting		Outomatiese lasverminding	Tydtarief-afmeting		Lastarief-afmeting	Tariefstroom-brekerbeheer
Toerusting	(R)		(R)	(R)		(R)	(R)
	Apart	Gekombineer		Tydskakelaar	Rimpelrelé		
Ampère-aanvraagmeter	36	–	–	–	–	–	–
kVA/kWh-meter	–	130	–	–	–	–	–
Seininspuittoerusting per verbruiker (gebaseer op 5000 verbruikers)	–	–	5	–	5	–	–
Rimpelrelé by verbruiker se installasie	–	–	70	–	70	–	–
Omskakeling – tydtariefmeter	–	–	–	36	36	–	–
Tydskakelaar	–	–	–	40	–	–	–
Omskakeling – lastariefmeter	–	–	–	–	–	50	–
Tariefstroombreker	–	–	–	–	–	–	2
Addisionele akkommodasie benodig by meterkabinet	25	–	verbruiker se koste	25	25	–	–
Installasie van toerusting by verbruiker se perseel	7	7	7	7	7	7	7
Aansluiting by verbruiker se warmwatertoestel	–	–	verbruiker se koste	–	–	–	–
TOTAAL	68	137	82	108	143	57	9

comparative costs of the different methods where an existing installation is changed.

Method	kVA or Demand Metering		Automatic load shedding	Time Rate Metering		Load Rate Metering	Tariff circuit Breaker Control
Equipment	(R)		(R)	(R)		(R)	(R)
	Separate	Combined		Time Clock	Ripple Relay		
Ampere Demand Meter	36	–	–	–	–	–	–
Combined kVA demand kWh meter	–	130	–	–	–	–	–
Signal inject. equipment per consumer (based on 5000 consumers)	–	–	5	–	5	–	–
Load Shedding (Ripple) Relay at consumer's premises	–	–	70	–	70	–	–
Conversion – Time-rate meter	–	–	–	36	36	–	–
Time Clock Conversion –	–	–	–	40	–	–	–
Load-rate meter	–	–	–	–	–	50	–
Tariff circuit breaker	–	–	–	2	–	–	–
Additional Accommodation required at meter cubicle	25	–	Consumer Cost	25	25	–	–
Installation of equipment at consumer's premises	7	7	7	7	7	7	7
Connections to consumers water heaters	–	–	Consumer Cost	–	–	–	–
TOTAL	R68	R137	R82	R108	R143	R57	R9

Keuse van metode

Die metode wat gekies is was lastariefafmeting en die redes vir hierdie keuse was soos volg:-

Ondervinding in ander lande

Lastarief-tariewe is onder andere met groot sukses gebruik in Noorweë sedert 1956.

Lewensvatbaarheid oor die lang termyn

Met die verwagting dat toekomstige energiebesparingsneigings tot gevolg kan hê dat sonkrag vir ruimte- en waterverwarming gebruik kan word, was dit die mening dat 'n non-tydselektiewe metode meer lewensvatbaar sou wees oor die lang termyn.

Onus op die verbruiker om aanvraag en verbruik te beheer

Behalwe vir stroombaanlasbeperkings en steuring van ander verbruikers se gebruik van elektrisiteit, is die verbruiker vry om die elektrisiteit in sy huis te gebruik soos hy die beste ag.

Omdat die oormaat kWhs slegs geregistreer word gedurende die periode waar die aanvraag die voorafingestelde limiet oorskry, betaal die verbruiker vir die aanvraag slegs gedurende daardie periode d.i. die verbruiker kan 'n partytjie hou en 'n groot aantal toestelle gebruik in die wete dat hy meer sal betaal slegs vir daardie aand.

Uitgawe op metertoerusting vergoed deur kostebesparings

In 1973 het die meters R35 plus R5 installasiekoste elk gekos. Die aanvraaghefffing betaalbaar aan Evkom was R2,40 per kVA. Gebaseer op 'n minimum verwagte besparing van 0,5 kVA NDMA per verbruiker, is die tydperk waaroor die totale koste van die meters vergoed kon word deur besparings in betalings aan Evkom, beraam op 54 maande.

Alternatiewelik, as die meterkoste gefundeer sou word deur 'n lening terugbetaalbaar oor 20 jaar, sou 'n maandelikse besparing van omtrent R0,90 per verbruiker terugbetaal kon word aan die verbruikers.

Choice of Method

The method that was chosen was Load Rate Metering and the reasons for this choice were as follows-

Experiences in other countries

Load rate tariffs have been used in Norway, amongst others, with great success since 1956.

Viability in the long term

In anticipation that future energy conservation trends could result in solar power being used for space and water heating, the use of a non-time selective method was considered to be more viable in the long term.

Onus on consumer to control demand and consumption

Apart from circuit load limitations and non-interference with other consumers' use of electricity, the consumer is free to use the electricity in his home in the manner that he deems best.

Because the excess consumption kWhs are only registered during those periods when the demand exceeds the pre-set limits, the consumer pays for the additional demand incurred during those periods only i.e. the consumer can hold a party and use a large number of appliances in the knowledge that he will pay more for electricity for that night only.

Expenditure on metering equipment offset by cost savings

In 1973, the meters cost R35 + R5 insyallation cost = R40 each. The demand charge payable to Escom was R2,40 per kVA. Based on a minimum anticipated saving of 0,5 kVA ADMD per consumer, the period over which the total cost of the meters could be recovered via savings in payments to Escom, was estimated to be 54 months.

Alternatively, if the meter costs were funded ex a capital loan redeemable over 20 years, a monthly saving of about R0,90 per consumer could be passed onto the consumers.

3. DIE LAAGSPANNINGSTARIEWE IN RICHARDSBAAI

Die laagspanningstariewe in Richardsbaai is soos volg:

Skaal 1

Enkelfasige verbruikers met las kleiner as 15 kVA.

Basiese Maandelikse heffing (R)	Energieheffing (sent kWh)	Oormaat-kWh-heffing (sent)
M x 2	E + 0,7	$\frac{M}{60}$

Waar M = Evkom se maksimum aanvraagheffing aan die Richardbaaise Dorpsbestuur.
= R4,9875 (in September 1977)
E = Evkom se energieheffing aan Richardbaaise Dorpsbestuur.
= 0,696 (in September 1977)

Die meters word ingestel om oormaat-kWhs te registreer wanneer die vrag 4 kW oorskry.

Omgesit in geldwaardes is die heffings in September 1977–

Basiese Maandelikse heffing	:	R9,975
Energieheffing	:	1,396 sent/kWh
Oormaat k-Wh-heffing	:	8,3125 sent/kWh

Die faktor "2" in die berekening van die basiese maandelikse heffing is gelyk aan die beraamde NDMA van Skaal 1-verbruikers gemeet wanneer die maandelikse kruinaanvraag voorkom.

Die faktor "60" in die berekening van die oormaat-kWh is gebaseer op 'n huishoudelike kruin wat voorkom gedurende 2 ure oor 'n periode van 30 dae.

Skaal 2

Driefasige verbruikers met laste groter as 15 kVA en minder as 40 kVA.

kVA-maksimum aanvraag/kWh-meters word gebruik vir hierdie groep verbruikers. Die tariewe is ook gekoppel aan Evkom se tarief.

4. 'N OEFENING IN OPENBARE BETREKKINGE OM DIE SAMEWERKING VAN HUISHOUDELIKE VERBRUIKERS TE VERKRY OM ELEKTRISITEITSAANVRAAG TE BEHEER

Omtrent 6 maande voordat die aanvraagbeherende tarief ingestel is, is 'n redelik omvattende publisiteitveldtog gevoer.

Omsendbriewe is gestuur aan alle verbruikers, persdekking is verkry en toesprake is gehou by die skole en organisasies soos die plaaslike Sakekamer, Belastingbetalersvereniging en diensorganisasies. Verder is die oormaat-kWh gebruik deur elke verbruiker op die maandelikse rekening aangetoon teen nultarief gedurende die veldtogperiode.

In hierdie veldtog is verbruikers voorsien van 'n lys met die kragverbruik van die algemene huishoudelike toestelle, is aangeraai om toestelle opvolgend en nie gelyktydig te gebruik nie, en om vragbeperkende termiese skakelaars te installeer. Die verbruikers is ook daarvan verwittig dat 'n vermindering in die NDMA van die groep mettertyd 'n vermindering in die maandelikse basiese heffing tot gevolg sou hê, d.i. die faktor "2" in die uitdrukking R(2 x M) sou verlaag word na 'n waarde gelyk aan die gemiddelde NDMA gemeet oor 'n tydperk.

'n Aspek wat beklemtoon is, was dat die doel van die tarief nie is om die voordele van die gebruik van elektrisiteit te beperk nie, maar om die doeltreffender gebruik van elektrisiteit aan te moedig.

Oor die algemeen het die publiek die nodigheid van die nuwe tarief aanvaar, hoofsaaklik vanuit die oogpunt dat die langtermynvoordele in hulle belang was.

Toe die tarief ingestel is, is 'n groot aantal klagtes ontvang. 'n Ontleding van die klagtes het getoon dat baie verbruikers nie hulle gemete elektrisiteitverbruik kon korreleer met die verbruik van individuele en kombinasies van toestelle nie.

Om hierdie probleem te oorbrug, is 'n lasregistreerdiens ingestel waar, op versoek van die verbruiker, 'n kaartregistreerammeter wat die totale installasielas opteken, in die kombuis van die verbruiker geïnstalleer word vir 'n dag. Die verbruiker word voorsien van 'n kaart waarop hy die gebruik van sy toestelle oor die 24-uur-periode moet opteken. Die informasie van hierdie kaart word dan oorgedra op die ammeterregistrasie-

3. THE LOW VOLTAGE TARIFFS IN RICHARDS BAY

The low voltage tariffs used in Richards Bay are as follows–

Sclae 1

Single phase consumers with loads less than 15 kVA.

Basic Monthly charge (Rands)	Energy charge (cent/kWh)	Excess kWh charge (cent/excess kWh)
M x 2	E + 0,7	$\frac{M \text{ (in cents)}}{60}$

Where M = Escom's maximum demand charge to Richards Bay Town Board.
= R4,9875 (in September, 1977)
E = Escom's energy charge to Richards Bay Town Board.
= 0,696 (in September, 1977)

The meters are pre-set to register excess kWh's when the load exceeds 4 kW.

Converted to monetary values, the charges in September, 1977 are–

Basic Monthly Charge	:	R9,975
Energy charge	:	1,396 cents/kWh
Excess kWh charge	:	8,3125 cents/kWh

The factor "2" used to calculate the basic monthly charge equals the estimated ADMD of Scale 1 consumers measured at the time the monthly peak demand occurs.

The factor "60" used to calculate the excess kWh charge is based on a domestic peak occurring during 2 hours each day over a period of 30 days.

Scale 2

Three phase consumers with loads greater than 15 kVA and less than 40 kVA.

kVA Maximum demand/kWh meters are used for this group of consumers. The tariffs used are also linked to Escom's tariffs.

4. A PUBLIC RELATIONS EXCERCISE TO OBTAIN THE CO-OPERATION OF DOMESTIC CONSUMERS IN CONTROLLING ELECTRICITY DEMAND

About 6 months before the demand controlling tariff was brought into operation, a fairly extensive publicity campaign was conducted.

Circulars were sent to all consumers, press coverage was obtained and addresses given to the schools and organisations such as the local Sakekamer, Ratepayers Association and service organisations. In addition, the excess kWhs consumed by each consumer were printed out on the monthly electricity accounts at 'no charge' during the campaign period.

In this campaign, the consumers were given lists of the power consumption of the common household appliances, were advised to use appliances sequentially and not simultaneously and advised to install load limiting thermal switches. The consumers were also advised that a reduction in the ADMD for the group would result in due course in a reduction in the basic monthly charge i.e. from the factor "2" in the equation R(2XM) to a lower factor equal to the average ADMD measured over a period of time.

An aspect which was emphasized was that the intention of the tariff was not to curb the benefits derived from the use of electricity but to induce the more efficient use of electricity.

In general, the public accepted the need for the new tariffs, primarily from the point of view that the long term benefits, both locally and nationally, were in their interest.

When the tariffs were brought into operation, a large number of complaints were received. An analysis of these complaints showed that many consumers were not able to correlate the electricity consumption of the individual and combinations of appliances with their measured electricity consumption.

To overcome this problem a load recording service was introduced whereby, on the request of a consumer, a chart recorder which measures the total load of the installation in amperes, was installed in the kitchen of the consumer for a day. The consumer is required to complete a form which details the appliances used over the 24-hour period. The information from this form is then transferred to the chart and the consumer ad-

kaart en die verbruiker word ingelig aangaande die gebiede waar besparings gemaak kan word. Aanvanklik is hierdie diens nie geadverteer nie, maar aan uitgesoekte verbruikers aangebied. Die resultate wat verkry is, was beter as wat verwag was.

Eerstens is gevind dat verbruikers in staat was om die verbruik van hulle toestelle en die nodige gebruiksaanpassings te vind binne 'n paar uur nadat die registreerders geïnstalleer is. Verbruikers wat van die dienste gebruik gemaak het (gratis), het klaarblyklik die resultate en bevindinge met hulle vriende bespreek aangesien, alhoewel die diens later geadverteer is, het slegs omtrent 3% van die verbruikers die diens aangevra in die eerste drie maande na die instelling. Laastens is waardevolle inligting verkry aangaande die toestelle wat verbruikers besit en die manier waarop hulle gebruik word.

Terugblikkend was die publisiteitsveldtog suksesvol maar kon meer suksesvol gewees het as vroegtydig meer aandag geskenk is aan die manier waarop elke toestel elektrisiteit verbruik d.i. sy kragverbruik, die tyd benodig om sy funksie te verrig en die manier waarop die termostate werk.

5. 'N ONTLEDING VAN HUISHOUDELIKE ELEKTRISITEITLAS

Die toestelle wat die vernaamste bydrae lewer tot hoë oormaat-kWh-verbruik is deur die verbruikers se lasregistrasies en ander ondersoeke geïdentifiseer.

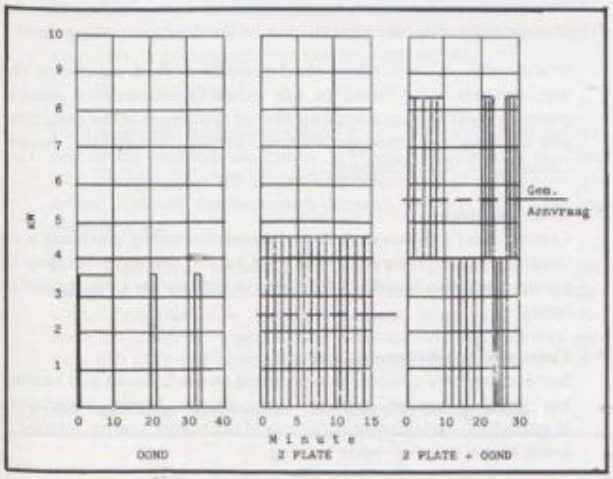
5.1 Elektriese stowe

Die meeste elektriese stowe in Richardsbaai is van die glasblad- of spiraalplaattipe en is oor die algemeen groot modelle wat 11 – 14 kW trek met al die plate en die oond aan.

Dit is gevind dat stowe die meeste bydra tot oormaat-kWh-verbruik. Deur opeenvolgende gebruik van plate en die oond, was verbruikers in staat om aansienlike besparings te bewerkstellig.

Een ondernemende huisvrou kook nou meeste maaltye in spesiaal ontwerpte potte in die oond. Nie net vermy sy energievermorsing in die vorm van hitte-uitstraling deur die potte nie, maar sy verhoed kruinelektrisiteitsaanvraag deur in die laat middag te begin kook. Aangesien die hitte in die kombuis minder is, is verkoeling van die kombuis nie meer nodig nie.

Die volgende is 'n tipiese registrasie van die verbruik van 'n elektriese stoof:



5.2 Warmwatertoestelle

'n Aantal huise is gevind met twee of drie warmwatertoestelle. Seersekerlik is daar in 'n warm klimaat soos dié van Richardsbaai baie min regverdiging vir hierdie tipe installasie. Nie alleen is gevind dat die addisionele warmwatertoestelle aansienlik bygedra het tot die oormaat-kWh-verbruik nie, maar ook tot die energieverbruik as gevolg van hitteverlies deur die warmwatertoestelle.

Hierdie probleem is opgelos deur party verbruikers wat die toestelle kruisverbind het en net een toestel gebruik vir normale ge-

vised in due course of the areas where he can make savings. Initially, this service was not advertised, but offered to selected consumers only. The results obtained from this service were better than anticipated.

Firstly, consumers were found to be able to analyse the consumption of their appliances and determine the corrective measures that needed to be taken within a few hours after installation of the recorders. Consumers who had taken advantage of the service obviously discussed the results with their friends, since although the service (at no charge) was advertised later, only about 3% of the consumers in Richards Bay requested the use of the service in the first three months after its commencement. Finally, valuable information concerning the appliances owned by consumers and the manner in which they are used was obtained from the recordings.

Viewed in retrospect, the publicity campaign was successful but could have been more successful if more attention had been paid at an early stage to the manner in which each appliance uses electricity i.e. its power consumption, the time taken to perform its function and the manner in which the thermostats operate.

5. AN ANALYSIS OF DOMESTIC ELECTRICITY LOADS

From the consumers' load recordings and other investigations, the main contributors to high excess kWh consumption were identified. Also the actions taken by the consumers to reduce high consumption were determined.

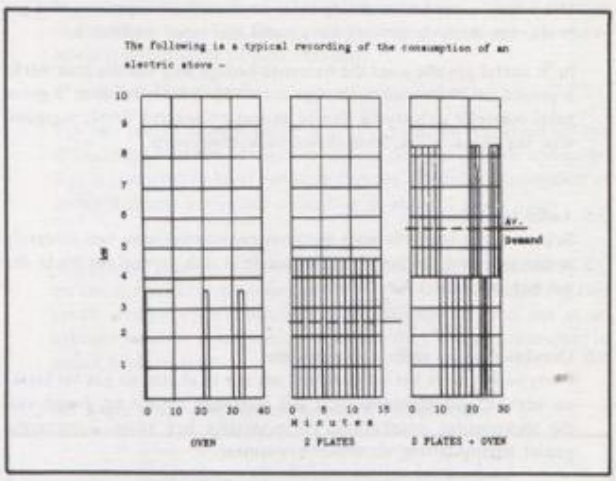
5.1 Electric Cookers

Most electric cookers in Richards Bay feature the spiral or glass-plate type of hot plate and generally are large models drawing 11 – 14 kW with all the plates and the oven on.

Electric cookers were found to contribute the most towards the excess consumption kWhs. By sequential use of the plates and the oven, consumers were able to make considerable savings.

One enterprising housewife now cooks most of her meals, using specially designed pots, in her oven. Not only does she avoid wasting energy in the form of heat given off by the pots on the plates, but she avoids peak electricity demand by commencing the cooking of the meal in the late afternoon. Since the heat in the kitchen is less, additional cooling of the kitchen is no longer necessary.

The following is a typical recording of the consumption of an electric stove–



5.2 Water Heaters

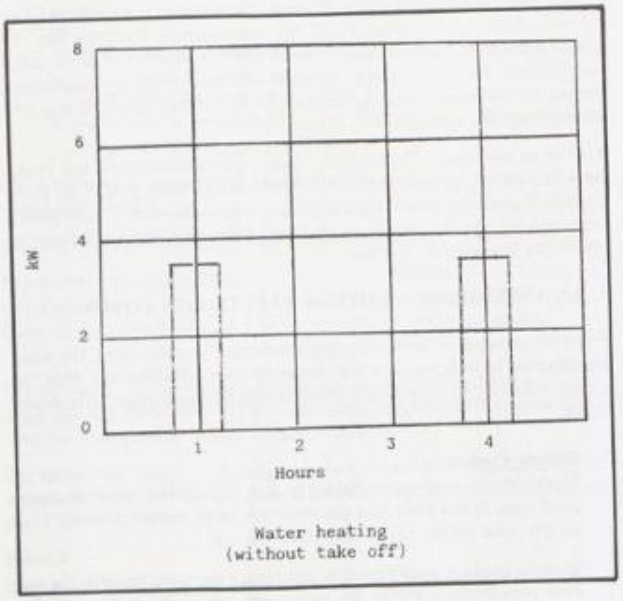
A number of houses were found to have two or three water heaters installed. Certainly in a hot climate such as Richards Bay's, there is little justification for this type of installation. Not only were the additional water heaters found to contribute significantly to the excess kWhs, but also to the energy consumption in making up the radiated losses from the heater casings.

This problem was solved by some consumers who cross-connected the hot water heaters and used only one heater for the dwelling.

bruik. Wanneer nodig, as besoekers gehuisves word, word die ander warmwatertoestelle vir 'n beperkte tyd gebruik.

Termiese lasbeperkerrelês word gebruik om die warmwatertoestel te isoleer wanneer ander las aangeskakel word.

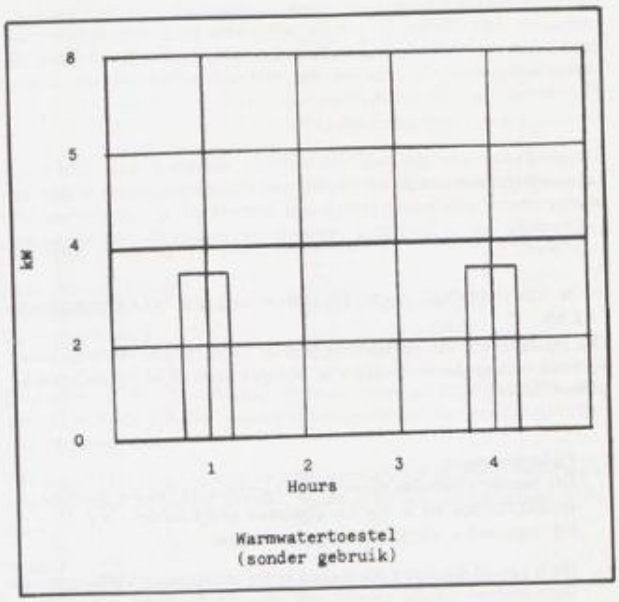
Die volgende is 'n tipiese registrasie van die verbruik van 'n warmwatertoestel–



When the need arises, say, when a number of visitors have to be accommodated, the other water heaters are brought into operation for a limited period only.

Thermal load limiting relays are fitted by consumers to isolate the water heaters when other loads are switched on in the house.

The following is a typical recording of the consumption of a hot water heater–



5.3 **Lugversorgers**
Verbruikers met lugversorgers bespaar oormaat-kWh deur òf die lugversorgers te gebruik in die slaapkamers onmiddellik voor hulle bed toe gaan, òf deur net die waaier te gebruik d.w.s. deur die kompressor uit te skakel gedurende tye wanneer ander toestelle aangeskakel is.

5.4 **Bediendes**
Die behoefte om bediendes op te lei om elektrisiteit spaarsaam te gebruik, het duidelik geword kort nadat die tarief ingestel is.

In 'n aantal gevalle waar die huisvrou bedags weg van die huis werk, is gevind dat bediendes oormatige aanvraag veroorsaak deur 'n groot getal toestelle gelyktydig aan te skakel en tegelyk kook, wasgoed was, tee maak, stryk, huis skoonmaak ensovoorts.

5.5 **Ander toestelle**
Sekere ander toestelle soos outomatiese wasmasjiene met integrale waterverhitters, en pottebakkersoonde is ook gevind om by te dra tot hoë oormaat-kWh-verbruik.

5.6 **Oorskakeling na ander energiebronne**
Party verbruikers het dit oorweeg om oor te skakel na gas vir kook- en verhitingsdoeleindes maar het daarteen besluit op grond van die toekomstige onsekerheid en moontlike hoë koste. Sonenergie geniet belangstelling vir waterverwarming.

6. DIE RESULTATE VAN DIE AANVRAAGBEHERENDE TARIEF IN RICHARDSBAAI

Aangesien die netwerke van so aard is dat die totale huishoudelike las nie apart gemeet kan word nie, is die aanvraag van 'n toetsgroep verbruikers gemonitor en die resultate gebruik om die aanvraag van al die huishoudelike verbruikers in Richardsbaai te raam.

Hierdie toetsgroep, genoem die Meerensee-toetsgroep, bestaan uit omtrent 200 verbruikers in behuising wat wissel van 2-slaapkamer-woonstelle tot drie-, vier- en vyfslaapkamerhuise. 'n Deursnee beroepe kom voor in die toetsgroep d.i. dokters, prokureurs, ambagsmanne, klerke ens.

5.3 **Air-conditioners**
Consumers with air-conditioners installed conserve excess kWhs and energy by either using the air-conditioners to cool their bedrooms immediately prior to going to bed at night or by using the fan only i.e. by cutting out the compressor, during those periods when other appliances are switched on.

5.4 **Servants**
The need to train servants to use electricity conservatively became obvious soon after the introduction of the load controlling tariff.

In a number of cases where the housewife worked out during the day, servants were found to use excessive amounts of electric power by switching on a large number of appliances at the same time and carrying out cooking, washing, ironing, tea-making, housecleaning etc. simultaneously.

5.5 **Other appliances**
Certain other appliances such as automatic washing machines with integral water heaters and ovens used for the baking and glazing of pottery were also found to contribute to high excess kWh consumption.

5.6 **Conversion to other energy sources**
Some consumers considered converting to gas cooking and heating but decided against this in view of the future uncertainty in availability and possible high costs of the energy source. Interest is being shown in solar water heating.

6. THE RESULTS OF THE DEMAND CONTROLLING TARIFF IN RICHARDS BAY

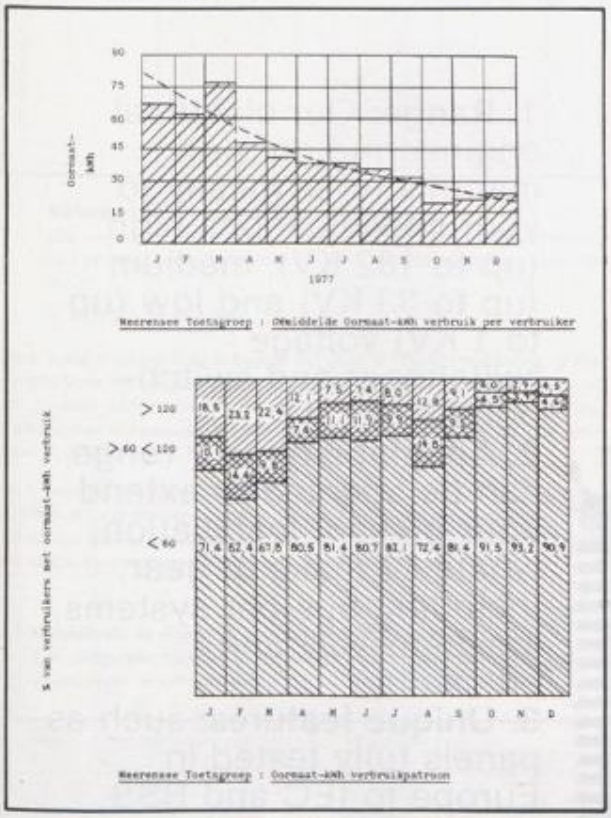
Since the networks are such that the total domestic load cannot be separately metered, the electricity demand of a test group of consumers was monitored and the results used to estimate the electricity demand of all the domestic consumers in Richards Bay.

This test group, named the Meerensee Test Group, comprises about 200 consumers living in premises varying from 2 bedroom flats to three, four and five bedroom houses. A cross-section of occupations is found in the test group i.e. doctors, lawyers, artisans, clerks etc.

Die resultate van die elektrisiteitverbruik van die toetsgroep en al die huishoudelike verbruikers in Richardsbaai word grafies voorgestel.

6.1 **Gemiddelde oormaat-kWh-verbruikgrafieke**
Die data vir hierdie grafieke is verkry van die maandelikse rekenaar-uitdruk.

6.1.1 **Meerensee-toetsgroep**



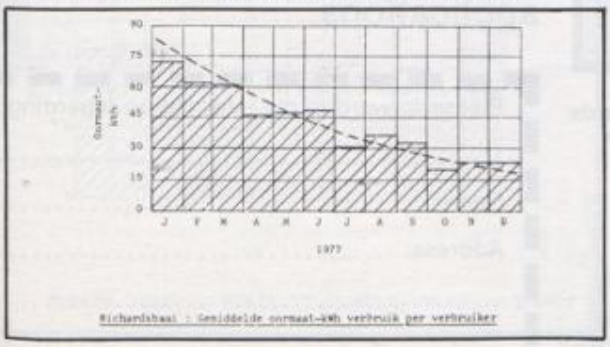
'n Ontleding van die neiging van oormaat-kWh-verbruik per verbruiker van die Meerensee-toetsgroep het die volgende vergelyking, met 'n korrelasiefaktor van 0,93 opgelewer.

$Y = 8,7 + 76,4\ (0,85)^X$

Vir die periode aangetoon is daar 'n 13% maandelikse vermindering op die verminderde balans. 'n Projeksie van hierdie resultate toon dat oormaat-kWh-verbruik sal afplat by 'n gemiddelde maandelikse verbruik van omtrent 9 oormaat-kWh per verbruiker oor omtrent 2 jaar.

In 'n soortgelyke ontleding het die kWh-verbruik met 4% per maand op die verminderde balans verminder vir die periode aangetoon. Projeksie van hierdie resultaat toon dat kWh-verbruik sal afplat by 'n gemiddelde maandelikse verbruik van omtrent 690 kWh per verbruiker oor omtrent 1 jaar.

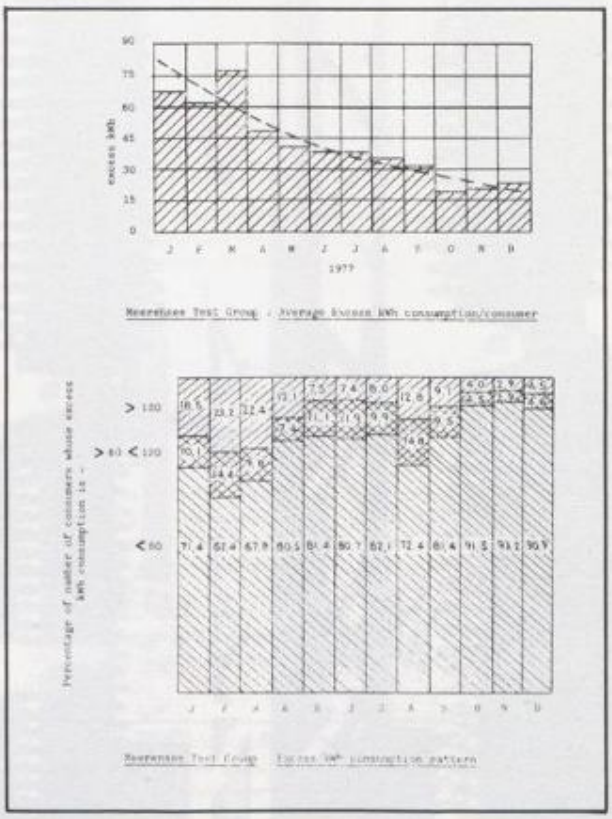
6.1.2 **Alle enkelfasige huishoudelike verbruikers in Richardsbaai**



The results of monitoring the electricity consumption of the test group and all the domestic consumers in Richards Bay are depicted graphically.

6.1 **Average excess kWh consumption graphs**
The data for these graphs was obtained from the monthly computer print-outs.

6.1.1 **Meerensee Test Group**



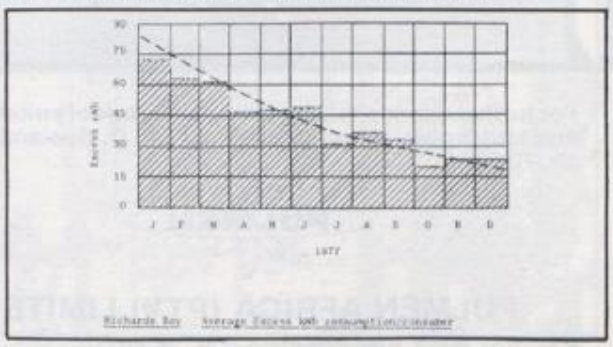
In analysing the trends of excess kWh consumption per consumer of the Meerensee Test Group, the following equation with a correlation co-efficient of 0,93 resulted.

$Y = 8,7 + 76,4\ (0,85)^X$

For the period shown, there is a 13% monthly reduction on the diminishing balance. Projecting this result, excess kWh consumption is predicted to level out at an average monthly consumption of about 9 excess kWhs per consumer in about 2 years' time.

In a similar analysis, the energy kWh consumption reduced by 4% on the diminishing balance for the period shown. Projecting this result, energy kWh consumption is predicted to level out at an average monthly consumption of about 690 kWhs per consumer in about 1 year's time.

6.1.2 **All single phase domestic consumers in Richards Bay**



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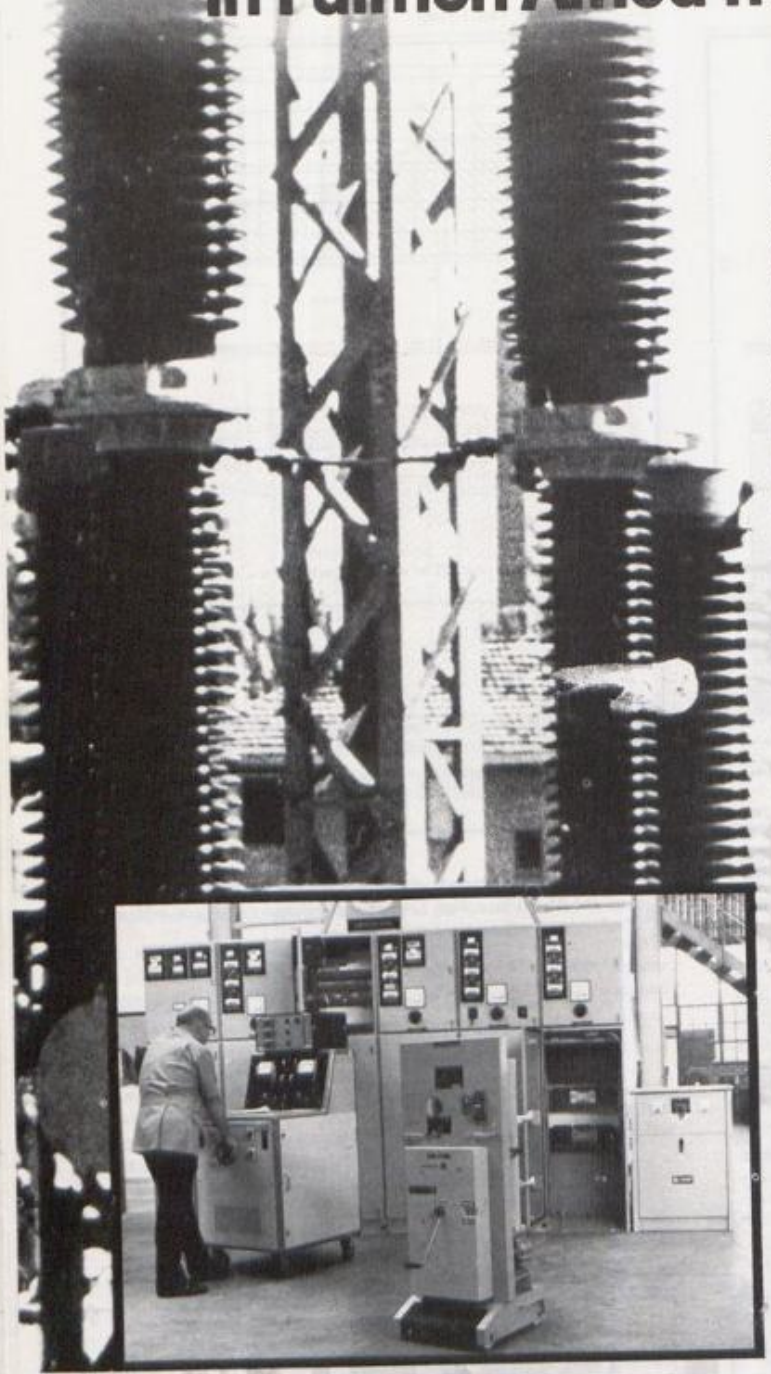

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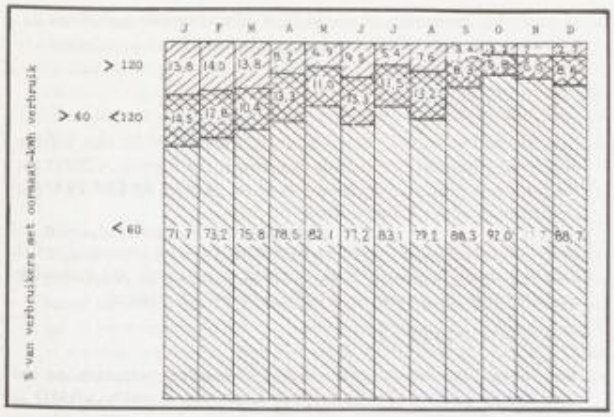


Richardsbaai : Oormaat-kWh-verbruikspatroon

Die vergelyking wat verkry is deur ontleding van al die huishoudelike verbruikers in Richardsbaai, met 'n korrelasiefaktor van 0,96 is:-

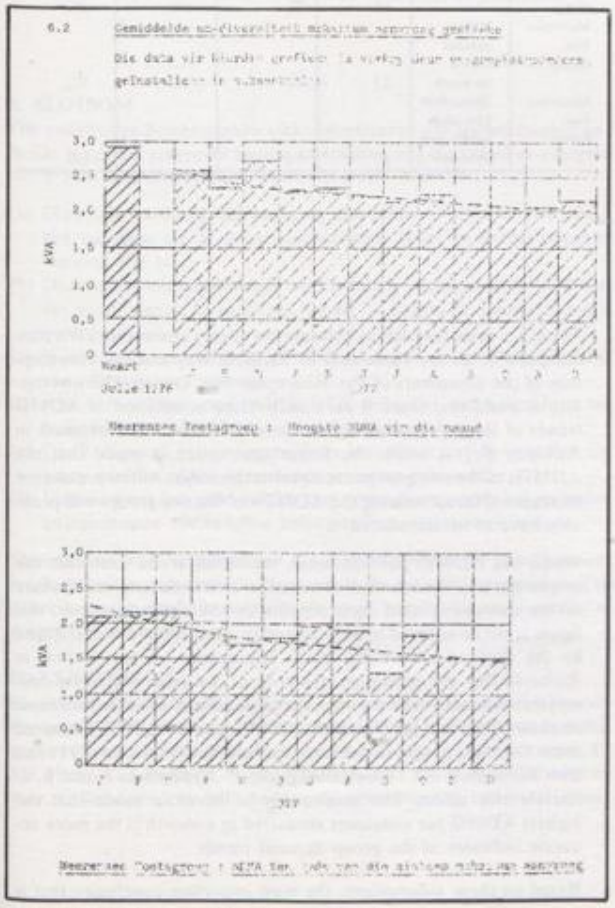
$$Y = 7,7 + 79,4\ (0,86)^X$$

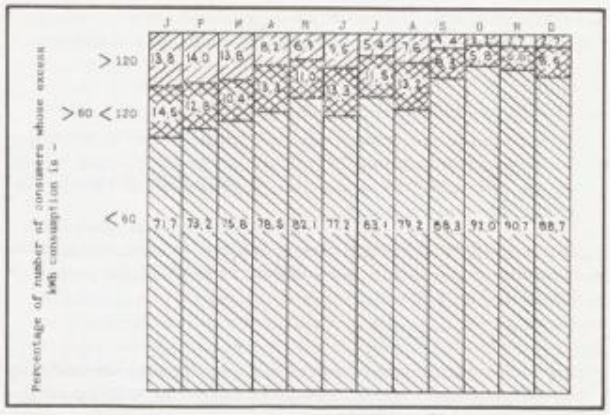
Deur hierdie vergelyking is bepaal dat daar 'n 12%-vermindering op die verminderde balans van maandelikse oormaat-kWh-verbruik bestaan vir die periode aangetoon. Projeksie van hierdie resultaat toon dat die maandelikse oormaat-kWh-verbruik sal afplat by 'n verbruik van omtrent 8 oormaat-kWh per verbruiker oor omtrent 2 jaar.

In 'n soortgelyke ontleding het die maandelikse kWh-verbruik verminder met 4% op die verminderde balans vir die periode aangetoon. Projeksie van hierdie resultaat toon aan dat die maandelikse kWh-verbruik sal afplat by omtrent 680 kWh oor omtrent 1 jaar.

6.2 **Gemiddelde na-diversiteit maksimum aanvraaggrafieke**

Die data vir hierdie grafieke is verkry deur lasregistreerders geïnstalleer in subsentrales.





Richards Bay : Excess kWh consumption pattern

With a correlation co-efficient of 0,96 the equation, that resulted from an analysis of all the Richards Bay domestic consumers is as follows-

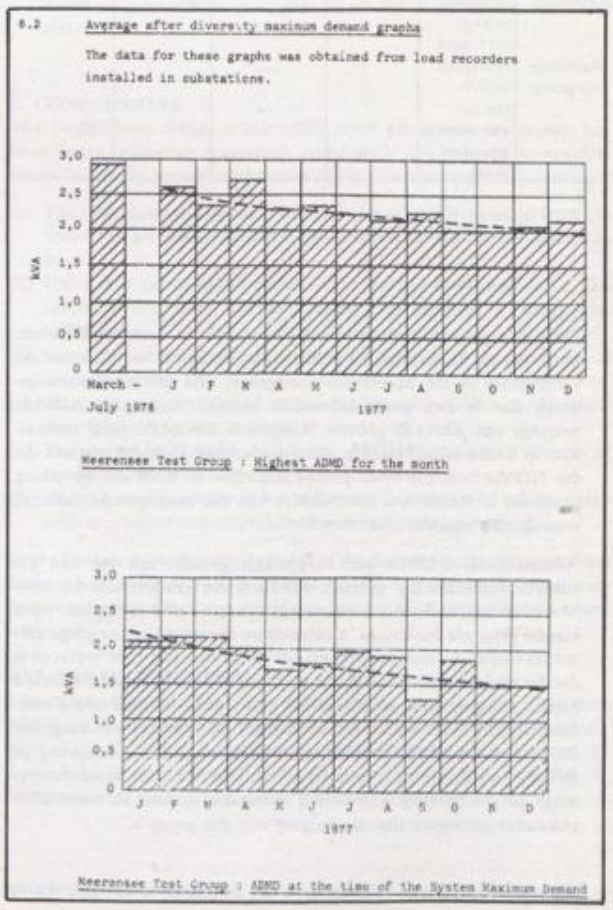
$$Y = 7,7 + 79,4\ (0,86)^X$$

From this equation it is calculated that there is a 12% reduction on the diminishing balance of excess kWh consumption each month for the period shown. Projecting this result, excess kWh consumption is predicted to level out an average monthly consumption of about 8 excess kWhs per consumer in about 2 years' time.

In a similar analysis, the energy kWh consumption reduced by 4% on the diminishing balance for the period shown. Projecting this result, energy kWh consumption is predicted to level out at an average monthly consumption of 680 kWhs per consumer in about 1 year's time.

6.2 **Average after diversity maximum demand graphs**

The data for these graphs was obtained from load recorders installed in substations.



'n Analise van die neiging van die hoogste na-diversiteit maksimum aanvraag vir die maand het die volgende vergelyking, met 'n korrelasiefaktor van 0,87 opgelewer.

$Y = 1,67 + 0,86\ (0,92)^X$

Vir die periode aangetoon is daar 'n 2% maandelikse vermindering op die verminderde balans. 'n Projeksie van hierdie resultaat dui aan dat die hoogste NDMA vir die maand sal afplat by 1,67 kVA per verbruiker oor omtrent 2 jaar.

In die geval van NDMA gemeet ten tye van die maandelikse sisteemkruinaanvraag, is die volgende vergelyking met 'n korrelasiefaktor van 0,77 verkry-

$Y = 1,54 + 0,72\ (0,81)^X$

Vir die periode aangetoon is daar 'n 3% maandelikse vermindering op die verminderde balans. 'n Projeksie van hierdie resultaat dui aan dat die maandelikse NDMA ten tye van die sisteemkruinaanvraag sal afplat by 'n gemiddeld van 1,54 kVA per verbruiker oor omtrent 1 jaar.

6.3 Samevatting en korrelasie van resultate

Die resultate verkry van die gemete hoeveelheid en statistiese grafieke word saamgestel in die tabel hieronder–

Verbruikers-groep	Gemete hoeveelheid per verbruiker	Verbruik voor aanvraagbeherende tarief	Maandelikse vermindering in verbruik sedert tarief ingestel is (%)	Voorspelde minimum gemiddelde verbruik (na 2-3 jaar)	Voorspelde maksimum vermindering in verbruik oor 3-4 jaar (%)
Alle Verbruikers	Oormaat-kWh	75	12%	8	89%
Alle Verbruikers	Energie kWh	760	4%	680	11%
Meerensee-toetsgroep	Oormaat-kWh	70	13%	9	87%
Meerensee-toetsgroep	Energie kWh	800	4%	690	13%
Mereensee-toetsgroep	Hoogste aanvraag in kVA vir maand	2,5	2%	1,67	33%
Meerensee-toetsgroep	Aanvraag in kVA ten tye van sisteem-kruinaan-vraag	2,3	3%	1,54	33%

Daar is 'n goeie korrelasie tussen die energie en oormaat-kWh-verbruik van al die verbruikers in Richardsbaai en die verbruik van die verbruikers in die Meerensee-toetsgroep. Die aanname word gemaak dat 'n ewe goeie korrelasie bestaan tussen die NDMA-neigings van die twee groepe. Aangesien die totale getal verbruikers in Richardsbaai klein is, word die verdere aanname gemaak dat die NDMA van die twee groepe dieselfde is. Soos die bevolking groei sal 'n faktor wat die NDMA van die twee groepe verbind, waarskynlik ingestel moet word.

Alhoewel die NDMA per verbruiker, gemeet ten tye van die sisteemkruinaanvraag, gebruik word om die aandeel van die huishoudelike verbruikers van aanvraagverwante koste te bepaal, word hierdie syfer nie beskou as 'n betroubare aanwyser van neigings veroorsaak deur die aanvraagbeherende tarief nie. Die rede hiervoor is dat die maksimum aanvraag van groot industriële verbruikers die tyd bepaal wanneer die kruin plaasvind, met 'n groot invloed op die huishoudelike NDMA wat dan gemeet word. Die grafieke van daaglikse las gemeet op 14 Junie 1977 en 28 September 1977, aangeheg as Bylae A en B, illustreer hierdie effek. Die aanname word dus gemaak dat die hoogste NDMA per verbruiker gemeet in 'n maand 'n akkurater aanwyser van die neiging van die groep is.

Gebaseer op hierdie aannames, is die belangrikste gevolgtrekking

In analysing the trends of the highest after diversity maximum demand for the month, the following equation with a correlation co-efficient of 0,87 resulted.

$Y = 1,67 + 0,86\ (0,92)^X$

For the period shown, there is a 2% monthly reduction on the diminishing balance. Projecting this result, the highest ADMD for the month is predicted to level out at an average of 1,67 kVA per consumer in about 2 years' time.

In the case of the after diversity maximum demand measured at the time the monthly system peak demand is obtained, the following equation with a correlation co-efficient of 0,77 resulted.

$Y = 1,54 + 0,72\ (0,81)^X$

For the period shown, there is a 3% monthly reduction on the diminishing balance. Projecting this result, the monthly ADMD at the time the system peak occurs is predicted to level out at an average of 1,54 kVA per consumer in about 1 year's time.

6.3 Summary and correlation of results

The results obtained from the measured quantities and the statistical graphs are summarised in the table below–

Consumer Group	Measured Quantity per consumer	Consumption prior to introduction of demand controlling tariff	Monthly reduction in consumption since introduction of tariff (%)	Predicted minimum average consumption (after 2-3 years)	Predicted maximum reduction in consumption over 3-4 year period (%)
All Consumers	Excess kWh	75	12%	8	89%
All Consumers	Energy kWh	760	4%	680	11/
Meerensee Test Group	Excess kWh	70	13%	9	87%
Meerensee Test Group	Energy kWh	800	4%	690	13%
Meerensee Test Group	Highest demand in kVA for mooth	2.5	2%	1.67	33%
Meerensee Test Group	Demand in kVA when system peak obtained	2.3	3%	1.54	33%

There is a close correlation between the energy and excess kWh consumption of all the consumers in Richards Bay and the consumption of the consumers of the Meerensee Test Group. The assumption is made that there is an equally close correlation of ADMD trends of the two groups. Since the total number of consumers in Richards Bay is small, the futher assumption is made that the ADMDs of the two groups are equal at this stage. As the population increases, a factor relating the ADMDs of the two groups will probably have to be introduced.

Whilst the ADMD per consumer, measured at the time that the system peak for the month is obtained, is used to determine the share of the demand related costs payable by the domestic group, this figure is not considered to be an accurate indicator of trends induced by the demand controlling tariff. The reason for this is that in Richards Bay the maximum demands of the large industrial consumers determine the time when the peak occurs, which in turn has a marked effect on the domestic ADMD per consumer measured then. The daily graphs of the loads measured on 14th June, 1977 and 28th September, 1977 which are attached - Appendices A and B, illustrate this effect. The assumption is therefore made that the highest ADMD per consumer measured in a month is the more accurate indicator of the group demand trends.

Based on these assumptions, the most important conclusion that is

dat die aanvraagbeherende tarief 'n noemenswaardige vermindering in huishoudelike elektrisiteitsaanvraag en 'n gepaardgaande vermindering in energieverbruik tot gevolg gehad het in die eerste 10 maande. Daarby is daar die statistiese voorspelling dat beide huishoudelike aanvraag en energieverbruik oor die volgende twee tot drie jaar sal verminder.

7. MEETTOERUSTING

7.1 Betroubaarheid van lastariefmeters

Sekere probleme is ondervind met die lastariefmeters in gebruik, die ernstigste waarvan die vassit van ratte van 220 meters van die eerste bestelling van 2 000 was. Dit is bevind dat die fout ontstaan het uit 'n vervaardigingsfout - 'n oormatige hoeveelheid smeermiddel is in die sinkrone motor geplaas, wat in warm weer op die ratte in die meter gedrup het en hulle laat vassit het. Die fout is herstel deur die vervaardiger.

Alle meters word volgens SABS 01-1953 getoets voor installering.

7.2 Koste van lastariefmeters

'n Bron van bekommernis is die stygende koste van lastariefmeters. As 'n alternatief vir die tipe wat nou gebruik word, naamlik 'n meter met 'n ingewikkelde rattesisteem en 'n sinkrone motor, is ondersoek ingestel na die moontlikheid om konvensionele kWh-meters om te skakel na lastariefmeters deur een van die volgende metodes-

Met die eerste metode word die skyf van die meter gebruik om pulse op te wek wat in 'n geïntegreerde stroombaan gebruik word om 'n sein op te wek wanneer 'n voorafingestelde las oorskry word. Die enkele register van die meter word vervang deur die dubbele register van 'n tydtariefmeter, en die lassein word gebruik om die solenoïde te beheer wat die tweede register in werking stel.

Met die tweede metode word die pulse gebruik om 'n aparte elektromeganiese teller in die meter aan te dryf.

Die aanduidings is dat enigeen van hierdie metodes kan meebring dat die prys van lastariefmeters kan verminder of stabiliseer.

8. SLOTSOM

Die enkelfasige huishoudelike elektrisiteitstarief wat lastariefmeters gebruik, is redelik suksesvol bevind en voldoen aan die vereistes neergelê vir 'n aanvraagbeherende of -metende tarief, naamlik-

(a) Die totale huishoudelike aanvraag is beduidend verminder sedert die tyd toe daar nie 'n aanvraagbeherende tarief in Richardsbaai in werking was nie.
(b) Daar is 'n ooreenstemmende vermindering in energieverbruik d.w.s. die vermindering in aanvraag het **nie** 'n styging in energieverbruik veroorsaak nie.
(c) Waardevolle statistieke word verkry vir gebruik in die beplanning van toekomstige netwerke.
(d) Alle verbruikers word redelik billik behandel met betrekking tot hulle bydrae tot die koste van elektrisiteitsverbruik.
(e) Die besparings in aanvraagheffings betaalbaar aan Evkom dek die koste van die addisionele metertoerusting geïnstalleer.
(f) Daar is geen bekende neiging dat verbruikers oorskakel na ander energiebronne nie behalwe belangstelling in sonverwarming.

Opsommend was die sukses van die aanvraagbeherende tarief om verbruikers aan te spoor om die laste van hulle toestelle opeenvolgend te gebruik sonder om hulle gebruik van enige kombinasie van toestelle te eniger tyd te beperk.

DANKBETUIGING

Ek bedank die Richardbaaise Dorpsbestuur en in besonder die Voorsitter, mnr. P.J.V.E. Pretorius, vir toestemming om hierdie referaat te publiseer en die personeel van die Elektrisiteitsafdeling, in besonder mnre. E. v.d. Horst, C. Lawrence, G. van Schalkwyk, D. Eksteen, E. Denman en mev. L. Weideman vir hulle hulp in die voorbereiding van die referaat.

drawn from the results is that the demand controlling tariff has resulted in a significant reduction in total domestic electricity demand with a concomitant reduction in energy consumption in ten months. In addition, there is the statistical prediction that both total domestic electricity demand and energy consumption will reduce further during the next two to three years.

7. METERING EQUIPMENT

7.1 Reliability of Load Rate Meters

Certain teething problems were experienced with the load-rate meters used, the most serious being the jamming of the gears of 220 meters of the first batch of 2000 ordered. This fault was found to have resulted from a manufacturing error – an excessive amount of lubricant was introduced into the synchronous motor housing which during hot weather dripped onto the meter gears causing them to jam. This fault has been rectified by the manufacturer.

All meters are tested in compliance with SABS 01-1953 before being installed.

7.2 Cost of Load Rate Meters

A source of concern has been the escalating costs of the load-rate meters. As an alternative to the type which is being used i.e. a meter which incorporates a fairly complicated gear system and synchronous motor, investigations have been carried out to establish the feasibility of converting conventional kWh meters to load rate meters using one of the following methods-

With the first method, the meter disc is used to generate pulses which are clocked in an integrated circuit to produce a signal when a pre-set load is exceeded. The single register of the meter is replaced with the double register of the time rate meter and the signal used to energise the solenoid thus bringing the second register into operation.

With the second method, the pulse generated signal is used to operate a separate electro-mechanical counter located in the meter housing.

Preliminary findings indicate that either of these two methods could result in a reduction or stabilising of the price of the load rate meters.

8. CONCLUSIONS

The single phase domestic electricity tariff using load-rate meters has been found to operate reasonably successfully and to meet the requirements laid down for a demand controlling or measuring tariff, namely-

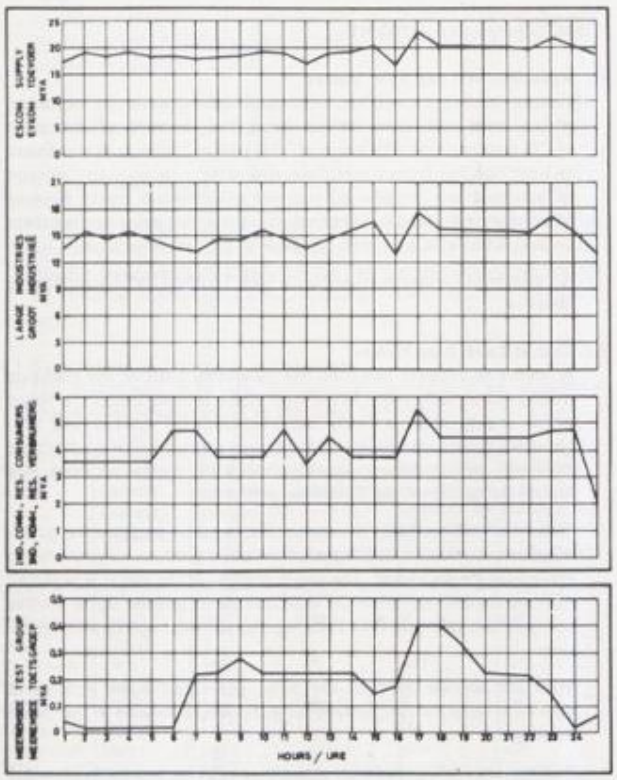
(a) The total domestic demand has been significantly reduced from the time when no demand controlling tariff was in operation in Richards Bay.
(b) There is a concomitant reduction in energy consumption i.e. the reduction in demand has **not** resulted in an increase in energy consumption.
(c) Valuable statistics are being obtained for use in the planning of future networks.
(d) All consumers are treated reasonably equitably with regard to their contribution towards the cost of electricity used.
(e) The savings in demand charges payable to Escom cover the cost of the additional metering equipment installed.
(f) There is no known trend by consumers to convert to other energy sources, apart from interest being shown in solar heating.

In the final analysis, the achievement of the demand controlling tariff has been to induce consumers to use the loads of their appliances sequentially without restricting their use of any combination of appliances at any one time.

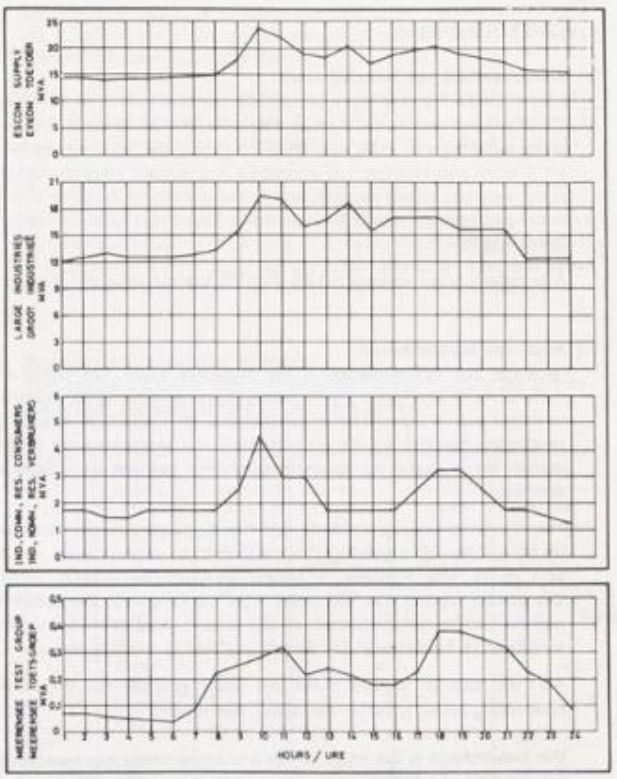
AKNOWLEDGEMENTS

I thank the Richards Bay Town Board and in particular the Chairman, Mr. P.J.V.E. Pretorius, for permitting me to present this paper and the staff of the Electricity Department, especially Messrs E. v.d. Horst, C. Lawrence, G. van Schalkwyk, D. Eksteen, E. Denman and Mrs. L. Weideman for their assistance in preparing the paper.

MONTHLY MAX. DEMAND AT 12,00 h ON 14 th JUNE 1977
MAANDELIKSE MAKS. AANVRAAG OM 12,00 h OP 14 JUNIE 1977



MONTHLY MAX. DEMAND AT 10,00 h ON 28th SEPTEMBER 1977
MAANDELIKSE MAKS. AANVRAAG OM 10,00 h OP 28 SEPTEMBER 1977



DISCUSSIONS/BESPREKINGS

K.G. Robson : President

I am now pleased to call on Mr F.W. Bamber, the City Electrical Engineer of Bulawayo, to open the discussion on the paper.

F.W. Bamber : Bulawayo

Mr President, at the outset I must congratulate Mr Hawkeswood on his excellent paper and, in particular, on the fact that his efforts have obviously borne fruit to the extent that domestic after diversity demand has been reduced.

But, even more so, he is to be congratulated and admired for his courage and foresight in embarking on an effective means of domestic demand control – something we in Bulawayo, and I am sure engineers in most undertakings in South Africa – have been toying with for many years.

Bulawayo has gone some way towards achieving this in that a load limiter tariff was introduced in the African townships, where the number of consumers now exceeds those in other areas. This has proved to be an extremely successful venture, which I will outline later.

The need to control domestic demand in Bulawayo is even greater than it is for you in South Africa for, compared with the purchase cost of electricity to Richards Bay, which is made up of 60% demand charge and 40% energy charge, a ratio of 80% and 20% applies in Bulawayo.

Although the undertakings in South Africa are saddled with the insatiable demands of ESCOM, at least you do not have to contend with the annual maximum demand charge that we in Rhodesia are called upon to meet by the Central African Power Corporation, in terms of which one half hour of peak on a particularly cold winter's evening, if allowed to go unchecked, would increase the average monthly demand charged over the year – July to June – to a frightening level. If this occurred in June, the charges would be made retrospective over the previous eleven months. This was recognised when the Central African Power Corporation tariff was introduced in 1961, and it was appreciated that the inequitable twopart domestic tariff, with room charges providing the estimated demand portion, could in no way compensate for such an eventuality.

As a consequence, investigations were carried out to determine an economic method of providing load control.

It was acknowledged at that time that water heating made a major contribution to morning and evening domestic demand and, since this was the easiest to control, causing the least inconvenience to consumers, this control formed the basis of our thinking.

We were fortunate in Bulawayo in that Salisbury (whose domestic consumers followed a similar life style to those in Bulawayo) had already had experience in this regard and had A.F. injection equipment in operation. It was ascertained from them that its average effect was 500 watts per consumer, a frighteningly low figure when taking into account the cost of A.F. injection and receiving equipment. Instinct told us that there appeared to be some discrepancy in this figure, since our records showed that the average installed capacity of water heaters per consumer in the city was some 1,97 kW, and an average reduction of approximately 1 kW could have been expected.

Sampling was therefore undertaken throughout our supply area to confirm our records, and our findings surprisingly indicated that more than 70% of the water heaters connected to our system had at least one faulty element. Subsequent checks indicated that the average life of one of the multi-element heaters is less than two years. It is interesting to note that few of the consumers were aware that the heat output of the water heaters had varied. I mention this particularly since similar conditions may have had some effect on the excellent results obtained in Richards Bay.

Having regard to the ESCOM monthly tariff, whilst it is appreciated that excess consumption, which relates to maximum demand, provides an income to cover the maximum demand charges levied, since the charges only apply to the particular meter reading month, consumers may well consider this charge to be acceptable for a very cold period, when space

heating could be used, or to a very hot period, when air conditioning would be used to full advantage – both for the general comfort of the household. Since this is the probable reaction of all consumers, reticulation design would have to provide for this and no saving in this regard could be anticipated. This is illustrated in paragraph 6.2 of the paper. In order to achieve any saving in respect of distribution costs, it would be necessary to apply the additional charge over, say, one year. Unfortunately this is not practicable in the case of domestic consumers, who are generally nomads. It may be of interest to note that the average number of changes of address in Bulawayo is 800 per month out of a total of some 20 000 European domestic consumers. Incidentally, this provides us with an annual income of some $29 000 in reconnection fees.

We are all Council employees, with an obligation to satisfy the ratepayers and especially our Councillors, and I doubt if there are many of us here who do not make substantial contributions to the rate funds of our towns. I am sure that what applies in Bulawayo applies elsewhere, in that any increase in rates is blamed on the Councillors, whilst an increase in electricity charges is attributed to short-comings of the Electrical Engineer. So, whilst we may be perfectionists and desire and strive for minimum charges to out consumers, politics cannot, and should not, be disregarded. In this regard room charges can be looked upon as a rate on the property, the rateable value of the property being somewhat in proportion to the number of rooms, so let us take care lest we bring down the wrath of our Councils.

I do not consider it is the responsibility of the Municipal Electrical Engineer to take a philanthropic attitude towards the conservation of energy. Our function is to provide electrical energy to those who demand it – let it be on their heads to conserve, or, alternatively, let a Government so decree.

In my opinion, Richards Bay undertaking has achieved its objective in the best possible manner by adopting the load rate meter, but I again reiterate that this is only possible because of the massive increase in the cost of capital plant and the rising cost of fuel, ESCOM could well find it necessary to introduce an annual maximum demand charge, thus negating to some extent the present achievements of Richards Bay.

My only misgiving is that they have introduced a further electro-mechanical device into a very simple, efficient and cheap piece of equipment in the form of a solenoid operated gear change, the former possibly susceptible to voltage surges (but, of course, Richards Bay may not be subjected to high incidence of lightning) and the latter to maladjustment and failure. Neither will be easily noticed by a meter reader. It would be extremely interesting to learn what percentage of failures will occur and how these will be determined.

We, in Rhodesia, have for the past fifteen years enjoyed a tariff based on hydro-generation, which was provided at comparatively low costs and at low rates of interest but, with the recent commissioning of Kariba North Bank Station and, earlier, the Kafue Station, escalation raised its ugly head and, during the past year, a 30% surcharge has been imposed by the Central African Power Corporation. This is looked upon as an interim measure and, if normality returns, we can expect a revision of tariffs, which I am sure will result in increased maximum demand charges out of proportion to the energy charge, since fuel will not be taken into account.

In this event, in spite of having an extensive coverage of water heater control, which is continually being extended, it is proposed to devise a tariff which will both provide the equivalent of the room charge and limit the maximum demand of any consumer to his desired level, for which he will pay, and will apply for such period as to ensure an income to cover the resulting annual maximum demand charges levied on my undertaking. Briefly this will be as follows:

(a) A kWh meter will measure energy
(b) A load limiter will limit the load (this will replace the present MCB and will cost only a few cents more). The minimum size of the limiter will be based on the number of rooms and a monthly charge will be imposed for any increase beyond this.

It is considered that such a tariff will nullify the adverse financial effect of electrically boosted solar heaters.

I mentioned earlier that a load limiter tariff is in operation in our African townships. This has been successful since 1958 – some twenty years – and now applies to approximately 25 000 consumers. No energy meters are installed and the charges based on the size of limiter are levied as a portion of the rent in the case of Council-owned houses, or as part of the service charge for privately-owned houses. (This is permitted in terms of the African (Urban Areas) Accommodation and Registration Act). Thus the cost of meters, meter reading, billing and Treasury expenses is eliminated. The Africans have become expert in their traditional manner in getting the absolute maximum benefit out of their expenditure and the tariff is extremely economic.

In the financial year ending June 1977, the cost per unit purchased in bulk by the African areas was 0,997c per unit, and the average cost to the consumers was 1,33c per unit – extremely cheap by modern standards. This resulted in an excess of income over expenditure of some $190 000 for the year which was credited to the African Areas Account, and apart from beer profits, was their largest source of income.

Load Limiter Tariff

2,5 amp	Rh$1,60
5 amp	2,85
7,5 amp	4,05
15 amp	5,50
22,5 amp	7,35
30 amp	9,15

Unfortunately such a tariff cannot be applied in the European areas,, since it does not comply with the Electricity Act, in terms of which measurements must be in kilovolt amperes.

It may be of interest to note that the after diversity demand of a group of 200 African consumers has climbed from 1 to 2 kW since 1958, whilst that in European areas rose from 2,5 to 4,5 kW – a figure somewhat higher than the design criteria at Richards Bay, but this is due no doubt to the very dissimilar altitudes.

Mr President I thank you for the honour you paid me in inviting me to address your Association at this my first Technical Meeting. I hope I shall have the opportunity to attend more of your meetings in the future. Thank you.

President: Thank you, Mr Bamber. Ek vra nou mnr Brummer, Elektrotegniese Stadsingenieur van Stellenbosch, om die bespreking verder in te lei.

J.G. Brummer : Stellenbosch

Mnr die President, as ek die referaat reg opsom word van die standpunt uitgegaan dat „billike bydraes tot die aanvraag-verwante koste van elektrisiteit ten opsigte van huishoudelike verbruikers verhaal moet word" en „ dat gestreef moet word na 'n situasie waar die spaarsamige verbruiker nie die koste van die verkwistende verbruiker van elektrisiteit moet subsideer nie". Die bykomstige vereistes word ook gestel dat die tarief 'n vermindering in beide aanvraag en energie-verbruik moet aanmoedig.

So 'n standpunt kan seker verdedig word as 'n mens na die volgende kyk nl.

(1) Evkom bereken dat hulle kapitaal-behoeftes elke vyf jaar meer as verdubbel. Hierdie syfer geld seker in 'n meerdere of mindere mate ook vir munisipale elektrisiteitsondernemings.
(2) Teen die huidige groeitempo word bereken dat die aanvraag in die R.S.A. teen die jaar 2000, 5 keer meer, en teen die jaar 2030, 25 keer meer sal wees as tans.
(3) **Tempo van groei in die R.S.A.** (Gebaseer op statistiek vir die jare 1945 – 1975).

Item	% Groei per jaar	Verdubbelings-tydperk in jare	Groeifaktor vir 100 jaar
Bevolking	2,5	28	12
Elektrisiteits-verbruik	7,9	9	2005

Dit behoort vir elkeen duidelik te wees dat die gemiddelde groeitempo van die afgelope 30 jaar nie sonder meer volgehou sal kan word nie. Munisipale elektrisiteitsondernemings wat tans meer as 'n derde van die krag verbruik wat Evkom lewer, sal ongetwyfeld ook op soortgelyke wyse geraak word.

Mnr. Hawkeswood het verskillende metodes van beheer of meting van enkelfasige huishoudelike verbruikers deur kommersieel beskikbare toerusting ondersoek en tot die gevolgtrekking geraak dat lastariefmeting die geskikste is vir dié doel. Vanuit 'n suiwer tegniese oogpunt beskou kan 'n mens hom miskien gelyk gee. Ek stem egter nie saam dat dit die beste metode is om sy doelstellings te bereik nie, om die volgende redes nl.

(1) Die koste van die meettoerusting is myns insiens te hoog. Dit sal 'n dorp soos Stellenbosch volgens Mnr. Hawkeswood se kostesyfers bv. R285 000,00 kos om sy ± 5 000 huishoudelike verbruikers na lastariefmeting oor te skakel.
(2) Dit lyk ook nie vir my prakties om die voorgestelde metode op driefasige huishoudelike verbruikers toe te pas nie en dit is 'n belangrike oorweging wat veral die meer gegoede dorpsgebiede betref.

(3) Die instandhoudingskoste van lastariefmeters sal aansienlik meer wees as die van konvensionele kWh-meters.
(4) Dit lyk ook vir my twyfelagtig of die gemiddelde huishoudelike verbruiker die nodige begrip aan die dag sal lê of selfs genoeg belangstelling sal toon in die feit dat hy gepenaliseer word wanneer 'n vasgestelde aanvraag oorskry word.

Ek is egter van mening dat presies dieselfde oogmerke, soos gestel deur Mnr. Hawkeswood, bereik kan word deur gebruik te maak van 'n „omgekeerde" bloktarief waar opeenvolgende blokke teen progressiefhoër tariewe aangebied word. Hierdie metode hou die volgende voordele in nl.

(a) Konvensionele kWh-meters kan steeds gebruik word wat 'n kostevoordeel en eenvoud van toerusting beteken.
(b) Geen verskil word gemaak tussen enkelfasige en driefasige huishoudelike verbruikers nie.
(c) Die tariefstruktuur kan in die lig van omstandighede baie maklik verander word deur slegs die rekenaarsprogram te wysig. Geen verstellings aan meterinstallasies deur tegniese personeel is nodig nie.
(d) Toetse het bewys dat die kVA-aanvraag feitlik proporsioneel is aan die kWh-verbruik in die geval van huishoudelike verbruikers. Dit is dus betreklik maklik om die eenheidskoste so te „laai" dat die aanvraagsverwante koste op 'n realistiese manier verhaal kan word.
(e) Die mate wat huishoudelike verbruikers ontmoedig word om energie kwistig te gebruik kan baie maklik gereguleer word deur so 'n tarief en dit sal waarskynlik as aansporing vir baie verbruikers dien om sonverhittingstoestelle aan te skaf.

Dit wil my egter voorkom asof die aanvraagsverwante koste in die toekoms baie vinniger sal styg as die energieverwante koste en dit sal ook in Evkom se tariewe weerspieël moet word. Daarom sal munisipale elektrisiteitsondernemings daarteen moet waak om nie kWh-verbruik te veel te ontmoedig nie omdat ons waarskynlik in steeds groter-wordende mate in die toekoms vir ons bedryfsoorskotte van die wins wat ons maak uit die verkoop van kWh en nie soseer kVA nie, afhanklik sal wees.

I would like to congratulate Mr Hawkeswood on a well prepared paper that has given all of us a good deal to think about.

In conclusion Mr Chairman, I feel I would be neglecting my duty if I omitted to remind the meeting of the value of coal, a commodity which we seem to be burning with gay abandon these days, by quoting a verse which appeared in "Punch" magazine at the turn of the century.

"There's hardly a thing a man can name
Of use or beauty in life's small game
But you can extract in retort or jar
From the physical basis of black coal-tar,
Oil and scent and war and wine
And the lovely colours called aniline
You can make what you like from a drug to a star,
if you only know how; from black coal-tar". Thank you.

President: Dankie, mnr. Brummer.

Gentlemen, this paper is now open for general discussion and I think that, in my opening remarks, I made a special appeal to our affiliates to take part freely in the discussion on all the papers and the members' forum during our two days together. I wish to reiterate this appeal to all affiliates.

Mr. K.I. Andrews : Somerset East

1. In load rate metering what prevents a consumer from drawing far in excess of his predetermined demand for a limited period of say 20 minutes which the supply authority would be expected to meet? (A circuit breaker tariff could prevent this).
2. The author indicates a price of R81,00 for the supply and installation of load rate metering (I assume single element). Indications are that supply of each item alone, has doubled since the end of 1977.

Mr. D.C. Palser : Cape Town

Mr President, Mr Hawkeswood is to be congratulated on an excellent, well researched, thought-provoking paper. As he rightly sates, in these days of high capital costs, high interest rates and repeated calls from the authorities to conserve our fossil fuel reserves, more attention will have to be given in the near future to the formulation of tariff rates that assist in reducing both consumption and demand and encouraging the more efficient and effective utilization of all our resources. Mr Hawkeswood has gone a long way towards the achievement of this objective.

Of all the metering systems considered by Mr Hawkeswood, I agree with him that the load rate system is probably the best compromise.

I do not consider, though, that the actual metering cost of the alternative systems is an important factor in reaching a decision as to the best system to adopt. On the basis of Mr Hawkeswood's figures, the metering cost ranges from R31 for a standard kWh time-rate installation to a maximum of R147 for a ripple controlled time-rate installation. These costs are negligible relative to the total capital cost incurred in supplying a consumer. For instance, in Cape Town, the mean incremental capital cost, including all transmission, distribution, street lighting and other related costs, is of the order of R2 000 per consumer. When one considers capital outlay of this magnitude, plus the cost of the consumer's residence which is many times the electricity supply cost, absolute metering costs are of little overall significance.

A more important factor than cost influencing the choice of metering scheme is, I consider, the relative simplicity and reliability of the metering installation, particularly the latter. Reliability and accuracy over long periods of time are essential requirements. I should be pleased, therefore, if Mr Hawkeswood could comment further on this aspect of load rate meters and on any progress made in the conversion of conventional kWh meters using the two methods he mentioned.

I was particularly interested in the statistical data contained in the paper and the comparison of the A D M D and consumption before, and the trend after, introduction of the load rate metering system. From the figures given in the paper it would appear that the overall long term effect will be the achievement of a reduction in the mean cost per unit of around 15% to 20%.

Percentage-wise this is a relatively large reduction but, viewed in the overall context of the consumer's income and his expenditure on other items, it is relatively small. I am accordingly not convinced that all the additional complications involved in introducing such a scheme are warranted.

I, and I am not alone in this view, have always felt that electricity tariffs have in the past been far too numerous in number and unnecessarily complex in structure. Simplicity, reliability and ease of administration, I would submit, are far more important than absolute accuracy. The cost of electricity is not a particularly large item in the average householder's budget. Hence, is there any real or urgent necessity to aim at scrupulous accuracy? I think not. All that is required is a relatively simple and reliable system that, on balance, is reasonably equitable to the majority.

Insofar as domestic consumers are concerned, I feel this requirement can most readily and reasonably be met by the adoption of the straightforward two-part block rate. Under this rate the mean cost per unit approximates closely to the actual cost of supply curve. A further advantage is that this rate lends itself to ready biassing, either in favour of low usage, and generally poorer, consumers or against the large usage, and usually more affluent consumer, all by the simple expedient of adjusting the relative cost of the two blocks.

It is even possible, as I mentioned at last year's Convention in East London during the discussion on Mr McCullough's paper on Johannesburg's electricity tariff rates, to reverse-bias the blocks, that is to pitch the follow-on rate above the first block rate, and thereby discourage heavy consumption.

But no matter what one's views on tariffs may be there is no doubt, Mr President, that Richards Bay has achieved what it set out to achieve and that is a reduction in not only demand but also in consumption through inducing consumers to restrict the simultaneous use of appliances. It is a system that I feel warrants further consideration, particularly if the reliability of the meters can be assured.

Mr. W. Barnard : Johannesburg

1. Mr President, the author recognises that the reduction in the demand purchased from Escom is of prime importance. He has produced a tariff in which he has attempted to encourage domestic consumers to reduce their peak demand and secondly provide an equitable means of charging consumers for their share of the supply authority's demand costs.
2. In my opinion his tariff fails to meet the latter objective for the following reasons :
   (a) The 'high rate' does not relate to system demand and the charge is therefore in the form of an 'arbitrary penalty', set apparently at a level to frighten consumers into switching-off appliances.

   The consumers 'excess demand' could occur either at the time of system peak demand or during off-peak. In the former instance he will pay the high rate for units consumed during a period which could be only 1 hour, whilst the supply authority will pay for this demand for the whole month, i.e. the consumer is not making a fair contribution.

   In the second instance the consumer is penalised for excess demand during off-peak when there is spare capacity and he should be encouraged to use efficient and convenient electrical energy rather that be forced into using, for instance, oil for off-peak heating.

   In any event I consider a higher follow-on unit rate to be a breach

of good faith with consumers who have always been encouraged to use the lower follow-on rate for off-peak purposes – mainly space heating and water heating.

(b) The consumer receives no warning that he is operating at the high rate which could occur at any time by the automatic switching on of thermostatically controlled appliances, even a stove oven.

3. The author can quite rightly claim that he has achieved substantial results in reducing demand, but it is debateable as to whether this is due to the tariff or whether it results from the effective public relations exercise.
4. Theoretically, the ideal method of charging for demand is obviously by measurement of the consumer's share of the system peak demand. In practice this cannot be measured economically for a large number of small consumers.

   If, however, it is accepted that similar classes of consumer have similar load-factors, then a two-stepped block tariff can be designed to recover most of the demand-related costs in the first block and mainly energy-related costs in the follow-on block.

   In Johannesburg it has recently been decided to apply a different tariff to flats and houses in order to achieve greater accuracy in recovering demand related costs.

   In fact it was found that the average flat tenant consumes 500 units per month.
5. The disadvantages listed under 'Automatic Load Shedding, are not valid and a comparison cannot be drawn between an incentive to reduce individual demand at random and a planned program of specific load shedding over system peak. Johannesburg's experience in the Indian township of Lenasia indicates that tampering is minimal and, with water heating representing 20% of controllable domestic load, significant savings in demand charges are achieved. This is also borne out by some 30 other local authorities in South Africa.

   This concept which has been applied in many overseas countries is planned to be applied to **large** commercial and industrial consumers in Johannesburg. Such consumers will have 'interruptable load' metered separately and charged at a 50% discount.

   The consumer will at his discretion shed load on receiving a signal that the peak tariff is being applied.
6. The author is to be commended on the initiative and enterprise he has shown and particularly his outstanding public relations exercise, but I nevertheless consider that 'load demand metering' will have a limited application in South Africa other than in comparatively small towns. Thank you.

Mr. E. Trautmann : Ladysmith

Mr President, in paragraph 1.4, the author makes the statement that bith demand **and** energy should be reduced.

When we consider that, at a not too future date, electricity will be the only viable form of energy, replacing that from oil, coal and gas, it can be taken that all domestic power requirements will be met by electricity. I cannot see that the use of energy should be restricted – however, the use should be associated with a high load factor (hence the curbing of demand only) to obtain an economic tariff charge.

Referring to paragraph 2.1(d) – Load rate metering – this method may be suitable for Richards Bay. However, since the applied penalty increase of charges applies to the domestic peak only, it would not have any beneficial effects in Ladysmith, where a morning system peak is experienced. The domestic peak evening load is very much appreciated since it flattens the load curve and improves the load factor.

May I ask the following questions regarding the L V tariff in Richards Bay:-

1. The domestic peaks differ in low class, middle class and high class living areas. Has this been considered in the calculation?
2. If the domestic peak does **not** coincide with the system peak, why does the author want to reduce his load factor?
3. Scale 2 would be too costly for a larger undertaking, both in equipment and labour. How is the excess charge applied here and why discriminate between consumers with demands below and above 15 kVA?
4. Have consumers with a 3-phase supply and demands above 15 kVA also been included in the Meerensee test group?
5. Is the predicted minimum average consumption after 2 – 3 years not too scientific, remembering the human attitude? The price of eggs is doubled; no one wants to buy eggs anymore. In a few weeks, all opposition is forgotten and we all enjoy our eggs again.
6. How has the load factor changed since introduction of the new system?
7. Referring to Appendices A & B, has Richards Bay generally a winter evening and a summer morning peak? It appears from the graphs that the industries are the dominating factors producing the peaks. A demand biased H T bulk tariff will do wonders and industrialists surely will rectify the uneconomic usage of electric power. Then the author could go back to the good old domestic tariff. Thank you.

Mr D. H. Fraser : Durban: Mr. Hawkeswood has endeavoured to reduce the demand of his domestic consumers by charging at six times the basic energy rate for consumption in excess of a pre-determined demand, at present 4 kW, with the object of reducing Escom's demand charges and the capital cost of his transmission and distribution systems. It is not surprising that this has reduced the individual maximum demands of these consumers and improved the load factor of the domestic consumer group. Provided that the domestic group's highest demand previously coincided with the peak load on the system, this reduction will be of benefit in reducing Escom's demand charges. However, when the system maximum demand occurs in mid-morning or the afternoon as in Durban, due to the dominance of industrial and commercial load, it seems probable that the levelling of the residential consumer's demand will actually increase the total system demand. Perhaps Mr. Hawkeswood would comment on this, particularly in the light of his conclusion in section 6.3 of his paper that the "on peak" demand of domestic consumers in Richards Bay, which is highly industrialised, will drop by 33 percent. It is unlikely that the anticipated 33 percent reduction in domestic consumers' A.D.M.D. over 3 - 4 years from the date of introduction of load rate metering will offer any material savings in the main transmission costs, particularly on a system with large industrial loads. There will of course be some saving in the cost of the residential area reticulation and service connections, if it is assumed that the reduced demands will prevail in the long term. Knowing the tendency of humans to become immune to pressures, even those affecting their pockets, after the initial shock has worn off, there may be some risk in such an assumption. I would have more confidence in load limiting techniques of a more positive type, such as water heater control or limitation of circuit breaker rating, with this class of consumer.

Load-rate metering suffers from the disadvantage that the consumer whose highest demand occurs in a system off-peak period is penalised at the same rate as another consumer with a similar demand occurring at the time of system peak. While the former will not affect costs, the latter with today's high demand charges will be responsible for substantial cost increases. In fact I would say that the tariff deviates from the spirit of the Electricity Act in not reflecting fairly the costs of providing the service.

Mr. Hawkeswood's comments about domestic tariffs with some artificial methods of recovering demand costs, such as a room charge, are fully supported. This method served reasonably well in the past, but with the advent of the all electric house, the number of rooms can no longer be accepted as a measure of demand and administration of such a tariff is difficult.

With reference to the load curves shown in appendices A & B, there appears to be a very marked change in the pattern and magnitude of the load in the 3rd curve i.e. for mixed Industrial, Commercial and Residential consumers, between June and September, 1977. Could Mr. Hawkeswood explain this, as the same sort of change is not reflected in the curves for the Large Industries or the Meerensee test group. It would also be interesting to compare the load curves for the domestic test group in the same months before and after the new tariff was introduced, to eliminate the seasonal effect. Were such preliminary tests done?

In Durban we have adopted a three block tariff in an endeavour to pass on to the consumer the savings of higher load factors and increased consumption. The first block which is also the minimum charge is intended to recover consumer related costs, system capital costs, energy costs and the portion of Escom's demand charges appropriate to the smaller consumption. The second and third blocks are intended to recover energy costs and the degree of increased demand charge which go with additional consumption. It is assumed that load factor improves with additional consumption, so that the demand component in the third block is less than that of the second block.

There can be no doubt about the importance of Mr. Hawkeswood's objectives in introducing load-rate metering, viz., to conserve capital and energy resources, However, we must bear in mind the importance of ensuring that our tariffs are as far as reasonably possible a true reflection of the cost of supply. It may be considered that Escom's tariffs available to large Local Authorities are not sufficiently sophisticated to encourage distributing authorities to apportion true costs of supply through their own tariffs.

If tariffs generally were designed to reflect the time of day variation (not forgetting weekly and annual cycles) in both demand and energy costs, distributing authorities and users of electricity alike would be encouraged to operate to the benefit of all concerned. Thank you.

Mnr J. A. Loubser : Benoni: Mnr die President, mag ek begin deur mnr Hawkeswood geluk te wens met sy baie interessante referaat. Ek het egter slegs enkele vrae om aan mnr Hawkeswood te stel en dit gaan slegs oor sy tariewe soos weergegee op bladsy 13 van sy geskrewe referaat.

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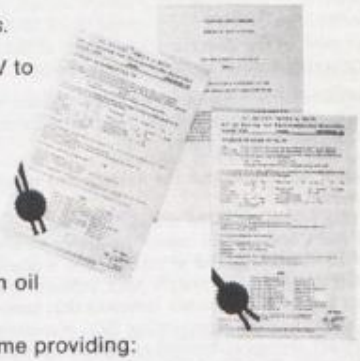

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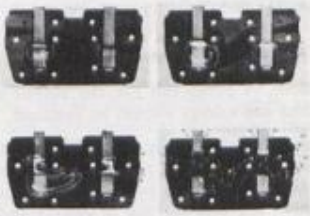

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1. Ek merk dat daar geen voorsiening gemaak is vir die kapitaalkoste om die verbruiker van krag te voorsien nie. Dink hy nie dit is nodig dat dit ook deel van sy tariewe moet uitmaak, sê, as 'n gedeelte van sy basiese tarief nie?

2. Daar word gemerk dat sy tariewe geheel en al afhanklik is van die Evkomtariewe. Beteken dit dat enige Evkomverhogings outomaties oorgedra word aan die verbruikers? En verder, is hierdie outomatiese formule reeds deur die Administrateur goedgekeur?

Dankie.

Mr K. A. Shepstone : Durban: I should like to associate myself with the other contributors in complimenting Mr Hawkeswood on a very interesting paper.

With regard to the "house-keeping" aspect of the "consumer's education", would an indicator light and soft audible alarm not be preferable to sequential usage of stove plates and oven? This would enable the housewife to decide what to switch off when the load reaches 4 kW.

Is it not preferable to have one geyser situated immediately above the bath and another small one above the sink? This would reduce "plumbing losses" and, if the thermostat of the geyser above the sink is set up high, the servants cannot wash dishes under a running tap.

$$\text{The overall Cost per Unit} = \frac{(\text{kVA} + \text{Energy})\ \text{Cost}}{\text{No of units used}}$$

At Richards Bay, the overall A D M D and Domestic A D M D do not appear to coincide. Reduction in the Domestic A D M D does not affect the overall A D M D appreciably. Also the administration and other costs making up the 19% of the overall electricity costs are virtually constant. In view of the above, does the progressive reduction in consumption by the domestic consumers necessitate regular increases in the Industrial and Commercial charges, in order to balance the electricity account budget?

In conclusion I would like to ask what the introduction of this tariff has meant to the Council in Rands and Cents.

Thank you, Mr President.

Mnr P. J. Botes : Roodepoort: My dank aan mnr Hawkeswood vir 'n hoogs interessante en prikkelende referaat. Hierdie soort van selfondersoek en self-oplossing van probleme lewer altyd interessante besprekingspunte asook sekere statistiek, en ook aannames. Dit is net jammer dat hierdie statistiek nie verteenwoordigend is van alle verbruikers in die Republiek nie.

Die metode deur mnr Hawkeswood ingestel behels noukeurige aandag aan elke verbruiker se lesings. Met 'n baie groot aantal verbruikers en met die gebruik van 'n rekenaar mag daar heelwat meterlesing en dataverwerkingskoste aan verbonde wees.

In Roodepoort word gebruik gemaak van 'n eenheidsprys alleen en die waterverwarmers word beheer deur middel van hoogfrekwensie-injeksietoerusting (Ripple relays). Aangesien Roodepoort by uitstek 'n lasverhouding van 60-65% huishoudelike verbruikers, 20% industriële verbruikers en die balans aan kommersiële verbruikers het, is die gemiddelde maandelikse lasfaktor 53% sonder die gebruik van die beheerstelsel. Die gebruik van die beheerstelsel met behulp van sy eie outomatiese beheertoerusting verhoog hierdie gemiddelde maandelikse lasfaktor na tussen 60 - 65%. As beheer uitgeoefen word met behulp van beheerbeamptes in plaas van die outomatiese beheerstelsel word sedert die instelling van laasgenoemde beheer dus sedert 1 Januarie 1978 'n maandelikse lasfaktor van tussen 69 - 72% verkry. Daar is ongeveer 20 000 relês geïnstalleer teen 'n aankoopkoste van toerusting alleen van R500 000. Teen vandag se pryse egter R1 700 000. Die besparing aan elektrisiteitaankoopkoste vir 1978 sal meer as R500 000 wees.

In Roodepoort sien ek nie kans om die tariefstelsel soos deur mnr Hawkeswood voorgestel, te gebruik nie, maar dit sal interessant wees om te sien of hierdie tipe die aanslag van die tyd in Richardsbaai sal weerstaan.

My bydrae, Mnr Die President, is net on aan te toon dat hierdie soort beheer meer aanvaarbaar gaan wees vir die verbruiker en hy sal definitief meer gemoedsrus hê.

Mr D. Haig-Smith : Queenstown: Mr President, allow me please to associate myself with the previous speakers in congratulating Mr Hawkeswood on an excellent paper.

In Queenstown our domestic consumers are very conscious of maximum demand due to the fact that a maximum demand tariff was introduced in 1960/1961. Various methods of registering or controlling the maximum demand of consumers were considered and the indicating maximum demand ammeter was decided upon and has been in use since that date. Whereas with a load limiting circuit breaker the consumer cannot effect voluntary savings, with the demand meter such savings can be effected.

Where a consumer elects to have say a 40 amps circuit breaker installed – and usually he cannot change this rating for 12 months - he says:

"I have to pay for 40 amps so I shall use 40 amps". There is no incentive for him to save.

The housewives in Queenstown, instead of starting their cooking of lunch at, say 11.45 or 12.00 p.m. now start their lunch cooking at 10.30 a.m.

As Mr Hawkeswood pointed out in his paper, there are various ways or means of recovering the demand related costs and depending upon the nature or make-up of a system's loading, one or other of these various methods may be the best in the circumstances. I have no question for Mr Hawkeswood but offer these few comments.

Thank you Mr President.

Mr K. J. Murphy : Somerset West: Mr President, I have no doubt that Mr Haig-Smith's domestic consumers understand how to regulate their loads and avoid imposing high demands. My experience is, however, that consumers resent the accidental maximum demands recorded over one unfortunate half hour period and thus connect MCB's in series with the recording meter. The use of this type of metering in a certain town with which I was associated, resulted in negative load growth at a time when a new power station had just been built. A simple circuit breaker controlling a consumer's M.D. results in no surprises when the electricity account is received.
Thank you.

Rld. P. de Waal : Richardsbaai: Mnr. Die President, aangesien die RBDB-tarief direk gekoppel is aan die Evkom-tarief, is 'n vermindering in verbruik van elektrisiteit of maksimum aanvraag nie 'n gevaar in die sin dat 'n verlies aan inkomste ondervind sal word nie.

Tariefstruktuur: Volgens die doelstelling van die RBDB moes die gewysigde tariefstruktuur: die lasfaktor verbeter;

besparing in die gebruik van elektrisiteit aanmoedig; (die aanmoediging om nie meer elektrisiteit te gebruik in nie-kruintye word as kontraproduktief en kort-termyn ekonomie beskou).

deur die verbruiker gedurig beïnvloed wees.

Die tariefstruktuur soos deur mnr Hawkeswood beskryf voldoen aan al hierdie vereistes.

Met die aksentverskuiwing in die Evkom-struktuur waardeur ± 60% van die koste verwant is aan maksimum-aanvraag, lyk dit bietjie sinneloos dat hierdie koste, wat direk deur die verbruiker beïnvloedbaar is, in 'n vastebedragtarief vervat word of geensins in aanmerking geneem word nie terwyl die energie-gedeelte (40%) tot op enkele persent-vlakke akkuraat gemeet word.

Die RBDB is baie beïndruk met die praktiese resultate wat met die instelling van die nuwe tariewe bereik is.

Die meeste huishoudelike verbruikers was in staat om hulle maandelikse rekening aansienlik te verminder (sonder verlies aan inkomste aan die RBDB) deur die installering van las-beperkingrelês en die kontinueerlike bewussyn dat skedulering van elektrisiteitsverbruik wat so 'n groot invloed op koste het as die aantal eenhede verbruik.

Verbruikersoptrede: Die meeste verbruikers het onmiddellik 'n 3 kW-lasbeperkingrelê geïnstalleer wat die warmwaterstelsel outomaties uitskakel. (Koste ± R15,00 geïnstalleer.)

Die voorsiening van 'n indikasielampie, parallel met die waterverwarmer gee aan die huisvrou duidelik indikasie dat die totale las te hoog is en dat sy die gebruik van die implemente moet heroorweeg – heroorweeg is die woord, die verbruiker behou die diskresie.

In 'n paar gevalle was dit vir verbruikers nodig om 4 kW verhitte-elemente te vervang met 2 kW-eenhede met geen praktiese nadelige gevolge nie.

In die geheel gesien word die tariefstruktuur as baie geslaagd beskou.

Verwysende na die syfers in die Tabel, par. 6.3 vir die Meerensee-toetsgroep kan dit maklik bereken word dat die verbruikspatroon verbeter het vanaf 320 tot 413 kWL per kVA maksimum aanvraag per maand.

Verbruikers is sekerlik meer sensitief maar in 'n positiewe sin omdat sy rekening, op maandelikse basis direk deur hom beïnvloedbaar is.
Dankie.

Mnr. A.J. van den Berg : Krugersdorp: Ek sluit my aan by vorige sprekers om mnr Hawkeswood te komplimenteer.

Ons is ingestel om in opdrag van ons Rade as 'n Handelsdepartement te fungeer en belastings te help subsidieer. Indien ons nou die verbruikers aanmoedig om hulle verbruik te beperk, wat word van die belastingheffings – ek verneem nou ook dat hierdie bron van inkomste deur Provinsie beperk gaan word. Is dit die beleid in Richardsbaai om nie profyt te maak op kragverkope nie? As ons almal hierdie metode sou toepas wat van Evkom se geïnstalleerde kapasiteit? Sal dit in landsbelang wees op die lang termyn?

Mnr. H. Barnard : Geaffilieerde: Mnr die President, die referaat hier gelewer was baie goed. Daar is een probleem wat egter hier opduik waarvoor ek nie 'n oplossing het nie en sal graag wil weet wat die VMEO se houding daarteenoor is. Met al die navorsing wat daar gedoen word deur die verskillende munisipaliteite is daar die feit van nie-standaardisasie, en wat doen die VMEO en sy lede om 'n standaardtarief op te stel? Elke dorp het nou sy eie tarief en elke dorp het sy eie metode van meting ens. en ek voel dat as hulle moontlik 'n standaardtarief kan vasstel, hul êrens baie gaan bespaar; nie net deur die verbruik te verhinder nie, maar ook op installasiekoste en die klas van ding.

Mr. G. Gerber : Farad (Pty) Ltd: Mr President, Gentlemen, I cannot agree with most points mentioned by Mr Hawkeswood, because of the negative approach to the problem. The positive approach is to try to improve the load factor in the Municipal network. This can often be achieved with the aid of Ripple Control Equipment, controlling hotwater geysers, underfloor heating, space heating, pumps, etc.

In South Africa there are about **140 000 hot water geysers controlled** with the aid of such Ripple Control Equipment (also called load shedding equipment). On an average 2,5 kW geyser only about **0,5 kW can be switched off** at any time (summer and winter) taking the diversity factor into account. This figure can be considered conservative, based on existing figures under South African conditions.

The saving is calculated as follows:

140 000 x 0,5 kW = **70 000 kW** as peak reduction

The approximate generating costs are	R350 per kW
The approximate (bulk supply) distribution costs are	R150 per kW
Total cost per kW	R500

The costs in the case of nuclear power stations are considerably higher. The savings on generation and distribution costs are 70 000 x R500 = **R35 000 000.**

This means making better use of existing power stations and saving foreign exchange on extensions.

The Municipalities with ripple control equipment in South Africa save on the total installed 140 000 ripple control receiving relays controlling hot water geysers as follows:

700 000 x R5 (average MD charge) = R350 000 per month.

R350 000 x 12 = **R4 200 000** saving per annum.

Cllr C. M. Lemmer : Benoni: I agree with the author of this excellent paper that, in principle, the peak demand for electricity must be levelled out for the benefit of both Escom and consumer.

I say both because Escom will need to spend less on generating plant to do the same job and still sell more electricity. At present Escom is buying its own money. Millions of Rands' worth of power stations are being built just to serve a few hours peak per day.

The consumer who is not only a ratepayer but also a taxpayer will get the same value for less money.

Can't a simple switching device be installed in the kitchen where the housewife can control the amount of electricity she uses without much technical complication. This switch should enable her to select a minimum amount of electricity at normal times on a low rate of say 1c per 1 unit, without depriving her of using more if she should need it but of course at a higher rate of say 3c per 2 units or 6c per 3 units. This switch must also be able to cut out non-essential items at peak. Thank you.

Mr S. N. Hammerschlag : Bedfordview: Mr President, I wish to add that, based on the rational argument put forward by Mr Hawkeswood, the idea of a load limiting tariff is essential in these days of limited energy. Also it is almost essential to have a self-correcting tariff. In particular in a small town like Bedfordview.

I wish to ask how this tariff could be applied for the resale of electricity to flats and in commercial centres for instance in an equitable manner.

Mr. S.W. Clives : Affiliate: I was interested in Mr Hawkeswood's paper and would endorse many of his points and remarks.

Mr Gerber mentioned a saving of some R11 000 00 as a result of possible use of ripple control. However, I wonder who funds the capital investment which at Kempton Park is for example, I believe, 6 000 dwellings at a cost of R800 000. Someone will have to pay this amount, presumably the consumer.

On a point made by a previous speaker, there are available on the market simple devices which assist the housewife or consumer silently and efficiently. These are available across a wide range as Load Control Relays or Load Limiters for placing in panelboards either old or new.

My last point is possibly one of humour which is really a question. With the application of ripple control to the Kempton Park areas and with the recent commissioning, it is noticeable when ripple control is switching heaters out. It is also very noticeable when ripple control switches back in and a complete blackout results. Can someone tell me more about this effect of blackout and if it is a common thing. What also is the effect on revenue loss when an area loses supply for a prolonged period.

Thank you.

Mr. J. L. McNeil : Kokstad: Mr President, I'm all for economy in every field, and in fact can say that my home is run on a 20 amp mcb with all the usual appliances, such as stove, geyser with load limiting relay, deep freezer, refrigerator and so on, and admittedly there have been many complaints from the housewife – one gets used to these after a few years.

However, regarding the objective of reducing the maximum demand, because of prevailing capital costs I have a sneaking suspicion that the end result would be an increase in the tariff of charges per kVA.

I also echo the comments of a previous speaker in referring to the remark that installing ripple control systems would result in a saving of R11 000 000/annum to the local authority.

I would like to know whether account has been taken of the cost involved in installing this expensive equipment.

Thank you.

Mr. S. H. Hawkeswood : Richards Bay: In reply to the comments on the paper:

Mr Bamber
Thank you for your comments. Concerning your remarks about the annual maximum demand charge levied in Rhodesia – all I can say is that I hope that it will never be levied here.

Only time will tell whether a great deal of maintenance will be required with the load-rate meters.

Mr Brummer
Having now obtained experience with single phase load-rate meters, I will be recommending to my Board shortly that three-phase load-rate meters and a corresponding tariff be brought into operation in Richards Bay.

In this paper, I have set out the results obtained which prove that the load-rate tariff is effective, but I do not claim that it is the best. I would suggest that a similar investigation be carried out with a Block Interval Tariff to prove how effective it is.

Mr Andrews
In reply to your question, all domestic installations are protected by 60 amp circuit breakers which prevent overloading.

Mr Palser
Thank you for your remarks and interest shown.

In reply to your question, two manufacturers are at present actively carrying out research into modified load-rate meters, but from the latest information, have not yet completed their work.

The same reply applies to Block Interval Tariffs as that given to Mr Brummer.

Mr Barnard
I refer to paragraph 6,2 and the graph 'ADMD at its time of the system maximum demand' which shows that the loadrate tariff has resulted in a reduction of the ADMD per consumer at system peak hours, irrespective of whether it occurs in the morning or evening.

I differ with Mr Barnard's interpretation that the success of the load-rate tariff is attributable to the public relations programme carried out – there is adequate evidence which shows that the public only reacted when the tariff affected their pockets.

As stated in my paper, there are considered to be valid grounds for comparing load control systems (ripple relay) with load-rate metering systems, especially in terms of initial cost.

Mr Trautmann
No differentiation is made between low, middle and upper income groups.

The loads of the three-phase consumers who live in Meerensee are excluded from the Meerensee test group results.

The laws of statistics have been used to predict the various consumption patterns given in the paper, and the credibility given to these results will depend upon how much faith one has in statistics. Further, I have no comment.

Mr Fraser
I can give no explanation for the change in the pattern of mixed industrial, commercial and residential consumers shown on the daily load graphs – appendices A and B in the paper. This change was probably the result of loss of load by one of the medium industrial consumers.

Recordings of the different parameters given in the paper were obtained prior to the introduction of the tariff. It should be noted that the load-rate tariff has only been in operation for 10 months. At least, in my opinion, another two or three years' results are necessary before absolute statements about its operation can be made, but certainly all indications are at this stage very positive.

Mr Loubser
In calculating the demand related costs and the contribution of domestic consumers, I used the following formula:
Demand related costs = Escom MD charge + cost items such as interest and redemption of loans, capital development fund, etc.
= Basic monthly charge + excess kWh charge.

In reply to the second question, the Administrator's (Natal) approval was obtained for the linked tariff and, in Richards Bay, consumers are advised by circular of any changes in Escom's tariffs.

Cllr Shepstone
I consider that the provision of a warning light is the responsibility of the consumer.

One geyser, which is well insulated and which has all its piping well insulated, uses less energy and has half the maximum demand of two geysers.

The savings obtained in reducing the maximum demand charges payable to Escom are passed on to the consumers. Having obtained results over a period of one year now, I will be recommending to my Board shortly that the Domestic Tariff – Basic Monthly Charge of 2 x m be reduced to 1,5 x m.

Mr A. van den Berg
As can be seen from my paper, Richards Bay budgets for a 3% contribution to its Capital Development Fund and a 3% surplus which is contributed to General Rate Fund.

Mr Gerber
I can also quote some impressive figures. Assuming that there are 1 000 000 domestic consumers in South Africa and assuming that as a result of installing load-rate meters, the ADMD per consumer is reduced by ½ kVA per consumer, the total saving in demand will be about 500 megawatts or the equivalent of a power station. The cost of a power station is about R400 to R500 million – hence the load-rate meters could result in a considerable saving to our country.

Mr Lemmer
Over the past few years, we have seen the price of electronic calculators reduce from a few hundred rands each to R20 to R30 each. Trade journals are already predicting that integrated circuits, the heart of the electronic calculator, will be used in the future in mini-processors to control loads in the home at a reasonable cost.

Mr Hammerschlag
The question relates to tariffs other than domestic tariffs and is considered to be beyond the scope of the paper. Finally I wish to thank the following for their comments and remarks on my paper –

Mr P. de Waal — Mr Barnard
Mr T. Botes — Mr Clives
Mr D. Haig-Smith — Mr McNeill
Thank you Mr President.

Mr K. G. Robson : President: Mr Hawkeswood, Gentlemen, there has recently been what I believe to be, ill-informed criticism in official municipal circles and at UME levels about conferences and I regret that the senior officials of the UME could not have sat in on this session this morning, which indicated I think in very emphatic terms how essential it is that we as Municipal Electrical Engineers and members of national organisations should come together regularly and discuss developments like this. I think the emphatic answer to that kind of criticism is listening to Mr Hawkeswood's paper this morning and the many valuable contributions that have been made confirm my conviction that we missed a tremendous opportunity in the fifties by not adopting a national demand tariff for domestic consumers. Events and time have confirmed this conviction. I think for that reason we need to congratulate Mr Hawkeswood on the evidence of impressive research work in the preparation of this paper regardless of the possible criticism. I think he knew he was inviting criticism in presenting this paper.

Mr Hawkeswood, I would like to extend to you my congratulations in having the courage to give us this paper at such an early stage. I am certain that Mr Hawkeswood would have liked another two years to more accurately evaluate his findings. We need time for this kind of development, but I am sure that if he continues you will perhaps be able to see some further interesting developments in a few years time. I was able to recall many interesting discussions about the vicissitudes and the techniques of tariffs with Mr Hawkeswood and it has given me a personal sense of satisfaction to see the development in his new thinking on this whole complex and fascinating subject of the method of charging for the electricity supply in a very, very complex and difficult situation. The co-operation which is evidenced between the user, the Town Electrical Engineer and a number of manufacturers of metering equipment is of significance and there is no doubt that it is this kind of development that stimulates important research and we congratulate Mr Hawkeswood on this development. This has been a valuable paper, and an extremely valuable record of AMEU proceedings. I have no doubt that we will all have been stimulated mentally and professionally by some of the thoughts and ideas that Mr Hawkeswood has had the courage to present to us this morning. It has been a really very good paper indeed.

Afgevaardigdes geniet die Burgemeester, Rld. West, se onthaal.

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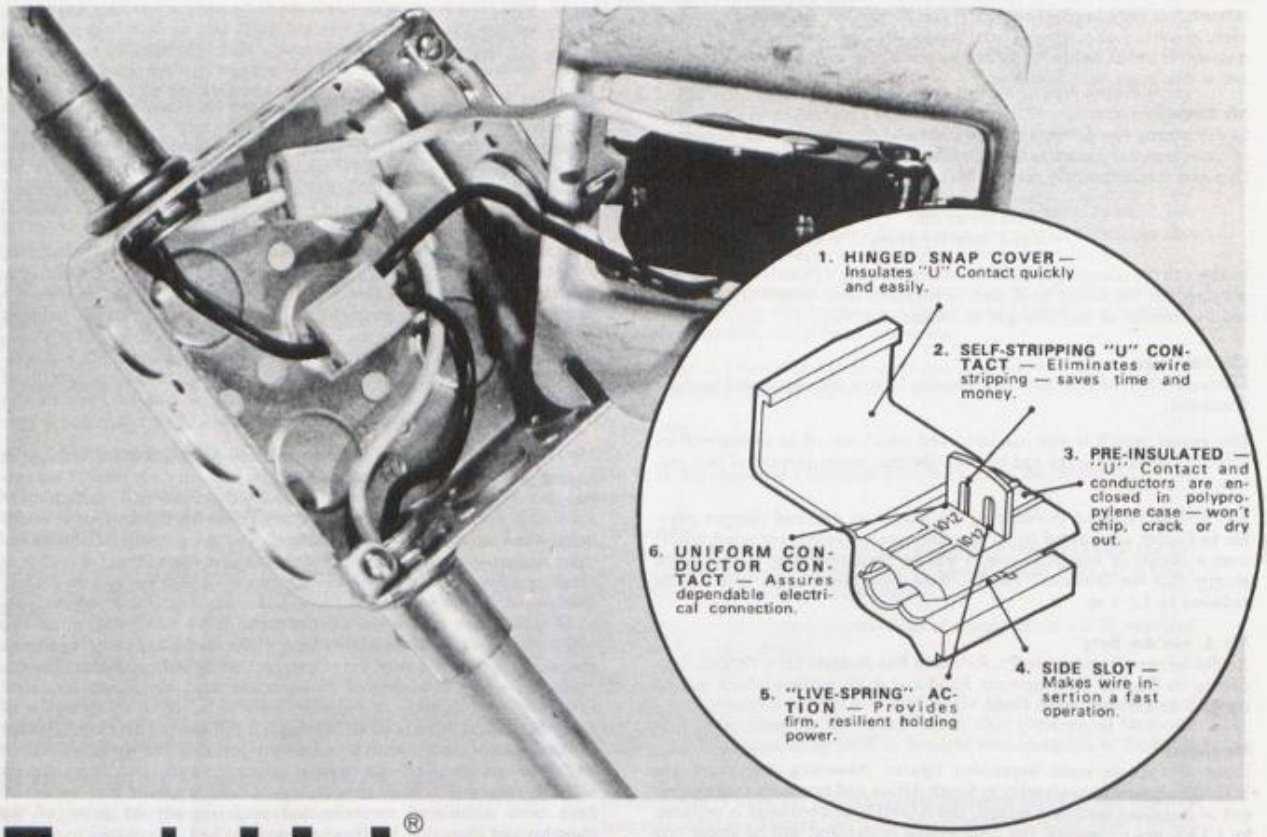

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F J PRINS

Elektriese Kabelafdeling, SABS
Electric Cable Division, SABS

Mr. Prins served his apprenticeship as fitter and turner after matriculating in 1935. He then obtained a B.Sc. degree in Heavy Current Electrical Engineering at the University of the Witwatersrand, followed by two years with the S A R on electrification construction.

He joined the SABS in 1949 and established the Electric Cable Division in the early fifties, and still heads the Cable Division.

He obtained a M.Com (Business Administration) degree extramurally from Pretoria University.

Mr. F.J. Prins.

DIE SPESIFISEER EN GEBRUIK VAN ELEKTRIESE KABELS

Gehalteversekeringsmense vertel ons dat jy nie gehalte in 'n produk kan inspekteer nie – dit het sy ontstaan met die ontwerp op die tekenbord en moet stap vir stap in die produk ingebou word. Daarby word natuurlik aanvaar dat die spesifikasie vir die produk volledig en voldoende is. As verkeerde afmetings of ongeskikte materiale gespesifiseer word, of daar nie behoorlik toegelaat word vir werks- en omgewingstoestande nie, dan kan die beste vervaardigings- en produksiekontrole nie 'n bevredigende produk verseker nie. Daarby gesê – die produk moet so ontwerp wees dat die vervaardiging daarvan binne die bevoegdhede van die betrokke mense en masjiene val.

In die geval van 'n elektriese kabel begin gehalte met die spesifikasie vir die betrokke tipe kabel. Heelwat ontwerpaspekte word in so 'n spesifikasie ingesluit. Die finale suksesvolle werking van die kabel of die vermoë om te doen wat daarvan verwag word, hang grootliks daarvan af hoe goed hierdie aanvoorwerk gedoen is. Soos u weet, is daar 'n groot verskeidenheid kabels in gebruik. Dit verteenwoordig op sy beurt 'n groot verskeidenheid van komponente, materiale en vervaardigingsprosesse. 'n Mens kan sê dat die opstel van 'n spesifikasie vir 'n kabel die gesamentlike kennis vereis van 'n metallurg, 'n werktuigkundige ingenieur, 'n elektrotegniese ingenieur en iemand wat 'n grondige kennis het van vervaardigingsprosesse en -toerusting. Dit is waarom die taak om 'n spesifikasie op te stel, gewoonlik toevertrou word aan 'n komitee van "deskundiges" en waarom kennis geneem word van soortgelyke werk deur ander groepe.

Die belangrikste aspekte wat in 'n spesifikasie gedek moet word, is die materiale wat gebruik moet word, die konstruksie (insluitende afmetings) en toetse om te verseker dat die kabel geskik is vir die voorgenome diens. Al hierdie aspekte is onderhewig aan slaggate en invloede van buite, waarvan die belangrikste seker dié van ekonomiese aard is. Die tegniese direkteur van 'n groot Europese kabelvervaardiger het eenmaal aan my gesê: "Ek word deur die ekonomie verplig om dinge te doen wat ek nie tegnies kan verantwoord nie". Wat in die ou dae aanvaar is as goeie kabelvervaardigingspraktyk, moet vandag versigtig in die spesifikasie ingeskryf word. Sulke dinge soos gedraaide are in 'n kabel met profielgeleiers en die rondheid van 'n kabel moet vandag noukeurig omskryf word. 'n Gedraaide aar was in die ou dae as 'n doodsonde beskou. Die profielgeleiers met 'n voorafgevormde spiraal vir 'n betrokke kabel is in een lengte op een masjien gemaak om te verseker dat hulle korrek saamval wanneer die are saamgeslaan word in die voltooide kabel. Netso is die papierisolering identies op die verskillende are aangebring. Hierdie benaderings is net so sonder enige argumente aanvaar.

SPECIFYING AND USING ELECTRIC CABLES

Quality assurance men will tell you that you cannot inspect quality into a product – it must start with the design on the drawing board and be manufactured into the product step by step until it is completed. This presupposes that the specification for the product is adequate. If incorrect dimensions or unsuitable materials are specified, or insufficient allowance is made for operational or environmental conditions, then the best manufacturing and production control methods will not lead to a satisfactory product. In addition, the design of the product must be such that it is within the manufacturing capability of the men and machines involved.

In the case of an electric cable quality starts with the specification for a particular type of cable, which incorporates many design features, and the final success or ability of that cable to do what is expected of it, will depend very largely on how well this foundation is laid. As you know there is a large variety of cables, involving many different components, materials, and manufacturing processes. To prepare a cable specification requires the combined knowledge of a metallurgist, a chemist, a mechanical engineer, an electrical engineer, and someone with a sound knowledge of manufacturing processes and the capabilities of machines and equipment. This is why the job of drawing-up a specification is entrusted to a committee of "experts" and close attention is paid to similar work done by other groups.

Probably the most important aspects to be covered in a specification are the materials to be used, the construction (including dimensions) and the tests to verify the adequacy of the cable for its intended use. All these aspects are subject to serious pitfalls and influences of which the most important is probably economics. The technical director of a large European cable manufacturer once said to me: "I am forced commercially to do things that I cannot justify technically." What used to be accepted in days gone by as good cable-making practice must today be carefully detailed in the specification. Matters such as turned cores in a shaped conductor cable and the circularity of a cable now require particular attention. A turned core used to be one of the biggest sins a manufacturer could be guilty of. The shaped, pre-spiralled conductors for a cable were made in one length on one machine to ensure that they would be laid-up correctly in the final cable. Similarly the paper-lapping of the cores of a paper-insulated cable was done in an identical manner. These points were not argued about, but accepted without question.

Om eenvoudige, selfs ooglopende, vereistes te spesifiseer is nie altyd so maklik nie. Neem bv. die rondheid van 'n kabel. Enigeen kan na 'n kabel kyk en sê: "Dit is rond, of vierkantig, of driehoekig, en dit kan gebruik word of nie." Maar lê nou daardie vereistes kwantitatief neer. Nadat baie moontlikhede ondersoek is en heelwat kabels bestudeer is, het ons vasgestel dat as die gemiddelde deursnee van die kabel oor die onderlaag of oor die buitemantel, met 'n deursneemaatband gemeet, die minimum deursnee, by dieselfde posisie met 'n noniuspasser gemeet, met nie meer as 1% oorskry nie, behoort geen probleme met die afeindiging van die kabel met behulp van meganiese drukstukke ondervind te word nie. In die praktyk sal 'n kabel wat redelik rond lyk, 'n waarde van ongeveer 0,6% en minder hê wanneer hierdie metode gebruik word. Dit het betrekking op rubber en PVC-geïsoleerde kabels.

'n Spesifikasieskrywer kan natuurlik ook weggevoer word deur sy entoesiasme en onpraktiese vereistes voorskryf – vereistes wat slegs teen groot koste en met baie ongerief gekontroleer kan word. Twee ander probleme waarmee hy te kampe het, is die korrelasie van toetse met werklike lewensduur en die noodsaaklikheid in baie gevalle om 'n kabel te vernietig tydens toetse om die gehalte te bepaal, of om tydens sulke toetse die kabel tot so 'n mate te beskadig dat dit met verloop van tyd in diens sal faal. Laat ons dit met 'n paar voorbeelde toelig – 'n sekere organisasie in Engeland het ge-eksperimenteer met die las van aluminiumgeleiers. Die lasse is onderwerp aan lassiklusse onder oorspanning- en oortemperatuurtoestande. 'n Besondere las het 2 500 sulke siklusse sonder enige nadelige gevolge deurstaan. Toe dit egter in 'n werklike installasie gebruik is, het dit na ongeveer 400 siklusse gefaal. Die 11-kV-papiergeïsoleerde generatorkabel in 'n Suid-Afrikaanse kragstasie is aan 'n driefasige foutstroom onderwerp as gevolg van 'n fout in die generatortransformator. Die kabelleiding het bestaan uit drie enkelaarkabels wat in driehoekformasie geïnstalleer was. Hulle was elke 30 duim in houtblokke vasgeklamp. As gevolg van die fout is hulle aan 'n geweldige plofkrag onderwerp. Na die gebeurtenis is hulle aan al die bekende elektriese toetse onderwerp. Daar kon geen aanduiding verkry word dat enige van die kabels defek was nie. Nogtans is daar getwyfel of die kabels nog bruikbaar is. Gevolglik is daar besluit om 'n stuk van een kabel uit te sny en te ondersoek. Daar is gevind dat elke isoleerband by elke klempunt gebars het. Indiens die kabels weer in gebruik gestel is, sou dit binne drie weke gefaal het.

Verbruikers skep ook probleme. Dit is bv. welbekend dat die suksesvolle werking van 'n kruis-gekoppelde poliëtileenkabel o.a. afhang van die verband tussen die geleier- en aarskerms en die diëlektrikum. Maar indien die korrekte verband tussen die aarskerm en die diëlektrikum voorsien word, kla die verbruiker dat dit moeilik is om die kabel te las of af te eindig. Hy verkies 'n lospassende skerm wat maklik verwyder kan word, alhoewel so 'n kabel 'n verkorte lewe sal hê.

Dit is belangrik dat verbruikers besluit wat se lewensduur hulle van 'n kabel verwag. Dit is bekend dat sekere kabels wat aan die begin van hierdie eeu in die Verenigde Koninkryk geïnstalleer is met die verwagting dat dit 'n lewensduur van 50 jaar sal hê, nog steeds goed funksioneer na 60 jaar en dat, tensy dit moedswillig beskadig word, die kabels waarskynlik vir nog 60 jaar lank bruikbaar sal wees. Maar nou word vir ons gesê dat die vervaardiging van sulke kabels onekonomies is – daar sou dan 'n te groot veiligheidsfaktor in hulle ingebou wees. Op sy beste moet 'n papier-geïsoleerde kabel net 50 jaar lank hou. En ek verstaan dat in Amerika 'n lewensduur van slegs 15 jaar van 'n PVC-geïsoleerde kabel verlang word, terwyl dit in sommige Europese lande 20 jaar is. Sou u belastingbetalers tevrede wees as hulle vir 'n nuwe kabel moet betaal terwyl hulle nog die oue afbetaal? En wat van die installeringskoste? Tien jaar gelede is daar beraam dat die gemiddelde koste om 'n kabel in die Verenigde Koninkryk te begrawe die gemiddelde koste van die kabel wat begrawe word, met 12,5% oorskry. Wat is hierdie syfer vandag? Sou u gelukkig voel as u die koord van 'n stofsuier na slegs 6 maande moet vervang? Sou u dit geniet om 'n eersteklas strykyster na drie maande weg te gooi omdat die koord ontydig die gees gegee het en daar dit permanent in die handvatsel bevestig is, kan u dit nie self vervang nie en kos dit meer om dit te laat vervang as om 'n nuwe yster te koop?

U het almal praktiese ondervinding gehad in die gebruik van kabels en party van u het in alle waarskynlikheid geëksperimenteer met verskillende tipes kabel en met verskillende tegnieke van installering. Dus is u in 'n posisie om 'n nuttige bydrae met die opstel van 'n spesifikasie te maak, en behoort u u stem te laat hoor. Per slot van sake is dit u wat die kabel moet bestel, daarvoor moet betaal en gerus moet slaap wanneer dit geïnstalleer is.

Wanneer dit die kies en installering van 'n kabel vir 'n besondere taak geld, is daar so baie aspekte wat aandag vereis, dat hulle nie in 'n praatjie

To specify the circularity of a cable has proved to be no easy task. Anyone can look at a cable and say: "It is circular, or square, or triangular, and it will do the job or it won't". But it is very difficult to state the criteria quantitatively. After a study of numerous cables, we established at the Bureau that if the mean diameter over the bedding or sheath, measured with a diameter tape, exceeds the minimum diameter, measured at the same axial position using a vernier caliper, by no more than 1%, no problem should be encountered in terminating such a cable by means of a mechanical gland. In practice a cable that looks reasonably circular will give a result of the order of 0,6% and less by this method. This applies to PVC and to rubber insulated cables.

A specification writer can also get carried away by his enthusiasm and write impossible requirements into a specification – requirements that can only be provided and verified at great inconvenience and expense. Two further problems that face him are the difficulty of correlating tests with actual service life and the need to test to destruction to prove a cable in many instances or risk incipient damage to the cable which will lead to eventual failure in service. To illustrate – a certain organization in England was experimenting with jointing techniques for aluminium conductors. They subjected the joints to load cycles under over-voltage and over-temperature conditions. A particular joint withstood 2 500 such cycles with no ill-effects. When the joint was used in an actual installation it failed after approximately 400 cycles. The 11 kV paperinsulated generator cable in a South African power station was subjected to a three-phase short circuit as a result of a fault in the generator transformer. The cable run consisted of three single-core cables in trefoil clamped at 30 inch intervals. As a result of the fault the cables were subjected to a tremendous bursting force. After the event they were subjected to all the known electrical tests without a single failure or suspect cable being indicated. But there was doubt whether the cables were unaffected. Accordingly a section of one cable was cut out and stripped. At every point of restraint every paper was burst. If the cables had been put back into service, they would have failed within weeks.

Customers and users also pose problems. For instance, it is well-known that a cross-linked polyethylene cable stands or falls by the interface bonding of the semi-conducting conductor and core screens and the dielectric. But if a proper bond between the core screen and the dielectric is provided, the customer complains that it is difficult to prepare the cable for a joint or termination. He prefers a loose-fitting screen which is easy to remove, although such a cable would fail prematurely.

It is essential that users decide how long they expect a cable to last. It is well-known that certain cables installed in the U.K. at the beginning of this century, and hopefully expected to last fifty years, are still going strong after 60 years and, unless intentionally abused, will probably last another sixty years. But now one is told that the manufacture of such cables was uneconomic – the built-in factor of safety was too large. At best a paper-insulated cable should only last 50 years. I believe in America a life of only 15 years is expected from a PVC-insulated cable and in some European countries 20 years. Would your ratepayers be happy to pay for a new cable while still paying off the old one? And what about the cost of installation? A decade ago it was estimated that the average cost of burying a cable in the U.K. was 12,5% greater than the average cost of the cable itself. What is this figure today? Would you feel happy about having to replace a flexible cord on a vacuum cleaner after six months? Would you revel in scrapping a perfectly good smoothing iron after three months because the flexible cord has failed prematurely and is permanently fixed through a popriveted backing plate to the iron so that you cannot replace it yourself and it costs more to have a new cord fitted than to buy a new iron?

You have all had practical experience in the use of cables and some of you have in all probability experimented with different types of cable and different techniques of installation. So you are in a position to make a useful contribution to the preparation of a specification and should let your voices be heard. After all, you have to order the cable, pay for it, and sleep soundly once it is installed.

When it comes to the selection and installation of a cable for a particular job, there are so many aspects requiring attention that they cannot be

soos hierdie gedek kan word nie. Die Buro is tans besig met die opstel van 'n Gebruikskode om die verbruiker te help en om u 'n idee te gee van die veld wat gedek word, sal ek u die hoofde van die verskillende hoofstukke gee:

Deel 1. Ontwerp van Stelsel en Kies van Kabels
Afdeling 1. Wetsvereistes
Afdeling 2. Kies van Kabeltipe en Metode van Installering
Afdeling 3. Aarding – Algemene Vereistes
Afdeling 4. Kenstrome vir PVC-Geïsoleerde Kabels volgens SABS 150
Afdeling 5. Kenstrome vir Papier-geïsoleerde Kabels volgens SABS 97
Afdeling 6. Kenstrome vir XLPE- en Elastomeries-geïsoleerde Kabels
Afdeling 7. Bepaling van Soortlike Termiese en Elektriese Weerstand van Grond

Deel 2. Installering en Werking van Kabels
Afdeling 1. Vervoer en Opberging
Afdeling 2. Voorsorgmaatreëls vir Veiligheid
Afdeling 3. Lê en Installering van Kabels
Afdeling 4. Las en Afeindiging van PVC-Geïsoleerde Kabels
Afdeling 5. Las en Afeindiging van Papier-geïsoleerde Kabels
Afdeling 6. Las en Afeindiging van XLPE en Elastomeries-geïsoleerde Kabels
Afdeling 7. Installering van Aardingstelsel
Afdeling 8. Toets, in Bedryfstelling en Foutopsporing
Afdeling 9. Voorbereiding van Roetekaarte

Vir hierdie bespreking gaan ek 'n paar belangrike punte uit die voorgaande neem. Laat ons begin deur na geleiers te kyk.

Die twee materiale wat feitlik universeel vandag vir geleiers gebruik word, is koper en aluminium. Die gebruik van koper dateer terug na die vroeë dae van elektrisiteit en die eienskappe van die metaal en hoe om dit te gebruik is algemeen welbekend. Dit sal swak hantering en 'n redelike mate van wangebruik verdra. Maar nie aluminium nie. Hierdie metaal het sekere inherente eienskappe wat dit noodsaaklik maak dat dit behoorlik en korrek gebruik word. Die belangrikste hiervan is:

1) Sy aantrekkingskrag vir suurstof met die gevolglike altyd-teenwoordige laag oksied wat 'n baie hoë smeltpunt het en 'n goeie isolator is;
2) sy negatiewe posisie op die elektro-chemiese skaal wat daartoe lei dat 'n galvaniese reaksie plaasvind wanneer dit met positiewe metale soos koper geassosieer word in die teenwoordigheid van vog;
3) sy neiging om te vloei onder druk;
4) sy neiging om te korrodeer as die toestande gunstig is, bv. wanneer dit in aanraking met grondwater kom; en
5) sy koëffisiënt van uitsetting met temperatuur, wat ongeveer een derde meer is as dié van koper.

'n Paar jaar gelede het mnr C T Carter van die Kaapstadse Munisipaliteit 'n uitstekende referaat oor die gebruik van kabels met aluminiumgeleiers by een van die jaarlikse byeenkomste van hierdie Vereniging gelewer (1971). Ek sou almal wat aluminiumgeleiers gebruik, aanraai om hierdie referaat te bestudeer.

Laat ek 'n paar aspekte van die las en afeindiging van aluminiumgeleiers toelig.

Wanneer 'n aluminiumgeleier gelas of afgeëindig word, is dit absoluut noodsaaklik dat

a) 'n behoorlik ontwerpte mof of skoen van die regte afmetings gebruik word;
b) die metaal waarvan die mof of skoen gemaak is dieselfde metallurgiese eienskappe as dié van die geleier wat gelas of afgeëindig moet word, sal hê om te verseker dat gelyke uitsetting en inkrimping plaasvind;
c) die korrekte gereedskap, ontwerp vir die besondere maak van mof of skoen, gebruik word vir die vashegproses;
d) die betrokke vervaardiger se aanwysings aangaande die vashegproses streng nagevolg word.

Ongelukkig is dit nie moontlik om net afmetings en toetse vir lasmowwe en kabelskoene voor te skryf soos vir ander produkte nie, omdat die menslike element so 'n groot rol speel in die suksesvolle las en afeindiging van 'n kabel. Die enigste manier om so 'n produk te beoordeel, is om dit aan 'n werkverrigtingstoets te onderwerp. Basies bestaan die toets daaruit dat die produk aan 'n lassiklus onderwerp word terwyl die temperatuurstyging van die mof of kabelskoen met betrekking tot dié van 'n verwysingsgeleier oor 'n sekere aantal siklusse gemeet word. Die Buro is tans besig om 'n spesifikasie vir so 'n toets en 'n metode om die

covered in an address like this. The Bureau is at present preparing a Code of Practice to guide the user and to give you some idea of the scope, I shall give you the headings of the different chapters:

Part 1 System Design and Cable Selection
Section 1. Statutory Requirements
Section 2. Choice of Cable Type and Method of Installation
Section 3. Earthing – General Requirements
Section 4. Current Ratings of PVC-Insulated Cables to SABS 150
Section 5. Current Ratings of Paper-Insulated Cables to SABS 97
Section 6. Current Ratings of XLPE and Elastomeric Insulated Cables
Section 7. Determination of Thermal and Electrical Resistivity of Soil

Part 2. Cable Installation and Operation
Section 1. Transport and Storage
Section 2. Safety Precautions
Section 3. Cable Laying and Installation
Section 4. Jointing and Termination of PVC-insulated Cables
Section 5. Jointing and Termination of Paper-Insulated Cables
Section 6. Jointing and Termination of XLPE and Elastomeric-Insulated Cables
Section 7. Installation of Earthing System
Section 8. Testing, Commissioning and Fault Location
Section 9. Preparation of Route Records

I am going to lift out a few of the cardinal points for this discussion. To start with let us have a look at conductors.

The two materials used almost universally today for conductors are copper and aluminium. The use of copper goes right back to the early days of electricity and the properties of the metal and how to use it are well understood. It will stand up to bad handling and a fair amount of abuse. Not so with aluminium. This metal has certain inherent characteristics which necessitate careful handling. The most important of these are:

1) Its affinity for oxygen resulting in an ever present layer of oxide which has a very high melting point and is a good insulator;
2) its negative position on the electro-chemical scale resulting in galvanic action when associated with positive metals such as copper plus moisture;
3) its tendency to flow under pressure;
4) its proneness to corrosion when the conditions are favourable, e.g. when in contact with ground water; and
5) its coefficient of expansion with temperature, which is approximately one third more than that of copper.

Some years ago Mr C T Carter of the City of Cape Town gave an excellent paper on the use of cables with aluminium conductors at one of the annual gatherings of this Association (1971). I would advise anybody using aluminium conductors to study this paper.

Let me highlight some aspects of the joining and termination of aluminium conductors.

When an aluminium conductor is joined or terminated it is imperative that

a) a properly designed ferrule or lug of the correct proportions be used;
b) the metal from which the ferrule or lug is made, should have a temper compatible with that of the conductor to be joined or terminated, to ensure equal expansion and contraction;
c) the correct tool, designed for the particular make of ferrule or lug, be used for the compression or crimping process; and that
d) the relevant manufacturer's instructions regarding the compression or crimping process be strictly adhered to.

Unfortunately it is not possible to prescribe dimensions and tests for ferrules and lugs as is done for other products, because the human element plays such a decisive role in the success or failure of a joint or termination. The only way to evaluate such a product is to run a performance test which basically consists of a load cycling test with the temperature rise of the lug or ferrule relative to a reference conductor being monitored over a certain number of cycles. The Bureau is at present preparing a specification for such a test and a method for evaluating the test results. The document will be based on the British practice as

resultate te beoordeel, op te stel. Die dokument is gebaseer op die huidige Britse praktyk soos uiteengesit in BS 4579.

Daar dien op gelet te word dat sommige oorsese vervaardigers van elektriese kabels nie die gebruik van druktipe bybehore saam met aluminiumstringgeleiers aanbeveel nie en andere distansieër hulself heeltemal van hierdie gebruik omdat dit so moeilik in so 'n geval is om 'n behoorlike metaal-tot-metaal kontak te verkry.

Die aandag moet ook daarop gevestig word dat waar 'n oorgang na koper plaasvind, 'n bi-metaalskoen of -mof, wat bestaan uit 'n koperdeel wat met behulp van 'n wrywingsweistegniek aan 'n aluminiumdeel gesweis is, gebruik moet word. 'n Aluminiumafeindiging moet bv. nie direk aan 'n kopergeleistam vasgeklem word nie weens die verskillende uitsettingskoëffisiënte van die metale.

Insgelyks, wanneer aluminium aan aluminium geklem of vasgebout word, moet sorg gedra word dat slegs aanbevole materiale gebruik word, dat die las oor die grootste moontlike oppervlakte versprei word, en dat een of ander vorm van veerwaster saam met 'n dik, plat waster voorsien word om sodoende die kontakdruk te handhaaf. Daar word natuurlik aanvaar dat behoorlik voorsorg getref is om metaal-tot-metaal kontak te verseker.

Laat ons nou na isoleringsmateriale kyk. Oorspronklik was die mees algemeen gebruikte materiale natuurlike rubber en olie-geïmpregneerde papier. Oor die jare is hulle aangevul deur 'n bestendige stroom van nuwelinge, 'n groot deel waarvan neweprodukte van die petro-chemiese nywerheid is. Hierdie nuwelinge kan rofweg in kunsrubbers en plastiek verdeel word. Aan die rubberkant is butielrubber, stireenbutadieenrubber, etileenpropileenrubber, nitrielrubber en silikoonrubber goed bekend. Aan die plastiekkant het polivinielchloried, poliëtileen en kruisgekoppelde poliëtileen geen bekendstelling nodig nie.

Die gebruik van olie-geïmpregneerde papiergeïsoleerde kabels is so diep gevestig en die ondervinding daarmee so volledig dat baie min daaraan toegevoeg kan word. In 'n sekere munisipale gebied in SA is 'n 11 kV-kabel wat al meer as 60 jaar lank goeie diens lewer en nog uitstekend funksioneer. Die enigste probleme skyn mense met pikke en meganiese grawe en die SAS met verdwaalde gelykstroom te wees. Dit is geen wonder dat 'n aantal erkende kabeldeskundiges van verskillende lande gesê het dat as hulle rustig wil slaap, hulle eerste keuse 'n papier-geïsoleerde kabel met 'n loodlegeringmantel en anti-elektrolise beskerming sal wees. Nogtans moet ons onthou dat hedendaagse kabels onderwerp word aan oorgangspieke en vinnigstygende pulse van tiristortoerusting, hoogoonde, ens. wat nie gegeld het vir die kabels wat in die vroeë jare van hierdie eeu vervaardig is nie.

So ook is die voor- en nadele van natuurlike rubber welbekend. Maar hierdie materiaal is tot 'n groot mate verdring deur PVC. PVC, wat tydens die dertigerjare in Duitsland ontwikkel is, is 'n betroubare pakperd en kan in 'n reeks toepassings gebruik word. Dit het feitlik oorgeneem van rubber vir die bedrading van persele en het insgelyks laagspanningspapiergeïsoleerde kabel vervang.

Wanneer PVC as 'n isoleringsmateriaal of as 'n buitemantel vir 'n kabel gebruik word, moet die volgende deeglik in ag geneem word:

1) PVC word verswak deur twee agente, nl. hitte en sonlig. Stabiliseerders en anti-oksideermiddels word gewoonlik by die verbinding gevoeg om hierdie verswakking teen te werk maar is in die geval van sonlig slegs effektief as die verbinding òf swart gekleur word deur die byvoeging van ± 1½% tot 2% koolswart om die ultra-violet lig af te skerm, òf deur die byvoeging van 8 tot 10% titaandioksied (rutiele vorm). Laasgenoemde is 'n wit pigment en is duur, gevolglik word dit net gebruik vir spesiale gevalle. Ons beveel dus aan dat waar PVC aan die son blootgestel word, dit swart gekleur word. Waar dit nie moontlik is nie, bv. die blootgestelde are van 'n meerarige kabel, moet die PVC beskerm word deur dit toe te wikkel met 'n swart isoleerband of dit te bedek met 'n swart isoleerhuls, bv. 'n hittekrimphuls.
2) PVC word aangeval deur 'n hele aantal stowwe, bv. onversadigde vetsure met lang kettings (soos die wat gevorm word wanneer vleis ontbind), sommige bitumineuse en asfaltmateriale, aseton, benseen, koolstoftetrachloried, chloor, chloroform, formaldehied, waterstofperoksied, petrol, gekonsentreerde swawelsuur, ens. Alhoewel daar normaalweg gereken word dat PVC bestand is teen olie, is dit nie eintlik korrek nie. Dit word geaffekteer deur minerale olies by temperature bo die normale. Daar dien ook op gelet te word dat die ligter aromatiese olies soos petrol en nafta, deur PVC dring, langs die binnespasies van 'n kabel kan beweeg en in skakeltuig, klemkaste, ens. kan vergader, waar dit dan 'n ontploffingsgevaar kan skep.

detailed in BS 4579.

It should be noted that some overseas manufacturers of electric cables do not recommend the use of compression or indentation accessories with stranded aluminium conductors and others completely disassociate themselves from such practice due to the difficulty of attaining a proper, durable metal-to-metal contact.

It should also be noted that where a transition to copper is required, a bimetallic lug or ferrule made from a copper part friction-welded to an aluminium part, should be used. An aluminium termination should not be directly clamped to a copper busbar for example, because of the different coefficients of expansion of the two metals.

Similarly, when aluminium is clamped or bolted to aluminium, care should be taken to use only recommended materials, to spread the load over an area as large as possible, and to provide some form of cup or spring washer in association with a thick, flat washer to maintain the contact pressure. It is, of course, assumed that proper care will be taken to ensure metal-to-metal contact.

Let us now look at dielectrics. Initially the most universally used dielectrics were natural rubber and oil-impregnated paper. Over the years these were augmented by a steady stream of newcomers, a large portion of which were products of the petro-chemical industry. The newcomers can be broadly classified into synthetic rubbers and plastics. On the rubber side the best known are butyl rubber, styrene butadiene rubber, ethylene propylene rubber, nitrile rubber, and silicone rubber. On the plastic side polyvinyl chloride, polyethylene, and crosslinked polyethylene need no introduction.

The use of oil-impregnated paper-insulated cable is so well established and the field experience gained so comprehensive that very little need be added. In a certain municipality in South Africa an 11 kV cable has been operating successfully for more than 60 years and is still going strong. The only problems would appear to be people with picks or mechanical shovels and the SAR with D.C. traction currents. It is no wonder that a number of top cable experts from different parts of the world have said that if they want to sleep peacefully their first choice is a paper-insulated cable with a leadalloy sheath and anti-electrolysis outer protection. However, one should, point out that present-day cables are subject to transient spikes and fast rising pulses from thyristor equipment, arc furnaces, etc. which did not apply to the cables made in the early years of our century.

Similarly the pros and cons of natural rubber are well known. But this material has been largely superseded today by PVC. PVC, developed during the thirties in Germany, is a solid work-horse and can be utilized in a number of applications. It has practically taken over from rubber for the wiring of premises and has similarly ousted low voltage paper-insulated cable.

When using PVC as a dielectric or outer-sheath, however, the following points must be given due consideration:

1) PVC is degraded by two agents, namely heat and sunlight. Stabilizers and anti-oxidants are normally added to the compounds to counteract this degradation but in the case of sunlight are only effective if the compound is either coloured black by means of the addition of ± 1½ to 2% of carbon black to screen out the ultra-violet light or by the addition of 8 to 10% of the rutile grade of titanium dioxide. The latter is a white pigment and it is expensive, so that it is only used for very special applications. We, therefore, recommend that where PVC is to be exposed to the sun, it should be coloured black. Where this is not possible, e.g. the tails of a multi-core cable, the PVC should be protected by wrapping it with a black insulating tape or by covering it with a black insulating sleeve, e.g. a heat-shrink sleeve.
2) PVC is subject to attack by a number of substances, e.g. by unsaturated long-chain fatty acids (such as those generated by decomposing meat), some bituminous and asphalt materials, acetone, benzene, carbon tetrachloride, chlorine, chloroform, formaldehyde, hydrogen peroxide, petrol, concentrated sulphuric acid, etc. Although PVC is normally classed as oil resistant, this is not strictly correct. It is affected by mineral oils at elevated temperature. It should also be noted that the lighter aromatics like petrol and naphta will permeate through PVC, move along the interstices of a cable and collect in switches, terminal boxes, etc., creating an explosion hazard. Cables to be used in areas where they may be exposed to such

Kabels vir gebruik in gebiede waar hulle aan sulke petroleumprodukte of die stort van sulke produkte blootgestel sal wees, moet van 'n loodmantel voorsien word.

3) PVC vloei wanneer dit onder druk geplaas word, en sal aanhou vloei totdat 'n ewewigspunt bereik word. Die belangrikste aspek van hierdie eienskap is, dat wanneer 'n kabel met 'n buitemantel van PVC begrawe word en sorg nie gedra word dat klippe en harde voorwerpe uit die grond verwyder word nie, hierdie voorwerpe, waar hulle direk in aanraking met die mantel is, uiteindelik daardeur sal dring en sodoende toelaat dat water inkom.
4) PVC werkverhard. Gevolglik sal die PVC in 'n bogrondse geleier wat onderworpe is aan hitte en koue en beweging in die wind, uiteindelik hard en bros word en bars.
5) PVC is inherent tot 'n mate brandvas. Deur spesiale tegnieke in die vermenging van die verbinding toe te pas, kan hierdie brandvastheid baie verbeter word sodat die PVC nie 'n brand sal versprei nie. Maar 'n mens behou ongelukkig die probleem van die digte, swart, giftige rook wat deur brandende PVC afgeskei word.

Poliëtileen is 'n wasagtige materiaal wat 'n betreklike lae smeltpunt, ± 108°C, het en maklik brand. Dit is gevolglik nie populêr as 'n materiaal vir gebruik in kragkabels in Suid-Afrika nie en sy grootste veld van toepassing in die kabelnywerheid is as 'n isolerings- en mantelmateriaal in telekommunikasiekabels, waar sy uitstekende elektriese eienskappe ten volle benut kan word. Maar, as die molekules kruis-gekoppel word (gewoonlik deur 'n vulkaniseerproses), word die karakter van die materiaal heeltemal verander en word dit 'n stabiele isoleringsmateriaal wat geskik is vir gebruik by redelike hoë temperature (90°C in bedryf, 250°C onder fouttoestande) en daarom baie geskik vir hoogspanningskabels. Hier moet ek waarsku. 'n Mens kan nie semi- of ongeskoolde arbeid gebruik om so 'n kabel te las of af te eindig nie. Inteendeel, soos 'n Europese kabeldeskundige dit gestel het: "Ek sou die beste vakman wat ek in die hande kan kry, gebruik en ek sou dit meer noukeurige aandag verleen as wat ek aan 'n las of afeindiging in 'n papier-geïsoleerde kabel sou gee." Die rede hiervoor is dat poliëtileen en kruisgekoppelde poliëtileen (XLPE) baie maklik beskadig word deur gedeeltelike ontladings of "corona" soos dit algemeen by die Amerikaners bekend staan.

Gedeeltelike ontlading vind plaas wanneer klein ruimtetjies of vuiligheid ingesluit word in die kabelisolering of wanneer 'n klein gaping tussen die isolering en aarskerm voorkom. Dit is daarom gebiedend noodsaaklik dat hierdie skerm en die isolering òf fisies solied aanmekaar verbind is òf dat 'n kontinue elektriese verband tussen hulle voorsien word, bv. deur middel van grafiet. Hoe meer 'n mens sukkel om die aarskerm te verwyder wanneer 'n kabelent voorberei word vir 'n las of afeindiging, hoe beter is die kans op 'n sorgvrye kabel. Daar moet vermeld word dat daar tans 'n nuwe semi-geleidende aarskerm ontwikkel is wat maklik verwyderbaar is en met behulp van 'n drieledige persproses aangebring kan word.

Die kabel moet met dieselfde sorg waarmee dit vervaardig is, gelas en afgeëindig word. Gelukkig is daar vandag spesiale toerustingstelle en tegnieke beskikbaar om hierdie taak te vergemaklik. Maar, wat 'n mens ook al doen, moet daar nie afgewyk word van die vervaardiger se prosedure-instruksies nie. Hulle moet letterlik nagevolg word.

'n Sintetiese rubber wat groot inbreuk op die diëlektriese veld gemaak het, is etileenpropileenrubber. In Suid-Afrika is dit hoofsaaklik die terpolimeer wat gebruik word. Dié materiaal het in die algemeen goeie eienskappe en kan by geleiertemperature van 85°C gebruik word, maar is brandbaar. Daarby – en dit is baie belangrik – dit kan nie skerp of gekapte golwe, soos dié wat deur 'n hoogoond veroorsaak word, verdra nie.

'n Ander sintetiese rubber wat baie gebruik word in kabels vir bedrading waar hittebestandheid vereis word, is silikoonrubber. Dit kan geformuleer word om 'n lang lewensduur by 150°C te hê, 'n verkorte lewensduur by 180°C en 'n baie verkorte een by 250°C. Sy voordeel is dat, alhoewel dit brand, die as 'n isoleermiddel is en as dit nie meganies versteur word nie, sal die kabel aanhou werk. Dit is nie meganies baie sterk nie en word daarom gewoonlik versterk deur middel van 'n glasomvlegting. Dit word ook geredelik aangeval deur ghries, olies en vette.

Ek het vroeër genoem dat een van die probleme wat met kabels met loodmantels geassosieer word, elektrolise is. Dit laat 'n mens onmiddellik aan swerfgelykstrome dink. Maar ek is bewus van twee gevalle van elektrolitiese korrosie waar daar geen moontlikheid van sulke strome was nie. In beide gevalle was die geaardheid van die betrokke grond en die grondwater teenwoordig die oorsaak van die probleem. Hierdie gronde het in die teenwoordigheid van water, galvaniese selle met die

petroleum products or spillage of such products should be lead sheathed.

3) PVC is subject to plastic flow, i.e. if subjected to pressure it will flow until an equalization point is reached. The most important result of this characteristic is that if a cable with an outer sheath of PVC is buried and care is not taken to remove stones or hard objects from the bedding soil, these objects, if bearing directly against the sheath, will eventually pierce it, allowing water to enter.

4) PVC work-hardens. Hence, in the case of an overhead conductor subject to heat and cold, and swaying in the wind, the PVC will eventually become brittle and crack.
5) PVC is inherently flame-retardant to a limited extent. By special compounding techniques this flame-retardance can be greatly enhanced so that in a fire the PVC will not propagate the fire. But one is unfortunately still faced with the problem of the dense, black, noxious smoke generated by the burning PVC.

Polyethylene is a wax-like material that has a relatively low melting point, ± 108°C, and burns easily. It is therefore not favoured as a power cable material in South Africa and its main use in the cable field is as a dielectric and sheath in telecommunication cables, where its excellent electrical properties can be fully exploited. However, if the molecules are crosslinked (usually by a vulcanizing process), its character is changed completely and it becomes a stable dielectric suitable for use at fairly high temperatures (90°C operating, 250°C under fault conditions) and therefore very suitable for high voltage cables. Here I want to sound a warning. One cannot use semi-skilled or unskilled labour to join or terminate such a cable. On the contrary, as a European cable expert put it: "I would require the services of the most skilled artisan I can lay my hands on and I would give it more meticulous attention than I would a joint or termination in a paperinsulated cable". The reason for this is that polyethylene and crosslinked polyethylene (XLPE) are very easily damaged by partial discharges or, as the Americans call it, "corona".

Partial discharges occur when small voids or contaminants are included in the cable insulation or when a gap appears between the insulation and core or conductor screens. It is therefore imperative that these screens and the dielectric be either physically solidly bonded together, i.e. properly married or that a continuous electrical bond be provided between the two components e.g. by the use of graphite. The more one battles to remove the core screen when preparing a cable-end for jointing, the better one's chances of a troublefree cable. It should be noted though that a new easily strippable semiconducting core screen, that can be applied by a triple extrusion process, has been developed.

The same care that is exercised in the manufacture of the cable must be employed in the jointing and terminating of the cable. Fortunately there are special kits and techniques available today that ease this task. However, whatever one does, one must not depart from the manufacturer's procedural instructions. They must be followed to the letter.

A synthetic rubber that has made great inroads in the dielectric field, is ethylene propylene rubber. In South Africa it is mainly the terpolymer (EPDM) that is used. The material generally has good properties, and can be used at conductor tempertures of 85°C, but it is flammable. Furthermore – and this is very important – it cannot take spikes or chopped waves, such as those generated by arc furnaces.

Another synthetic rubber that is widely used in heat-resisting wiring cable applications is silicone rubber. It can be formulated to give long service at 150°C, reduced service at 180°C, and very much abbreviated service at 250°C. Its advantage is that, although it burns, the ash is an insulant and, if not disturbed mechanically, the cable will continue to function. It is not mechanically strong and is therefore usually reinforced by means of a glass braid. It is also readily attacked by grease, oils, and fats.

I mentioned earlier that one of the problems associated with lead-sheathed cables is electrolysis. This immediately brings to mind stray d.c. currents. But I know of two instances of electrolytic corrosion where there was no possibility of such stray currents. In both instances the nature of the soils involved and the soil water present caused the trouble. These soils, in the presence of water, formed galvanic cells with the lead sheath. It is possible that stray-alternating currents also played a role. In

loodmantels gevorm. Dit is selfs moontlik dat swerfwisselstrome ook 'n rol gespeel het. In die een geval moes die kabel na ongeveer 'n jaar vervang word. In die algemeen is die veiligste benadering dus om te verseker dat alle kabels wat begrawe word, voorsien is van 'n anti-elektrolitiese buitemantel. Gewoonlik is dit 'n PVC-mantel. 'n Mantel van afwisselende lae rubber en ander materiaal is ook doeltreffend. Daar moet natuurlik sorg gedra word dat die kabel behoorlik in die grond gelê word.

In die gebruikskode word een afdeling gewy aan die vervoer en opberging van kabels. Dit dek 'n wye veld wat ek nie nou hier wil bespreek nie, maar 'n onlangse voorval noop my om te vra: Hoeveel van u is bewus van die voorsorgmaatreëls wat getref moet word wanneer oliegeïmpregneerde, papiergeïsoleerde kabels vir enige tydperk opgeberg moet word? As gevolg van die feit dat die kabel so staangemaak moet word dat die windinge in 'n vertikale vlak is, neig die olie om weg te dreineer van die hoogste na die laagste punt, d.w.s. om in die onderste helftes van die windinge te versamel. En hoe hoër die lugtemperatuur, hoe makliker geskied dit. Wanneer die kabel uiteindelik afgerol en gelê word, het dit 'n reeks droë en versadigde dele wat ooreenstem met die boonste en onderste helftes van die windinge. Ionisering sal plaasvind in die droë dele en die kabel sal uiteindelik faal. Indien 'n kabel in die ope buitelug geberg word, sal die hout, wat gewoonlik nie behandel is of teen die weer beskerm is nie, begin verrot en uiteindelik sal die haspel nie beweeg kan word sonder dat dit ineenstort nie. Die korrekte manier om so 'n kabel op te berg, is weg van die son en reën en om die haspel gereeld deur 180° te draai – sê eenmaal per maand, of as dit baie warm is, eenmaal elke veertien dae. Die haspel moet nie net in een rigting gedraai word nie, maar moet afwissel na beide kante. Dit is waarskynlik raadsaam dat dieselfde prosedure toegepas word op kabels wat met 'n nie-dreinerende tipe olie geïmpregneer is, alhoewel die gereeldheid waarmee dit gedoen word, verslap kan word.

Wanneer 'n kabel gekies word vir 'n besondere werkverrigting, word die keuse van geleiergrootte beïnvloed deur drie hoofvereistes, nl. die stroomdravermoë, die spanningsval en die ontwerpkortsluitstroom. Vir 'n normale 600/1 000-V-installasie, waar die kabel beskerm word deur sekeringe of stroombrekers met gevormde hulse, sal die kabel na alle waarskynlikheid nooit aan 'n kortsluitstroom onderwerp word nie en sal stroomdravermoë en spanningsval die grootte van die kabel bepaal. Soos uit die meegaande grafieke blyk, is stroom die bepalende faktor vir kort lengtes, terwyl die spanningsval 'n al hoe belangriker rol speel namate die afstand groter word. Byvoorbeeld – 'n algemene geleiergrootte wat in bedrading gebruik word soos 2,5 mm² sal sê 25 A dra. Maar as die lengte 27 m oorskry, sal die spanningsval meer as 2½% wees, wat miskien nie aanvaarbaar is nie, en 'n groter geleier sal dan gebruik moet word. In die geval van die groter geleiers, word spanningsval eers 'n ernstige beperking wanneer 'n lengte van 100 m oorskry word (fig. 1).

In die geval van hoogspanningstelsels waar die kabel gewoonlik deur 'n stroombreker beskerm word, sal baie groter geleiers as wat deur die normale stroomtoelating vereis word, gebruik moet word om die stelselfoutstroom te dra vir die duur van die tydperk wat dit die stroombreker neem om uit te skakel. Laat ons na fig. 2 kyk en as 'n tipiese voorbeeld die geval van 'n 1 500-kVA-transformator neem. Die transformator sal 'n normale vollasstroom van minder as 80 A by 11 kV hê en dit wil voorkom dat 'n papiergeïsoleerde kabel met staaldraadpantsering en kopergeleiers van 16 mm² geskik sou wees vir 'n installasie waar die kabel direk begrawe word. Maar die kabel moet ook in staat wees om die stelselfoutstroom (250 MVA is gelykstaande aan 13,1 kA) vir 'n tydperk van 0,5 s te dra. In terme van fig. 3 is die kleinste kabel wat hierdie stroom kan dra, een met 95 mm² kopergeleiers. Dit is gebaseer op die veronderstelling dat die geleier 'n temperatuur van 160°C sal bereik onder kortsluittoestande. Indien die aardfoutstroom van die stelsel ook 13,1 kA sal beloop, kan 'n 95 mm² kopergeleier hierdie stroom vir 'n tydperk van 0,5 s dra, mits die kabel met staaldraad bewapen is. Maar, indien dubbele staalbandpantsering gebruik is, moet die loodmantel alleen die foutstroom dra en dan moet 'n kabel met 'n geleiergrootte van minstens 185 mm² gebruik word, soos in fig. 4 aangetoon word.

Al hierdie aspekte word ten volle in die gebruikskode gedek. Tabelle met stroomtoelatings, kenfaktore, grafieke vir beperkings as gevolg van spanningsval en riglyne om toe te laat vir verskillende foutvlakke, word aangegee. Daar dien op gelet te word dat die stroomtoelatings wat aangegee word, van toepassing is op kabels wat enkel geïnstalleer is. Waar kabels gegroepeer of saamgebondel word, moet die toelatings verminder word om toe te laat vir die effek van wedersydse verhitting. Waar kabels net eenvoudig in 'n trog of kanaal saamgegooi word, word die posisie vanuit die stroomtoelatingsoogpunt gesien, net eenvoudig onhoudbaar. Uit die ondersoek van sekere kabelfoute, het ons tot die

the one case the cable had to be replaced after about a year. In general the safest approach is to ensure that all buried cables are provided with anti-electrolysis outer sheaths. This usually takes the form of a PVC sheath. A rubber-sandwich sheath is equally effective. Care must of course be taken to ensure that the cable is properly bedded in the soil.

In the Code of Practice one section is devoted to the transport and storage of cables. It covers a wide field and I do not want to discuss this aspect, but a recent incident prompts me to ask: How many of you are aware of the precautions that have to be taken when oil-impregnated paper-insulated cables are stored for any length of time? Due to the fact that the cable has to be stored with the convolutions in a vertical plane the oil tends to drain from the highest to the lowest point, i.e. to gather in the bottom halves of the turns. And the higher the ambient temperature, the more easily this occurs. When the cable is then laid it has a series of dry and fully saturated half loops. In the drained areas ionization will take place, and the cable will eventually fail. If a drum is stored in the open, the timber, which will not normally be treated or protected from the elements in any way, will start to deteriorate and eventually the drum cannot be removed without collapsing. The correct way to store such cable is away from the sun and rain and to rotate the drums through 180° say once a month, or if the weather is very hot, once a fortnight. The rotation should not be in one direction only, but should alternate. It is suggested that the same procedure be applied to cables impregnated with non-draining type compounds, although the frequency can be reduced.

When a cable is selected for a particular application, the choice of conductor size is influenced by three main considerations, the current-carrying capacity, the volt drop and the short-circuit rating. For normal 600/1 000 V installations where the cable is protected by fuses or moulded case circuitbreakers, the cable is unlikely to see a short circuit and current carrying capacity and volt drop will decide the size of the cable. As shown by the accompanying figures, current is the determining factor for short runs with volt drop increasing in importance as the runs become longer. For example, a common conductor size used in wiring, such as 2,5 mm², will carry say 25 A. But when the length of the run exceeds 27 m the volt drop will exceed 2½%, which may be unacceptable, and a larger conductor will have to be used. On the larger conductor sizes it is not until a length of 100 m is exceeded that volt drop is a serious limitation (Figure 1).

For higher voltage systems where the cable is normally protected by a circuit-breaker much larger conductor sizes than those required by normal current rating may have to be employed to carry the system fault current for the fault clearance time of the circuit-breaker. As a typical example let us refer to Figure 2 and consider a 1 500 kVA transformer. The transformer would have a normal full load current of less than 80 A at 11 kV and a 16 mm² copper conductor PILCSWA cable would appear to be suitable for a laid direct installation. The cable, however, would have to be able to carry the system fault current (250 MVA equals 13,1 kA) for say 0,5 s. The smallest cable that can carry this current in terms of Fig. 3 has a 95 mm² copper conductor. The foregoing is based on a conductor short circuit temperature of 160°C. If the earth fault current of the system is also 13,1 kA, a 95 mm² copper conductor cable can carry this current for 0,5 s provided it is steel wire armoured. But if double steel tape armour is used, the lead sheath alone cannot carry the fault current. In this case a minimum conductor size of 185 mm² would be required as shown in Fig. 4.

All these aspects are fully covered in the code of practice. Current rating tables, rating factors, graphs for limitations due to volt drop, and guides to allow for various fault levels are given. It should be noted that the current ratings given apply to cables installed singly. Where cables are grouped or bunched together the ratings have to be reduced due to the effect of mutual heating, i.e. the cables have to be derated. And where cables are just thrown together in a duct or trench the position becomes well nigh impossible from the rating point of view. From the examination of certain failures we have come to the conclusion that this aspect of cable installation is not always given due consideration.

gevolgtrekking gekom dat hierdie aspek van kabelinstallasie nie altyd die aandag geniet wat dit behoort te kry nie.

Wanneer papiergeïsoleerde kabels met loodmantels voorgeskryf word, moet daar onthou word dat suiwer lood onderhewig is aan vermoeienisbarse wanneer dit aan vibrasie of buiging as gevolg van hittesiklusse, onderwerp word. Wanneer 'n kabel in 'n omgewing wat aan vibrasie blootgestel is, gelê moet word, soos bv. naby 'n pad of spoorweg of swaar masjiene, of as dit oor lang afstande vervoer moet word voordat dit gelê word, moet 'n loodlegering gebruik word. Gewoonlik word legering E gebruik waar middelmatige vibrasie verwag word en legering B waar daar verwag word dat die vibrasie straf sal wees. Maar let daarop dat legering B verouder en verhard as dit staan en daar gevolglik groter versigtigheid aan die dag gelê moet word wanneer dit gebuig en geïnstalleer word.

Meer aandag moet ook gegee word aan die beskerming van substroombane. Dit help bv. nie om 'n 16-mm²-kabel korrek te beskerm met behulp van sekerings met 'n hoë breekvermoë en dan direk daarvan af te tak met 4-mm²- of 2,5-mm²-kabels nie. Indien 'n hoë impedansiefout in laasgenoemde voorkom, sal die sekering nie reageer nie en die kabel sal opgeoffer word.

'n Praktyk wat blykbaar baie algemeen geld vir 600/1 000-V- PVC-geïsoleerde en gepantserde kabels, is om slegs 'n paar van die pantserdrade deur te neem wanneer 'n kabel gelas word. Dit is moeilikheid soek. **Al** die pantserdrade moet deurverbind word en hulle moet teen korrosie beskerm word. Indien 'n aardfout agter die las sou voorkom, sal die foutstroom, indien dit net deur die verroeste pantserdrade of net 'n klein aantal van die pantserdrade gedra word, die onderlaag oorverhit met die moontlikheid dat die kabel self defek raak alhoewel die oorspronklike fout nie naby die las was nie.

Ten laaste, kan ek u daaraan herrinner om die binne-ent van 'n kabel los te sny voordat 'n haspel afgerol word en om nie te probeer om 'n kabel wat PVC as 'n onderdeel bevat, te lê as die temperatuur van die kabel onder 10°C is nie. PVC is 'n termoplastiese stof en by temperature onder 10°C kan dit te bros wees om te hanteer.

Die outeur wens die Raad van die Buro vir Standaarde te bedank vir toestemming om hierdie referaat te lewer.

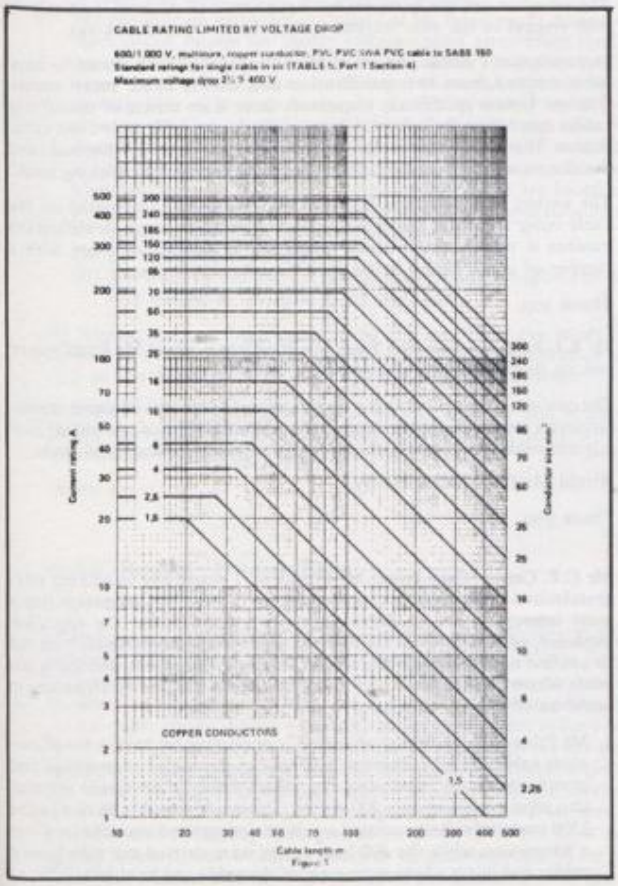
When paper/lead cables are specified it must be remembered that pure lead suffers from fatigue fracture when subjected to vibration or bending resulting from thermal cycling. When cable is to be laid in a region subject to vibration, for example near a road or railway or heavy machinery, or is to be transported over long distances prior to installation, a lead alloy should be used. Normally Alloy E is used where moderate vibration is expected and Alloy B where vibration is expected to be more severe. But note that Alloy B age hardens on standing, which necessitates increasing care during flexing and installation.

More thought should also be given to the protection of subcircuits. It is no use, for instance, to correctly protect a 16 mm² cable by means of HRC fuses and then to branch off directly from this cable with 4 mm² or 2,5 mm² cables. If a high impedance fault should occur in the latter the fuse will not see it and the cable will be sacrificed.

A practice which appears to be very common where 600/1 000 V, PVC insulated, armoured cables are jointed, is to carry over only a few of the armour wires and cut off the remainder. This is asking for trouble. **All** the armour wires should be carried over and they should be protected from corrosion. If an earth fault occurs beyond the cable joint, the fault current, if carried by corroded armour wires or a small group of armour wires only, will cause the armour bedding to be overheated with possible consequent failure of the cable, even though the fault was some distance from the joint.

Finally, may I remind you to cut free the inner end of the cable before a drum is unwound and not to attempt to lay a cable incorporating PVC as a component if the temperature of the cable is below 10°C. PVC is a thermoplastic and at temperatures below 10°C can become too brittle to unwind.

The author wishes to thank the Council of the South African Bureau of Standards for permission to read this paper.



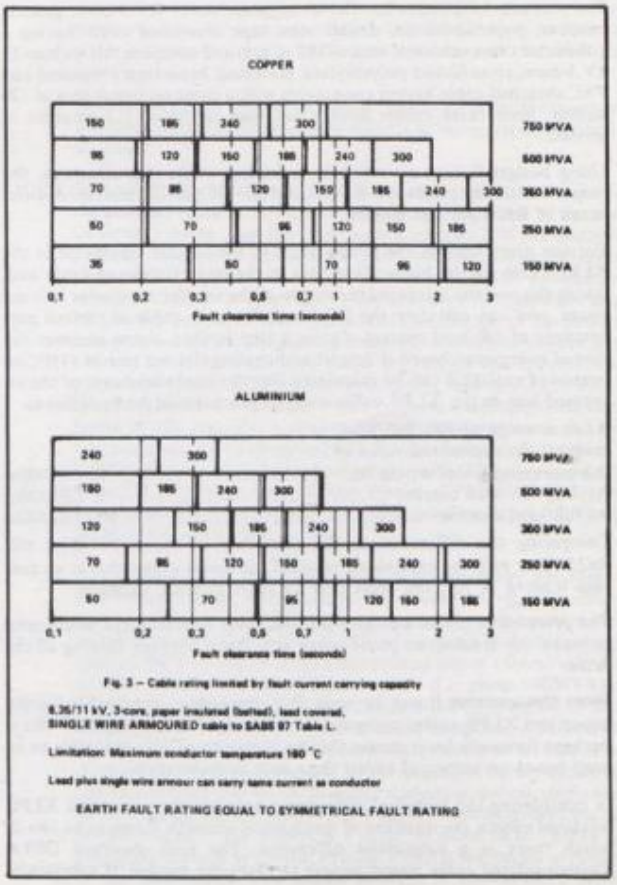


Fig. 3 – Cable rating limited by fault current carrying capacity

6,35/11 kV, 3-core, paper insulated (belted), lead covered, SINGLE WIRE ARMOURED cable to SABS 97 Table L

Limitation: Maximum conductor temperature 160 °C

Lead plus single wire armour can carry same current as conductor

BESPREKINGS/DISCUSSIONS

Mr K.G. Robson : President: Thank you, Mr Prins. I will now call on Mr Hugo of Sandton to open the discussion of the paper

Mr A.H.W. Hugo : Sandton: Mr. Prins must be congratulated on a most interesting paper. I found the paper particularly thought-provoking and the theoretical and practical references to actual case histories held one's interest throughout the paper.

Of particular interest to me were Mr. Prins' comments on the electrolytic corrosion of lead sheaths in buried, paper-insulated cables. We, in Sandton, have experienced a number of instances of severe sheath corrosion, some of which was unquestionably due to jute corrosion. In others, the reasons have been obscure. Invariably, the corrosion occurs in association with surface water. The conclusion which we had reached was that the corrosion was caused by chemicals in the water, which must contain the residues from the many French drains which existed for some years in the area. An examination of the sheath by a leading manufacturer concluded, however, that the corrosion was consistent with electrolytic attack.

The situation is in many aspects similar to the experiences mentioned by Mr. Prins where electrolytic corrosion occurred in damp areas remote from traction circuits. His explanation of the corrosion being caused by the formation of galvanic cells tied in well with our experience and seems to be the logical explanation of our troubles.

In order to overcome these difficulties, we now specify cables with an extruded PVC sheath over the lead sheath. Cables which we have ordered to this specification have not been in the ground long enough for us to say, at this stage, whether or not the provision of an anti-electrolysis barrier is going to be effective.

The difficulties experienced with lead sheath corrosion naturally led to consideration being given to the specifIcation of XLPE cables in place of the oil-impregnated paper-insulated cables which have always been used.

If I may digress a little, it is interesting to consider the economic comparison of paper and XLPE insulated cable. On first examination XLPE would appear to be very much less expensive than a paper-insulated cable of the equivalent current carrying capacity but, if one takes into account the increased I^2R losses associated with the smaller cross-sectional area conductors in the XLPE cable and then capitalises these losses, the picture becomes rather different.

For purposes of comparison, let us consider an 11 KV 3-core, general purpose, paper-insulated, double steel tape armoured cable having a conductor cross-sectional area of 185 sq.mm and compare this with an 11 kV 3-core, cross-linked polyethylene insulated, brass tape armoured and PVC sheathed cable having conductors with a cross-sectional area of 120 sq.mm. Both these cables have a full load rating of 315 amperes in ground.

Using budget figures provided by a leading cable manufacturer, the respective selling prices are R2 420 and R1 795 per 100 metres. A difference of R625 per 100 meters.

For any given current the temperature of the smaller conductor in the XLPE cable will be higher than that in the paper-insulated cable and, taking this and the increased resistance of the smaller conductor into account, one can calculate the I^2R losses for each cable at various percentages of full load current. Going a step further, if one assumes the cost of energy purchased at 2c/unit and a ruling interest rate of 11,0% on borrowed capital, it can be calculated that the capitalised cost of the increased loss in the XLPE cable over 25 years would be as follows:-

At an average of 50% full load current, the capitalised value of the increased losses would be ..... R 275/100m
At 70% full load current ..... R 620/100m
At full load current R1 110/100m

Comparing the difference in the first cost of the two cables viz. R625/100m with the capitalised value of the losses shows that at an average loading of 70% the costs over 25 years become identical.

The prospect of higher energy costs and lower interest rates would tend to make the break-even point occur at a lower average loading of the cable.

From this exercise it can be seen that, price-wise, reasonably loaded paper and XLPE cables compare very closely. For the Engineer this is perhaps fortunate for it means that he is able to specify the cable to be used based on technical rather than cost considerations.

In considering the technical differences between the paper and XLPE insulated cables, the question of mechanical strength seems to be one in which there is a substantial difference. The lead sheathed DSTA paper-insulated cable would appear to carry the burden of substantial cost premium due to the provision of a substantial outer protection which, to a large extent, appears to be absent in the brass tape armoured XLPE cable.

As a point for discussion, do we perhaps not overspecify the mechanical protection on paper-insulated cables? I ask the question – could not one consider dispensing with the double steel armour tapes in specifying a lead and PVC sheathed paper-insulated cable which is to be buried directly in the ground?

In any Electricity Department's budget, cable as we all know, forms an extremely large portion of the total expenditure. It was therefore a great privilege for me to be invited to open the discussion on a paper covering such an important subject and I wish to thank you, Mr. President, for the honour in extending this invitation to me.

Mr S.N. Hammerschlag: Bedfordview: Mr President, may I also express my congratulations to the speaker for a very interesting and maybe a slightly controversial paper, which is after all what the object of the meeting is.

Due to the high cost of copper a couple of years ago, there was a very obvious economic need to use aluminium in place of copper with all its associated problems. These are very adequately covered in this paper, the main being the oxidisation and cold welding of aluminium. With copper, if there were problems, you just used a larger hammer.

Based on the very good paper presented by Mr V.R. Raynal of Johannesburg with regard to reticulation of townships, we have introduced the use of solidal cables with a substantial saving in reticulation costs at the time. These came down from R1200 per stand to R850 – R900 per stand using aluminium. However, these costs differences have now narrowed.

Initially problems were found with the components and accessories. These, however, now appear to have been solved by the manufacturers. The specification may have been to blame by specifying minimum cable sizes and not maximums. This causes the cable sizes to increase as the dies wear, the sector sizes increase resulting in problems with accessories.

Also, with the installation of stranded H.T. aluminium cables, problems were found in the jointing but this is, as Mr Prins says, no doubt the human element. Perhaps the cable manufacturers are considering solid H.T. cable which will eliminate a lot of these problems.

The selection and use of cables has been very well covered, particularly with respect to the ever increasing fault levels of undertakings.

In conclusion I would like to mention an aspect which seems to have been omitted from the specification and that is cable batch identification. Unless specifically requested, there is no means of identifying cables apart from their drum number, with the manufacturer's test certificates. This applies particularly if the cable has been re-drummed (and the drum no. not recorded). Then there is no means of checking back.

The answer may be a tape laid with the cores or an embossing on the cable outer sheath. If the cables are embossed with some identification number it will have the added advantage of identifying them with a number of other cables in the same trench or cable rack.

Thank you.

Mr K.I. Andrews: Somerset East: Mr President, I found Mr Prins' paper and his discussion of great interest.

The one statement I find in his discussion not to tie in with cable manufacturer's indicated claims/disclaims is the fault rating of equivalent aluminium cables as apposed to copper of equal cross sectional areas.

Would Mr Prins please clarify.

Thank you.

Mr C.T. Carter: Cape Town: Mr President, I would like to add my congratulations to those of previous speakers to Mr Prins on presenting a most interesting and readable paper in a manner that the electrical engineer, as distinct from the scientist, can readily understand. I intend to confine my comments thereon to particular situations and those aspects where experience within the Cape Town Electricity Department could be of interest to others.

1. Mr Prins makes mention of a particular jointing technique for aluminium cables which withstood 2500 load cycles under overvoltage and over-temperature conditions, but which failed in an actual installation after approximately 400 cycles. This could possibly be due to the 2500 load cycles being carried out in an unrestricted situation in air, in a laboratory, while the 400 load cycles were carried out with buried cables and joints where movement of the cable and joint boxes due to

expansion would be restricted. Perhaps Mr Prins could elucidate on this point.

2. One of the characteristics of aluminium mentioned on page 3 of the paper is that the co-efficient of expansion with temperature of aluminimum is approximately one third more than that of copper. Superficially this would indicate that under equivalent restrained conditions aluminium would fare worse than copper. This is not so in fact, as the differences in the moduli of elasticity of the two metals more than compensate for the higher expansion rate of aluminium.
3. This leads on to Mr Prins' statement that when aluminium conductor is jointed or terminated it is imperative that the metal from which the ferulle or lug is made should have a temper compatible with that of the conductor to be jointed or terminated to ensure equal expansion and contraction. This does not appear to line up with Cape Town's successfull practice over the last eight years of using tinned weakback copper ferrules for soldered through-joints on paper insulated aluminium cable or tinned copper lugs for soldered terminations of aluminium tails to copper busbars. It is not unusual practice in Cape Town to straight joint a copper cable to a larger equivalent sized aluminium cable. The diameter of the copper conductor is built up to the correct size, using tinned copper wire, to suit the tinned copper ferrule and a soldered joint made. No problems or failures have yet been experienced on aluminium to aluminium or aluminium to copper soldered joints even on cables loaded to their cycle loading limit.
4. Reference is made to the effects of voltage spikes and chopped waves on ethylene-propylene rubber. Could Mr Prins please advise to what extent cross-linked polythene reacts to these phenomena?
5. I was very interested to read Mr Prins' remarks on the storage and suggested periodic rotation of cable drums. Could Mr Prins advise whether any analytical tests have been carried out in this regard? In the case of the now out-moded design of resin-oilfilled paper cable, insulant 'shift' could take place if the cable drum was subjected to great extremes of temperature, especially if the outer sheath was of heat absorbing black PVC. This process would be minimised if the cable had been properly impregnated in the first place.

   The compound in a non-draining type cable only starts to 'shift' at approximately 84°C and with properly battened drums and under normal climatic conditions it would appear to me that the periodic rotation of drums of this type of cable is unnecessary. In this connection I would mention that it is not the practice of the Cape Town Electricity Department to rotate drums of paper insulated cable, whether of the resin-oil or non-draining type, at its store. No adverse effect has yet occurred because of this, even in the case where drums of relatively slow moving cable have been stored for a considerable number of years and subsequently put into commission.
5. The penultimate paragraph on page 7 of Mr Prins' paper dealing with short circuit ratings for higher voltage cables gives much food for thought. With increasing fault levels on say the 11kV systems of the larger municipalities, many a municipal electrical engineer has apparently little right to sleep soundly at night in view of the disparity between the fault capabilities of his installed cables and what these should theoretically be. There is, however, a measure of consolation in that theoretical short circuit ratings of cables are conservative when applied to actual practice. Theoretical values are based on:
   (i) The conductor being at its maximum rated operating temperature at the instant of short-circuit.
   (ii) Zero earth-fault resistance.
   (iii) The short-circuit current remaining constant throughout its duration instead of falling as it normally does.

No trouble has ever been experienced in Cape Town due to shortcircuits on 11 kV cables even with old cables of cross section as small as 0,0225 sq in (16mm²) installed on a 250 MVA fault level system.

A further important consideration is that the primary unit protection usually operates well before the back-up protection, on which time short-circuit ratings are usually conservatively based.

Thank you.

Mr S.G. Hancock : Pietermaritzburg

1. General:

Apart from the papers of T.C. Carter (Cape Town, 1971), A.J. Eriksson (Kempton Park 1972) and D.H. Booth (Pietermaritzburg, 1973) in the particular contexts of aluminium conductors, crosslinked polyethylene and the effects of general developments in dielectric practice respectively, a general paper on the subject of electric cables appears not to have been presented to your Association for a considerable time. The present paper is therefore highly opportune, but the text seems to present a gloomy view, which I trust my remarks will redress. In particular if the adverse illustrations cited in the paper are to be regarded as other than isolated occurrences and containing valid ground for criticism of the local cable making industry, their incidence needs to be quantified against the normal output of some 1500 km of power cable per month on 1976 figures.

2. The specification

2.1 Interpreted literally, the opening paragraph could be seen to assert that significant inadequacies in local cable specifications have only just been recognized. Such inadequacy must be firmly denied, as it is known that they enjoy a high technical respect, nationally and internationally. The purpose of a specification can be summarised as:
   (a) to identify the product, relative to its appropriate general or restricted field of use;
   (b) to identify realistic levels of physical parameters relative to their employment, and how these are assessed, either directly or by analogue;
   (c) to specify only such dimensional details and properties as are relevant and non-redundant.

   It is NOT a manufacturing handbook, and it MUST assume that the manufacturer of his product possesses and will apply the necessary competence and skill in his art.

   It is entirely right that attention should be paid to parallel foreign specification work. Do not however fall into the trap of demanding inclusion of an attractive foreign requirement because of its origin alone; it can easily be related to an entirely valid condition in its country of origin which is just not repeated in the South African context.

2.2 Any consistent occurrence of the malpractices referred to in paragraphs 3 and 4 is now regarded as a matter of history as the result of a known change in the local manufacturing pattern. I have already referred to the need for their quantification. For a cable maker there IS no argument to excuse a turned core, but to suggest that all paper insulated cores must be lapped in a single tandem length is irrelevant.

2.3 To require in a general specification a quantitative measure of the circularity of a cable, and one assessed by two methods of measurement of conflicting readability and apparently non-consistent conflicting accuracy is a unique departure from the general norm of national and international specification practice. The single case known, Electricité de France, is content in its private specifications for power station cabling with a 6 per cent variation of minimum and maximum diameters relative to the mean value taken over six measurements. This is a special requirement for a defined application, yet still many times more generous than the flat one percent proposed by the SABS for all purposes.

   Clearly, this is closely related to gland design principles, and to the intended national specification for glands, which has not yet been prepared. I would seriously suggest that it be shelved at least until some progress has been made in committee with the draft gland specification.

2.4 One may well ask whether the SABS has considered the question of withdrawing its quality mark for defects of recognised practice such as these?

2.5 Successful extrapolation of a specification to realistic service-life in the product results from the development testing skill of the manufacturer. I doubt, that the case quoted on page 2 of the aluminium jointing system was intended to infer that the service failure was shrugged off unresolved. I have knowledge that this difficulty was recognised some 16 years ago in the course of development testing by another producer who emphasized that the use of his particular compression system for jointing stranded conductors must be avoided only for compound filled burial because of this specific risk of premature failure. All his cards went on the table for those who had time to read them. I have also repeated these warnings myself consistently in this country; a system was nevertheless developed about two years ago which complied with the type test requirements of the UK Electricity Council specification (now BS4579) as successfully as the solid aluminium compression system. C79/BS4579 is currently being used as a foundation of the corresponding South African performance specification.

2.6 It is to be regretted that, because of its historical age, the short circuit example could not be adequately quantified but, on account of the rarity of this type of occurrence, a partial reconstruction (based on ERA Reports F/T 195 and 202, which dealt with the analogous case of the bursting of large unarmoured paper cables) may be of interest. A fault current of 30kA at 11kV (i.e. about 600MVA) on a circuit of 3 x 800mm² single core cables installed in trefoil at 750mm clamping intervals, will produce an electromagnetic repulsion force per bay of nearly 10kN and a bending moment of 62 Nm at each clamp. Assuming that, because of the impulsive nature of the force and the internal friction in the paper dielectric, we can apply simple structural engineering theory, a first approximation to the fibre stresses developed in the papers is a range os some 54 to 73MPa from conductor surface to sheath, exerted within a few cycles of initiation of the shortcircuit. The tensile strength of impregnated paper is

around 55MPa, so the result reported by the author is entirely credible. By contrast, banding such a trefoil at 250mm intervals reduces the repulsion force to 3.3kN, bending moments to 69Nm, and the fibre stress range from 6 to 8 MPa.

So if you experience a shortcircuit resulting in birdcaging of single core cables, see to ordering fresh cable, because you will need it. The reference to "all known electrical tests" not having indicated any degree of damage is however too vague and I trust that it means only that the conventional field tests available at the time and place gave this negative result. These tests should presumably have included conventional over voltage and dielectric resistance measurements, and other fault locating loop tests, which are all of low sensitivity. An ionisation test carried out correctly with an inverted Schering Bridge circuit in an insulated high voltage Faraday cage might however have given some indication of an anomaly in the internal capacitance and loss tangent parameters even in the absence of initial values.

The later generation of impulse and pulse reflection fault location techniques would, on the other hand, almost certainly have indicated abnormality if not a "fingerprint" in the shape of regular reflections from the change of permittivity at each point where the paper dielectric was crippled as found on inspection.

3. Economic life

3.1 More heat than logic is generated in arguments over premature failure of a product, and it is easy to wax emotional. The ultimate operational life of a power cable is notoriously difficult to predict, but a conservative expectancy of 25 years can usually be taken from extrapolation of development test results relative to an assumed continuous operating temperature. Historical bonuses arose from the rudimentary knowledge of the art of cable design early this century with resulting reliance on factors of uncertainty that could never be tolerated today; other relevant factors are effective underloading, the cable remaining undisturbed mechanically, and not being made obsolete by load growth and change of system voltage.

3.2 Expected life must still be related to basic economic policy and philosophy. A 15 year period in the USA is consistent with their known national "scrap and rebuild" outlook. In any event, the economic yardstick can only be the amortization of all initial costs over a planned life determined by the conditions of financing; any further period of service is then bonus. Premature failure during the repayment period cannot be condoned, but the reference to ratepayers (third paragraph of page 2) suggests that this is regarded as a type of recurrent risk.

3.3 Planned obsolescence is a recognised feature of modern design of domestic goods, but is not recognisable in the power cables field. The references to domestic appliance failures appear likely to be non-representative and in need of quantification. The SABS Design Institute exists to develop responsible standards of industrial design, which must cover ease of repair. Is the local consumer perhaps too idle to repair minor defects, as suggested recently in the media (e.g. Citizen ca 12-13 April 1978) thereby encouraging a design philosophy of planned obsolescence?

I commend to you the words of John Ruskin on quality-"There is hardly anything in the world that some man cannot make a little worse and sell a little cheaper, and the people who consider price only, are this man's lawful prey."

4. System Engineering

4.1 Codes of Practice: The resurrection, after a long period in limbo, of the SABS code for the selection and employment of power cables is a matter for considerable satisfaction, even though it may not provide any continuing permit revenue for the Bureau of Standards. It repeats largely what the cable manufacturing industry has been saying for years with varied success and the addition of the authoritative title might succeed in putting the message across that expensive material can be ruined by failure to respect elementary rules. The Central Organisation for Trade Testing might consider the need for more emphasis on its contents in the training of electrical artisans.

4.2 Aluminium Conductors: The necessary conditions for successfully using aluminium conductors in power cables are fully understood and have been widely publicised. This metal presents no difficulties if these conditions are recognised and the manufacturer's advice is followed to the letter. I am glad this was emphasized in Mr Prins' presentation. Failures are caused by taking ill-advised or unadvised short cuts; item (d) at the top of page 4 is a case in point, but no reference is seen to the successful use of soldering and welding techniques. As indicated before, durable compression/indentation systems for jointing stranded conductors are known and have been proved to be fully effective.

Connection of aluminium lugs to tinned copper busbars is fully effective where the lug manufacturer's proven recommendations are followed to the letter.

4.3 Dielectrics:

4.3.1 Butyl and styrene-butadene synthetic rubbers have become largely obsolete with the arrival of ethylene propylene rubber. Nitrile rubber is suitable for low voltage use in an oily environment but it is not basically a dielectric material. EP rubber could be protected against voltage spikes by the use of surge diverters, similarly to mineral insulated cable, if provision is made for space required.

4.3.2 The properties of PVC depend entirely upon its formulation, and its response to chemical agents can be expected to vary widely as a result. When coloured it is sensitive to superficial sulphur staining when lead stabilised (as is normally the case). It has a high evolution of acid fume when burnt, unless suitably formulated to suppress this toxic characteristic.

4.4 Jointing: The degree of skill required in jointing XLPE cables may possibly be reduced relative to metal sheathed systems, but the attention necessary to detail is still as great.

4.5 Electrolysis: Future development by the SAR in electric traction is likely to be at 25kV 50Hz, as the traffic capacity of the 3kV dc system reaches saturation. Conventional undirectional leakage current electrolysis could be expected to disappear, but concentration-cell and non-linear impedance AC corrosion are likely to require the continued need for anticorrosion protection of all metal sheathed cable designs. A convenient way of monitoring the effectiveness of such protection is a dc proof voltage applied for 60 seconds between the inner metal component and a graphite skin on the outside of the extruded sheath.

4.6 Vibration: Wire armouring of paper cables improves the vibration protection of the sheath metal by increasing damping. Thus wire armour over a plain lead sheath is regarded as equivalent to unarmoured Alloy E; addition of armour to the latter approximates to unarmoured Alloy B, but for the worst conditions, wire armoured Alloy B is essential.

4.7 Current ratings

4.7.1 Increased short circuit duties argue in favour of curtailing the range of practical conductor sizes, recognising as preferred minima at 11kV, 50mm² in copper and 70 or 95mm² in aluminium.

4.7.2 Sustained current ratings are determined by the thermal balance of I^2R loss generated in the conductors with that dissipated to the environment as a heat sink. It is essential to recognise the need to derate from tabulated ratings for variations from their standard values of ground thermal resistivity, ambient temperature, depth of laying and proximity of multiple circuits. Failure to do so can well be disastrous.

Thank you.

Mnr. E de C Pretorius : Potchefstroom: Mnr die President, ek wil ook graag mnr Prins bedank vir 'n baie uitstekende referaat wat ons dikwels weer sal naslaan vir inligting. Daar is een paragraaf of sinsnede wat ek wil uithaal wat vir my baie belangrik is. Ek wil dit beklemtoon nl. op bladsy 3 waar mnr Prins sê: "Per slot van sake is dit u wat die kabel moet bestel, daarvoor moet betaal en gerus moet slaap wanneer dit geïnstalleer is." Mnr die President, ek wil net noem dat ek op een van die komitees dien wat met die opstel van spesifikasies vir XLP-kabel belas is en ek kan u die versekering gee dat u verteenwoordigers hul deeglik laat geld en hierdie aspek baie swaar op die hart dra. Ons betaal daarvoor en ons sal vra wat ons wil hê. Saam daarmee, mnr die President, hoop ek dat ons nooit in Suid-Afrika in die toestand, soos hier gesê word deur 'n Europese kabelvervaardiger, beland nie, nl. dat ons deur die ekonomie verplig word om dinge te doen wat ons nie tegnies kan verantwoord nie. Ek hoop eerlik waar nie ons kom tot daardie toestand nie.

'n Ander sakie wat myns insiens sover nog hopeloos te min aandag geniet het deur die VMEO, is die elektrolitiese verwering van kabels en ek wil 'n beroep doen dat by die volgende konvensie, as dit moontlik is, tydens die vraerubriek, indien daar wel een is, iemand ons 'n bietjie inlig oor elektrolitiese korosie.

Nog 'n aspek waaroor ek mnr Prins net 'n vraag wil vra, gaan oor die berging van kabels. Dit is wenslik dat kabels onder dak geberg word vir beskerming van direkte son waar moontlik. Waar dit nie moontlik is nie, soos in ons geval, verf ons die kabel met wit kalk. Nou is ek egter bekommerd dat waar die kabel met PVC bedek is dit die stroomdravermoë van die kabel kan beïnvloed, deur die hitte-uitstralingvermoë te beïnvloed.

Een laaste vraag, mnr die President, die tegniese komitee, belas met die opstel van XLP-geïsoleerde kabelspesifikasies – het twee vergaderings

gehad, een waarvan ek nie kon bywoon nie. Op die eerste vergadering het ek die idee gekry dat ons baie goed vorder. Die 2de vergadering is gehou en dit lyk of die hele saak eenvoudig doodgeloop het. Wat het geword van daardie spesifikasie? Dankie.

Mr W. Barnard : Johannesburg: The author has produced a paper covering a very wide field of continual interest to all municipal engineers, and one in which members of the AMEU already have a wealth of hard practical experience. For the record, Johannesburg has installed over 670 km of high and low voltage underground cables during the past 10 years, valued at over R10 million.

The charts and much of the information have been extracted from the long-awaited draft code of practice entitled "The Handling, Installation and Operation of Cables up to 20 kV" which, it is hoped, the Bureau will soon be able to make generally available.

I have the following specific comments which it is hoped will add value to the paper:-

(1) Page 3:
The low melting point of aluminium, which has a 40% lower melting point than copper, is a disadvantage. On two occasions, fires in minisub LV compartments in Johannesburg reduced the aluminium cables completely to molten metal, but copper cores of other cables remained intact.

Melting point of Cu	- 1082°C
Melting point of Al	- 658°C
Melting point of Steel	- 1371°C

(2) Page 3:
Friction welded surfaces are inclined to pull apart under heat and tension in service.

(3) Page 5:
Manufacturers of PVC cable should follow the practice used for XLPE and paper cable by making all cores black insulated with standard core identification. (Black PVC is superior to coloured PVC when exposed to sun, etc)

(4) Page 6:
In the instance of corrosion damage not due to stray DC current, apparently the lead sheath was not protected by bituminous paper, jute or armouring. Lead cables should not be buried bare. PVC is more expensive than bituminised jute as an outer covering, but has the advantages that

(a) It is easier to lay PVC covered cables.
(b) Cables frequently must be drawn through pipes at road crossings, and this is very much easier with a PVC outer sheath. Also, the cable can be withdrawn from the pipe if required (e.g. due to a fault) with little difficulty. With a bituminised jute outer cover, this is almost impossible if the cable has been subjected to heavy loading for some years.
(c) PVC can be coloured for easy identification. In Johannesburg an orange coloured outer PVC serving is standard for all high voltage cables.

(5) Page 7:
Oil impregnated cable is now rarely manufactured or used, and the author's comments in regard to rotating drums is not applicable. Based on our experience with MIND (non-draining) cable drums should be turned every two years and covered if stored in the open to avoid the oil migrating to the bottom of the drum.

Mr D.H. Fraser: Durban: With reference to the termination of aluminium cables, Mr Prins has indicated that direct clamping of Al. to Cu. should be avoided because of differential expansion. This has not caused any problems in Durban where such connections in indoor situations have been in service for about five years on various sizes of Al. cables up to 600mm². 'Ardox' paste is used on the junction faces which are bolted together using mild steel bolts with a flat and a spring washer. So far no sign of dissimilar metal corrosion has been evident, in spite of our notoriously humid, salt-laden atmosphere. In outdoor situations, of course this practice would be completely unsatisfactory.

In respect of corrosion of buried cable sheaths, it is interesting that in the Durban area the incidence of proven electrolysis damage to sheath and armouring of plain jute or hessian served cables has been extremely low, despite the existence of extensive D.C. tramway and railway systems going back nearly seventy years. This we have attributed to the multiplicity of substation earth mats present in the distribution system forming alternative low resistance paths for stray direct current in parallel with that via the jute served sheath to earth. It is therefore difficult to justify the use of an anti-electrolysis sheathed cable except for crossings of railways and cathodically protected pipelines in view of the substantially increased cost, which is of the order of 10 percent.

Paper cables may be expected to give fifty to sixty years of service under normal operating conditions based on previous experience. One is therefore reluctant to change to alternatives which have still to demonstrate long term stability, unless there are other advantages such as cost, ease of installation, robustness, simplicity, etc. In view of the inconvenience and expense of relaying underground cables, I subscribe to the view that cables should have an indefinite life and only be retired from service through normal obsolescence and changes to the system. At present it appears that this can be attained without paying any material premium by sticking to paper insulated cables, installed up to fifty years ago which are now being up-rated to 11 kV quite successfully.

Thank you.

Mr H.F. Forsyth: African Cables Ltd: Mr. President, Mr. Prins' printed paper and presentation this afternoon cover a very wide field and much of his paper is devoted to the well established cable types – it would have been interesting if he had given more detail on how to specify the design and the proving testing of newer cable constructions, particularly those with the newer types of insulants.

Turning to more specific comments we find that in the third paragraph of page 1 Mr. Prins quotes the technical director of a lagre European cable manufacturer as saying "I am forced commercially to do things that I cannot justify technically" and uses this to imply that good cable making practice is nowadays ignored. This is a most disturbing statement and could be taken to mean that the manufacturer concerned is producing cable which is not expected to meet customers requirements. I hope this is not the case. Would it not be more true to suggest that nowadays there is a more sane approach to cost effectiveness and cables should be made to meet a particular requirement at the most economic cost. Bad manufacture cannot be condoned but equally one cannot condone the squandering of resources. Is it not inevitable that in any engineering solution one always must weigh up both technical and economic factors?

Still on page 1 but in paragraph 4, on the question of circularity of cables, Mr. Prins implies that as a result of experimental work it has been established that the difference between mean and minimum diameter should not exceed 1% in order that no problem be encountered in terminating a cable with a mechanical gland. It would be interesting to have details of this experimental work because the only other specification in which I have found reference to a test for circularity is a French Standard for cables in power stations – this stipulates that mean diameter is determined by taking the average of six readings taken in pairs mutually at right angles at three points along the sample and that neither minimum nor maximum readings should differ from this mean by more than 6%. Furthermore it is well known that the importance of circularity varies according to whether the cable is one of the larger or one of the smaller sizes allowed in a particular gland. There has been considerable discussion in committee on this point and I suggest the figure of 1% is open to question both on the ground of validity as a specification limit and on the ground of practicability.

The test proposed by Mr. Prins for circularity also causes some concern since it is inherently inaccurate through the use of a diameter tape which, on perfect cylinders, will give readings showing inaccuracies which increase with the diameter being measured. At a diameter of 45mm this inaccuracy is of the order of plus 0,55%. This degree of inaccuracy may be acceptable when talking of an out of roundness of say 5% but would obviously not be acceptable for a specification limit of 1%.

On page 3 Mr Prins emphasises certain inherent characteristics of aluminium and implies that copper is the preferred conductor material. I am impartial over the choice between copper and aluminium, but I feel that he perhaps over-emphasises possible problems with aluminium. No one would disagree with the statement that sensible precautions have to be taken when using aluminium as a conductor metal, but it must be pointed out that these precautions are no more onerous than many other aspects of the jointing technique. It cannot be denied that aluminium conductors both solid and stranded enjoy considerable acceptance throughout the world.

In discussion of PVC as a dielectric or sheath Mr. Prins on page 5 makes two statements which I feel might create a wrong impression. To the best of my knowledge PVC does not work-harden – embrittlement is I think more the result of loss of plasticiser than work-hardening. Secondly the wrong impression may be given by stating that special compounding techniques are necessary to enhance the flame retardant properties of PVC. Up to this time it has not been necessary to change compounding techniques – changes are in compound formulation.

The statement in the paragraph at the top of page 6 regarding the skills required for jointing of XLPE cable cannot really be supported and Mr. Prins himself discounts this in paragraph 3 on page 6. There are a number of reduced skill systems for both jointing and terminating XLPE cables with which of course, as with anything else, it is important that the manufacturer's instructions should be followed.

Mr. Prins also suggests that the more one battles to remove the core screen the better the chances of having a trouble free cable. However it must be pointed out that the more one battles to remove the core screen

the more are the chances that something can go wrong or short cuts be taken in making the joint or termination; and from the cable user's point of view a joint or termination failure is just as efficient at putting a circuit out of action as is a cable fault. The cable user should not want a loose screen but is quite entitled to prefer a tight but easily strippable screen – this of course is not necessarily easy to manufacture.

Regarding the handling of cables, one other point Mr. Prins could well have made is the importance of rolling drums only in the direction indicated by the manufacturer to avoid turns slackening and trapping each other on the drum.

Mr Prins has presented and is to be congratulated upon a thought-provoking paper which has resulted in some stimulating and fruitful discussion.

Mr J.D. Dawson : Uitenhage: In Mr Barnard's comments he indicated that the cable sheaths affected by electrolysis could not have been protected in any way.

This is not so as the cables that failed in Uitenhage were protected with two layers of bitumised paper but this was insufficient to prevent the loss of 2 kms of 11 kV cable.

Mr A.J. van den Berg: Krugersdorp: Mr President, 33 kV oil filled corrugated sheathed aluminium cables with PVC serving designed for a serving test voltage of 5 kV are giving severe problems in Krugersdorp.

Serving samples sent overseas for expert investigation revealed that breakdowns are due to lighting and bad installation procedures.

Supertension cables were installed by successfull tenderers in toto. The cables I am referring to are technically sound with paper insulated aluminium conductors but, Mr President, I maintain that these cables are unreliable as they have been in service for less than 10 years, and one specific cable for less than 5 years.

This type of cable is as reliable as the serving providing protection against corrosion of the aluminium sheath.

Now the cables in question are to be tested for serving faults regularly. I'm sorry to say that the serving is in such a poor state that breakdown occurs at voltages of less than 100 volts.

Oil leaks have occurred due to pin holes in the aluminium sheath.

We were advised to call for high density polythene serving but we did not know that high density polythene is subject to cracking due to its inherent properties. I need not mention that a load of approximately 20 MVA (3 x 10 MVA transformers) at one of our industrial townships today is supplied by 3 sick cables – one gas filled and two oil filled. The cable capacities are 13 MVA, 20 MVA and 20 MVA respectively. Due to the time required for maintenance of these cables, I am forced to erect a twin circuit aluminium 40 MVA overhead line costing R750 000 to this area. The investment in cables I need not mention, but the example quoted indicates what can happen if cables are not reliable. At one stage we had two cables out of commission and the third one had a leak but was kept in commission for obvious reasons.

It is not my intention to condemn oil filled cables of all suppliers, as we do have similar cables giving satisfactory service.

I just wish to stress that great care should be taken when supertension cables are specified if trouble free service is to be ensured.

Thank you.

Mr F.J Prins: SABS: I would like to thank the various speakers for their comments on my paper and to reply to them as follows:-

Mr Hugo
I am very glad that Mr Hugo has carried out an excercise on capitalisation of losses and was very interested to hear the results. I have for years been telling engineers to carry out this exercise to prove a point that a cheap cable from the operation point of view is one that runs cold. As regards the possible over protection of paper-insulated cables and dispensing with armour, I refer to figures 3 and 4 of my paper in which an indication is given of the role played by armour when a cable rating is limited by fault current carrying capacity. If armour (and specifically wire armour) is not provided, some other form of earth return path must be available.

Mr Hammerschlag
As far as accessories for solidal is concerned, it must be remembered that the physical dimensions of the locally produced conductors differ slightly from those of the imported ones and hence one must ensure that the correct type of ferrule and lug is used to obtain a good fit. Regarding the identification of a cable after installation with manufacturing records, various methods could be considered. If an order is large enough a special embossing wheel could be made or a special marking tape for inclusion in the cable could be printed, but where the quantity of cable involved does not justify the cost of these methods, the only practical answer is a good record system referring back to the original drum number. Normally a manufacturer's test records are associated with a drum number.

Mr Andrews
Mr Andrews queried the relative fault current ratings of copper and aluminium conductors. Referring to figure 3 it will be seen that for the same conductor size copper has a better rating than aluminium.

Mr Carter
I think the question on the aluminium joint has been answered by Mr Hancock in his contribution. Mr Carter's comments relating to the different coefficients of expansion of copper and aluminium and the compatibility of aluminium with different tempers is very interesting and illustrates once again that practical experience does not always turn out to be what one expected. Referring to the question of the effect of spikes on XLPE, I cannot give a definite answer. I have been led to believe that it has the same detrimental effect as on EPDM. Possibly Messrs Anderson and Ericson of the CSIR can help here. As far as the storage of paper-insulated cables is concerned, all the old hands at the game that I consulted were adament that if rosin-oil was used and the weather was hot, the drums should be rotated once a fortnight. If a non-draining type of compound has been used, I would think that if the cable is stored under hot conditions an occasional rotation will do no harm. The picture is, of course, different for a drained type cable or a cable with pre-impregnated paper dielectrics. Another aspect that must not be lost sight of is that the timber from which the drums are made is usually not treated and if the drums are stored in the open, exposed to the weather, the timber will rot, making it difficult or impossible to handle the drums. I agree with his comments on fault ratings.

Mr Hancock
Basically four South African National specifications for cable have been involved up to now, i.e. SABS 97 for paper-insulated cables for general purposes, SABS 98 for paper-insulated cables for mining purposes, SABS 150 for PVC-insulated cables and SABS 168 for rubber-insulated cables. These were all sound specifications and this, associated with the fact that manufacturers all worked to an unwritten code of good manufacturing practices, led to good quality cable being produced. However, during recent years we have come across occasions of diversion from good manufacturing practices, with the result that we are now obliged to write these into specifications. This should prove no hardship to the reputable manufacturer who is proud of his product. I would like to add that the instances were not isolated.

The Bureau's proposal for circularity was based on the requirement for a simple practical test which can be carried out anywhere in the factory or on site without the need for elaborate laboratory equipment. We considered basing our requirements on a maximum allowable deviation of the maximum and minimum value from the measured mean value and it is interesting to note that the cable which I hold here just meets Mr Hancock's proposed 6% criterion. But according to the Bureau's proposal it would have an eccentricity of 8,4%. Though the figure of 1% is required for the correct fitting of flame-proof glands, the lack of circularity of a cable with a figure of 0,5% to 0,6% is immediately obvious. We have suggested, however, that a value of 1,5% be written into the relevant specifications to allow for possible inaccuracies of measurement.

The case of the aluminium jointing system was quoted to show how difficult it is to correlate laboratory tests with actual practice.

The short-circuit sample was quoted to indicate how inconclusive the normal electrical tests can sometimes be. If my memory serves me right the actual cable run was approximately 400 feet, and the cables were clamped at 750mm centres between hardwood blocks held by two ± 12mm bolts. Many of the blocks were shattered and a number of the bolts were sheared. The cables were scalloped along the whole length between the clamping points – trying to get as far away as possible from each other. The only practical tests that could be carried out were the d.c. high high voltage test and the leakage current test.

As regards economic life, I doubt whether any of us, including our local manufacturers, support the planned obsolescence approach. Mistakes do occur and we do get cable failures as a result of manufacturing defects, but I can truthfullty state that the majority of failures that I have seen were due to wrong installation. But we have to be careful that we do not unwittingly become victims of planned obsolescence – especially in the field of domestic flexibles.

We have not had sufficient experience of soldering to be really able to comment. The experience we did have was not good. I do have a slide here which depicts a typical example of this experience. It shows the termination of stranded aluminium conductors in copper lugs by means of soldering. As can be seen the efforts were not very successful. I personally would not recommend terminating an aluminium conductor in a copper lug. As regards electrolysis, I agree with Mr Hancock that this is not only dependant on or a product of d.c. currents.

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5891/4 Lindsay Smithers - FCB

Mr Pretorius
Mr Pretorius raised a number of points. Regarding the first one, which relates to the remark by the continental cable manufacturer, it may be useful to sketch the background. During an I.E.C. T.C.20A meeting dealing with solid dielectric cables, I sat opposite the German delegation of six men, comprising four commercial representatives and two engineers. I noted that the German contributions came essentially from the commercial people and that an engineer had to get permission from his commercial colleagues if he wanted to say something. After this meeting I visited a large cable factory and recounted this experience to the technical director. His reply was that it was a fact of life that the commercial aspect was so important that it was usually the determining factor and then he made the remark which I quoted. I mentioned this to stress the importance of not losing sight of the commercial influence on our technical decisions.

His question on the effect of white-wash on the heat dissipation of PVC is not so easy to answer as this aspect has not been examined by us or anybody we know of. Theoretically one would say that it will have some effect.

Coming back to the specification for polymeric cables, it became clear at the last meeting of the committee that there was uncertainty about certain technical aspects. It was therefore decided to carry out shortcircuit tests and try and get some answers before resuming the meetings. Samples had to be obtained and our short-circuit station at Appollo is out of commission until the end of this month due to alterations and maintenance, with the result that there has been a delay.

Mr Odendaal (on behalf of Mr Barnard)
The remarks concerning the behaviour of friction-welded bi-metallic surfaces under the action of tension and heat are very interesting. Regarding the cable failure due to electrolysis at Uitenhage, I want to confirm that the cable was served with well-bituminized jute rovings.

Mr Fraser
Mr Fraser's remarks about their experience with the clamping together of copper and aluminium and their experience relating to electrolysis is very illuminating and again shows how practical experience does not always support theory. The influence of good and adequate earthing on electrolysis is something to be borne in mind.

Mr Forsyth
I think most of the points raised by Mr Forsyth were answered in my previous replies, with only the one relating to the newer types of cables remaining. Because the field I had to cover was so wide, I decided to limit my address to the older types of cables. We are planning a cable symposium for March next year and provision is being made to spend some time on the newer types with, for instance, practical demonstrations on different jointing techniques. Mr President, I wish to thank all the contributors. It is apparent that they have put a lot of thought and time in their efforts, and this is really appreciated.

Thank you.

Mr K.G. Robson: President: Thank you, Mr Prins, for the presentation of your paper. Mr Prins has given us the benefit of his many years of experience and of his investigations into the causes of cable failures and it is obvious that this discussion could have gone on for several hours. I believe he has focused attention on our responsibilities as Municipal Electrical Engineers in the field of cables where a good deal of capital expenditure has become necessary, particularly in recent years. The other very important aspect of his paper was the many valuable contributions given by a number of speakers in the discussion of the paper.

Another very obvious element is Mr Prins' ability and enthusiasm, which has remained unchanged through all the years I have known him as a recognised cable authority in South Africa. I am sure that his paper will be taken back and studied in many electricity undertaking offices with very great care. We are very grateful to you Mr Prins for what you have given us here to-day, and we trust that when your symposium takes place the continued benefits will be obtained.

R R Gilmour Pr. Eng. C. Eng. FIEE FSAIEE

Test and Metering Engineer Electricity Department Cape Town

Mr Gilmour is a son of an electrical engineer, born at Paarl, educated at Rondebosch Boys' High School where he matriculated. Technical education was received at the Cape College for Advanced Technical Education and he received awards during the course for obtaining distinctions in electrotechnics and mathematics, eventually satisfying all the requirements for corporate membership of the IEE London. He subsequently lectured at the Cape College for 5 years on a part time basis preparing students for National Diploma and SAIEE examinations in electrical measurements.

He has completed nearly 43 years' service with the Cape Town City Council's Electricity Department, Test and Metering Branch. He was appointed Test and Metering Engineer to head the Branch during 1963. Apart from metering etc, his responsibilities include line and radio communication, traffic signals and computerised systems.

He is registered as a Professional Engineer and is a Fellow of the SAIEE, having served on its Cape Western Centre's Committee since 1955, being its Vice-Chairman in 1964, Chairman in 1965 and again Vice-Chairman in 1978.

He is also a Fellow of the IEE London and a chartered engineer, and is also a Fellow of the South African Acoustics Institute.

He is Chairman of the Cape Western Regional Field Corrosion Committee, and was also Chairman of the previous Wiring Regulations Sub-Committee of the SAIEE and, when this was taken over by die S A Bureau of Standards, he continued in this capacity for 6 more years until the end of 1976.

Mr Gilmour is the author of at least 8 papers presented and published including one on electrical accidents which he presented to the AMEU at its convention held in Margate during 1963.

He has been associated with amateur radio communication for most of his life, his call sign being ZS1K.

A number of his contributions to discussions on papers have been published in SAIEE and IEE (London) Journals, an Escom premium having been awarded to him for his contribution dealing with a paper entitled "A 66 kV grid in Northern Rhodesia" during 1952.

Mr. R.R. Gilmour.

A REVIEW OF MODERN ELECTRIC METERING PRACTICE

1. SUMMARY

Improvements in the design of electricity meters and testing methods are reviewed in relation to requirements in South Africa of large and small undertakings, standard specifications, the South African Bureau of Standards Code of Practice for the testing of electricity meters and modern equipment. One of the principal factors singled out is the question of torque, which arises in many forms in an induction meter, since this primarily affects accuracy of registration.

Block and thermal types of demand meters are compared with particular reference to the time interval and accuracy of timing devices.

Some metering methods are referred to briefly and modern testing procedures and standardizing equipment are discussed.

2. INTRODUCTION

The art of electrical measurements covers a very wide field today as there are now so many applications. Further, the metering of electrical power and energy features prominently in the form of registered energy consumption of many millions of users of electricity throughout the world.

To some people the technique may superficially seem to be a simple routine process but meter engineers will confirm that there is a great deal of technology involved. During the year 1906 a British meter engineer referred to the rapid growth of the electricity supply industry for the 15 year period 1891 to 1906 when large numbers of electricity meters of many types, depending for their action on various principles, were introduced. What then is the position 72 years later?

Reference to a similar paper (1) presented by Mr A M Albertyn to this Association at its thirteenth convention held at Pietermaritzburg during 1935 shows that a review of meter design and metering practice is necessary, as standard specifications have been updated and a meter testing code has appeared. Meter ratings have been superseded and direct-current meters are almost extinct now. Routine "in situ" tests are rarely carried out on meters now.

Drastic changes in meter testing equipment and procedure were described by Mr W A Nash in a SAIEE paper (2) during 1956. Changes in testing techniques are invariably influenced by staff shortages but to a larger extent by trends in meter design e.g. ratings, electronic principles and sophisticated telemetering equipment.

A paper (3) by Mr E L Smith published during 1951 dealt adequately with the maintenance of electricity meters but due also to the above-mentioned factors and the current economic climate, the position in respect of repairs and renewal of parts has to a large extent changed also. In some countries worn meters are replaced by new ones as a regular practice when more economical to do so.

Of the three classes of electricity meter testing stations the A category is obviously faced with the heaviest responsibility and it is therefore desirable to refer to the relevant equipment.

3. SOME FACTORS INFLUENCING THE PERFORMANCE AND ACCURACY OF METERS

It is not intended to describe or discuss the theory of the operation of the induction watthour meter in this paper. The following factors are however considered important enough since continuous accurate metering is the responsibility of all municipal electrical engineers.

3.1 Driving Torque

Torque manifests itself in a number of forms in the performance of meters and is probably the most important factor. Apart from its dependence on the fluxes produced by the voltage and current

coils, the driving torque for a given frequency is also proportional to the quantity

$$\frac{rtc}{d}$$

where r is the mean radius of the disc with respect to the pole centres
t is the thickness of the disc
c is the conductivity of the disc material
d is the distance between the pole centres.

It is obvious therefore that the product rtc is important and therefore for a given optimum driving torque, material having the highest possible conductivity is desirable if a large thick disc is to be avoided. At one time, when for example the 10 A single phase meter was popular, all technical and operating data was generally related to the full load or marked current of this meter. With the change to the so called "long range" meter followed by the "MCR" version and the latest BS system of rating meters, technical details have to be studied closely and carefully when comparing the merits of different makes of meters as is often necessary when considering tenders.

The average full load torque at unity power factor for various makes of the older vintage single-phase meters is about 44 mm gm and average rotor weight 16 gm, giving a torque to weight ratio of 2,75. The corresponding average values for MCR meters are respectively about 209 mm gm, 19 gm and ratio 11. The highest known values for a particular make are respectively 290 mm gm, 17 gm and ratio 17, for 4 turns on the series coil. It appears therefore that while there has been no reduction in rotor weight, as might have been expected, the driving torque has been improved considerably, and is approximately 1 mm gm per ampere turn.

3.2 **Braking Torque**

The braking i.e. balancing torque is as important or possibly more so than the driving torque and has a very definite effect on the accuracy of the meter. Although the series coil flux also tends to exert a braking effect, particularly at overloads on older meters, the permanent magnets provide the main braking torque which is adjustable in all meters.

There appears to have been little change in rotor speed in spite of improved driving torque which indicates an improvement in the design of permanent magnets. The important requirements of a good braking system include permanence and constant operating flux with a positive adjustment which does not disturb this flux, and effective temperature, or class I error, compensation.

Cobalt steel magnets have now been generally replaced by high energy/coercive force alcomax anisotropic properly aged magnets which are fitted in pairs. These have proved to be most reliable and practically immune to external fields. It can be shown that apart from other parameters the magnet braking torque is proportional to the speed of the rotor and the square of the magnet flux which means that if the magnets should weaken by say one per cent the rotor speed, and consequently the meter error, would increase by two per cent, for the changed braking torque to balance the existing driving torque. This characteristic emphasises the importance of reliable magnets for sustained accuracy.

3.3 **Friction Torque**

The damping torque of friction which affects the accuracy of meters at low loads and the shape of the curve is of course due to the bearings and register mechanism. No one seems to have devoted more time to research on meter bearings than the late Mr G F Shotter who was employed by the North Metropolitan Company, England. His observations and those of other investigators showed that provided the correct type and grade of oil is used on lower jewelled bearings the duration of sustained accuracy was extended. Careful handling of the meters is necessary when steel pivots on jewelled bearings are used in order to avoid mushrooming the pivot or crushing the jewel since the contact pressures are over 100 kg per mm^2. However, with the introduction of magnet bearing systems the need for close attention in respect of bearings falls away.

With regard to the registers, unless these are of the fixed mesh form severe friction can be introduced if not correctly placed in position. Certain cyclometer or roller types can be troublesome also. Pronounced friction can occur when roller or jumping wheels change from one number to the next. It is significant to note that only in recent years has BS 37 provided for cyclometer registers with special provision for jumping number wheels. However, design of these registers has improved considerably over the last decade or so and their popularity has increased among consumers and meter readers. From testing considerations, however, pointer types are still preferred.

3.4 **Harmonics**

When mercury arc rectifiers were used to a larger extent than they are today comparatively little concern was displayed over the harmonic problem and the effect on the accuracy of meters. Many d.c. traction supplies were metered with d.c. meters using a.c. meters as a check and for statistical purposes. With the phasing out of d.c. meters practically all d.c. traction systems are now metered on the a.c. input. The harmonics did incidentally interfere with ripple control systems. With the increasing use of solid state rectifiers and other electronic devices their effect on system voltage waveform cannot be ignored and filters are generally insisted upon by supply undertakings.

3.5 **Distorted Waveform**

Distortion of the voltage wave tends to reduce registration at unity power factor while the converse appears to be the case at lagging power factors, particularly if both voltage and current fluxes are distorted. BS 37 makes no reference to harmonics but it provides for changes in frequency i.e. a change of ± 5 per cent from the reference frequency shall not cause a change in meter error by more than 1,5 per cent.

3.6 **Frequency**

Occasionally system frequency varies but sustained departure for long periods is usually far less than 5 per cent and when it does change by an appreciable amount, which is then usually a fall in frequency, this is due to partial interruption to generating capacity or failures in other sources of supply when load shedding or even complete shut down usually follows. Incidentally, agreements or conditions for supplies of electricity do not appear to specify tolerances for frequency or departure from a sine wave. The South African Bureau of Standards Code of Practice requires a meter to be tested at the reference frequency of approximately sine wave form. No finite limits are specified anywhere. However, the only occasion on which the effects of frequency and waveform variations could have some significance is a case of a disputed meter whose error is on the border of a prescribed legal limit.

3.7 **Stray Fields**

The effect on stray field's on the accuracy of a meter has not, however, been overlooked by either South African Bureau of Standards or BS 37. The former provides for sub-standard meters, the errors of which shall not change by more than 1,5 per cent when placed in the centre of a coil of 100 ampere turns and diameter of one metre.

BS 37 allows a change in error of up to 3 per cent when subjected to an external field of 0,5 m T. The position selected for erecting a meter is therefore important. However, the effect of external fields on brake magnets has been considerably reduced by the development and use of anisotropic magnets. It is of course also important to ensure that a meter of an appropriate rating is installed in relation to the magnitude and type of load to be metered.

3.8 **Connections**

Incorrect connections are another source of metering errors even when the meters themselves are accurate. This is a more serious problem when instrument transformers are associated with meters. Even where check meters are installed these errors can go undetected for long periods since main and check meters can be slowed down by the same amount. In one recorded instance it was discovered after a considerable period that an internal common link associated with the voltage coils in a two element polyphase meter was missing with the result that all meters i.e. main kW.h, check and kVA demand meters were under-registering considerably. Another somewhat unusual case involved a current circuit in which one conductor was pinched by a terminal box cover associated with the high voltage switchgear incorporating the metering transformers. The insulation was severely strained resulting in a partial

short circuit affecting all meter elements on the phase concerned to the same extent.

3.9 **Tampering**

Another important factor related to meter accuracy is tampering with meters and associated equipment by unauthorized persons. According to one report a recent inspection made of 10 000 meters installed in an American city revealed that 2 500 meters had been tampered with, of which number one third were installed on commercial premises, and the estimated loss to the supply undertaking was R5 million. Other reports indicate that in certain parts of this country, particularly the Transvaal, tampering with meters is causing concern. However, in Cape Town this practice occurs on a very limited scale. During 1975 for example 1 889 meters were inspected on consumers' premises and 3 865 meters were changed on a routine basis i.e. 5754 meters were inspected of which 5 had the seals removed or 0,1 per cent compared with 25 per cent in the American city. Thus the importance of proper sealing and regular inspection of meters cannot be over-emphasised. The usual form of sealing is well known i.e. wire with ends pressed in lead blocks, the tool having appropriate initials and number die stamped in the metal. Sometimes tinned steel is used instead of lead. Some manufacturers prefer recessed screws for covering with wax or a special locking tool.

3.10 **Handling and Maintenance**

If tested properly and carefully handled and transported, meters usually remain accurate for very long periods. Careful overhauling prior to calibration of old meters removed from service is another important factor. An obsolete pattern single-phase meter was recently cut-off after being in service on the same circuit for 45 years and the average error was only 0,3 per cent fast with practically no droop in the curve, which is probably a record. The duration for a certified meter is 10 years after which it should be changed. An interesting approach in this respect (13) is to assume that except for the rare cases when meters speed up due to weakened brake magnets for example, a meter slows down at a constant rate during its period of service and it is economical to change it for overhaul and test when the relevant cost is equal to the loss of revenue which has accrued during this period. It can be shown that this period is then equal to

$$\sqrt{\frac{2c}{r}}$$

where c is the cost of changing, overhauling and testing the meter and r is the rate of revenue loss arising from the increasing error.

On this basis if meters slow down by 0,05 per cent per annum and if the average annual consumption is 12 000 kW.h the meters should be changed every 7 to 8 years.

4. APPLICATIONS OF THE SINGLE-PHASE METER

Credit Meters

Meters such as ampere-hour and electrolytic types or for that matter any direct current meter, and the so called split or Z coil polyphase alternating current meter, have now been phased out for billing purposes.

The most versatile and popular meter today is undoubtedly the single phase a.c. meter. It may be regarded as a basic a.c. meter influencing the form taken by polyphase meters. In the early days ratings of 5 and 10 amperes were in common use when the demand for electricity was much lower than it is today.

Before the last war all supplies in Cape Town over 2 kW were given as 3 phase 4 wire connections using 3 element polyphase meters of appropriate capacity – usually 15 amperes per phase for domestic connections. However, with the introduction of MCR single-phase meters coupled with much cheaper two-wire connections this combination was adopted for domestic supplies up to 10 kVA, initially using 40 A MCR meters and 50 A miniature circuit breakers. Due to higher demands and nuisance tripping of the circuit breakers the two-wire limit was raised to 13 kVA, say 60 A. An investigation was carried out as a result of which it was decided to standardize on 80 A MCR meters using 80 A circuit breakers for protection. The results of these tests are shown in Figs. 1, 2 and 3.

Some undertakings prefer using 3 single-phase meters to a polyphase meter on 3 phase 4 wire straight metered supplies. While this has distinct advantages the method surely results in more administrative work and possibly complications in a computerised accounting system. Experience has emphasized that single-phase meters serve a most useful purpose as check meters on installations requiring instrument transformers, particularly on 3 phase 3 wire supplies, usually high voltage systems, arranged on the two-wattmeter principle. In such cases the single-phase meters serve a dual purpose, viz., monitoring the accuracy of the polyphase, i.e. billing, meter and the average power factor, Cos ϕ, where

$$\phi = \text{Tan}^{-1} \left(\frac{\sqrt{3}(W1 - W2)}{(W1 + W2)} \right)$$

and W1 and W2 are the readings on these two meters. A spot check can of course be readily determined from the ratio of the rotor speeds as shown in Fig. 4.

In one recorded case where a wiring error caused all meters, including a demand meter, to under-register by the same amount, no error in respect of the polyphase meter which the two singlephase meters were checking was evident. However, the two meters had indicated a leading power factor ever since the meter panel wiring was disturbed, whereas the power factor was normally lagging. It was as a result of the apparent changed power factor, which the consumer could not explain, that a thorough subsequent inspection of the metering system revealed the wiring error. Had it not been for the inclusion of these single-phase meters the consumer might have been undercharged for an indefinitely long period with severe loss of revenue to the undertaking.

The cost of meters has risen sharply over the last few years, namely 21% per annum over the last 5 years. Fig. 5 illustrates this trend in the case of single-phase meters.

4.2 **Prepayment Meters**

Before leaving single-phase meters it may be relevant to refer briefly to prepayment meters, predominantly in the form of singlephase meters. These meters seem to have lost their popularity in this country. It is understood that even in a country like the United Kingdom, where these meters are manufactured, supply authorities are not keen on their use any more. During the period 1947 to 1966 their use among domestic consumers of electricity dropped from 30% to about 13%.

Experience has indicated that the only real advantage of a coin operated prepayment meter is that it avoids debts i.e. enforces the co-operation of unwilling or thriftless consumers, whereas the main disadvantages may be summarized as follows:

(1) Break-ins more rife than tampering with credit type meters.
(2) Inconvenient supply interruptions due to coin switching problems.
(3) Meter reading and collection problems – counting cash and watching for bad or foreign coins.
(4) Call backs necessary when premises are locked.
(5) Maintenance and testing costs higher.
(6) Changes in tariff.

Some of the disadvantages are being overcome with the development of token operated mechanisms. The tokens have to be bought in advance and cannot be re-used. In many instances, such as ironing rooms in hotels, caravan parks or other public places, coin or token operated time switches have replaced conventional prepayment meters.

5. DEMAND METERS AND ASSOCIATED TELEMETERING SYSTEMS

5.1 **Characteristics and Timing Considerations**

As all supply engineers know one of the objects of a two-part tariff is to encourage improvement in load factor and, where kVA is measured instead of kW, improvement in power factor. Also a more direct and fairer contribution to capital investment in generation and distribution apparatus is possible. Measurement of instantaneous quantities in respect of demand is a less fair and less significant index of the stress upon apparatus heating limitation than a demand averaged over an appropriate period. Temperature is the principal factor which limits the amount of load which can be imposed on electrical equipment. The length of the period and the form the max-

imum demand meter should take is generally a matter of opinion and costs, each undertaking making its own decision or choice. Recording demand meters are used on a relatively small scale in this country as they are more expensive than indicating types in respect of outlay, reading and maintenance.

5.2 **Lagged (Thermal) Meters**

The familiar decay characteristic, such as is evident in an expression for current in a circuit containing resistance and inductance, also relates temperature rise to final temperature and time, at a constant and sustained load, viz.

$$dT = T\ (1 - e^{-kt})$$

Thus the temperature rises rapidly initially then the rate slows down appreciably until the final steady temperature has been reached. This suggests that a meter designed in such a way that the pointer advances in accordance with this law would enable an equitable principle in demand metering to be achieved. Modern thermal demand meters, also known as lagged types, conform to a similar law and are used fairly extensively in South Africa. The demand period for such a meter is arbitrary and really depends upon the definition in a tariff, agreement or contract. Certain makes of this type of meter state the period as 15 minutes although the final value may be indicated at the end of 30 mintes. Generally these meters are designed so that under steady load conditions deflection reaches 90% of the final value in 10 minutes. These meters are virtually wattmeters with a heavily overdamped movement.

5.3 **Integrating (Block Interval) Meters**

The integrating, or block interval type demand meter registers a value which is the average load over the specified period or time interval, when the kilowatthours have been a maximum. The effect is equivalent to taking readings on a kW.h meter every 15 or 30 minutes, or whatever the defined interval is in the tariff or contract. Unlike the lagged meter the deflection is directly proportional to time at constant load, and furthermore a timing device is required. The important advantage of integrated type demand meters is that they are adaptable for telemetering. Furthermore, they are easier and cheaper to test. South African Bureau of Standards requirements are somewhat more severe for lagged meters in this respect.

Telemetry facilities for demand monitoring and control purposes are usually provided in the form of transmitted pulses from the demand meter. Consumers frequently request this facility by suitable and acceptable arrangement with the supply undertakings. Certain major municipal undertakings which both generate and purchase electricity from a national system rely on telemetry techniques to ensure that a target demand set on the imported supply is not exceeded and kept within an operating margin when it is more economical to do so.

Fig. 6 is a photograph of an electronic monitor which computes and indicates what corrective action is necessary.

5.4 **Timing Devices**

Most integrating demand meters rely on timing devices run by synchronous motors for controlling the specified interval or period and resetting the driving needle. The disadvantage of this form of timing device is that the actual length of period is governed by the frequency of the supply. Thus, when the frequency falls, which usually happens when generators are overloaded at peak times, the period is lengthened causing proportional over-registration on the demand meter. When the frequency falls to 49,5 Hz from 50 Hz for instance, the error of the meter is increased by one per cent and if the inherent error of the meter is already one per cent fast the overall error will be two per cent fast. Although this error is probably within the limits specified in a by-law or an agreement, its effect is most significant economically. For example, a city taking a load of 200 MW from a grid system would stand to loose R10 000 in one month if the system frequency dropped by one per cent and was sustained there for the full demand period and assuming a demand charge of R5 per kW. According to South African Bureau of Standards "all other timing devices shall be accurate within plus or minus 0,5%". Thus it appears that no provision has been made for frequency variation and it seems therefore desirable for the South African Bureau of Standards to consider an appropriate amendment to this section of its code of practice.

Developments in electronics engineering have today made it possible to time out the demand integrating period very accurately with devices comprising crystal controlled oscillators. These devices are commercially available for about R800 but can be constructed by an undertaking having the facilities and expertise for a quarter of this price. For many consumers this would be a small price indeed to pay for the increased accuracy obtainable.

5.5 **Comparison of Characteristics and Performance**

Thermal demand meters tend to over-register on short peaks while the integrating meter splits peaks. A number of tests have been carried out with the object of comparing the two types. The first series of tests were conducted on a test bench using a 15 minute period integrating meter and a thermal meter on which 90 per cent of the final value is reached in 15 minutes the final value being indicated after another 15 minutes had elapsed i.e. 30 minutes total. These results are set out in Table A.

Pre-test condition of thermal meter	Error of thermal meter referred to integrating meter	
	After 15 min.	After 30 min.
Cold start	11,0% slow	4,3% slow
Hot start	13,5% fast	22,2% fast

TABLE A

The second series of tests was made under typical load conditions at 10 selected factories by installing similar thermal demand meters in circuit with the permanently installed integrating meters. Of these tests only in two cases did the thermal meter register in excess of the integrating meter, viz. 15,1% fast on average as will be seen in Table B where the percentage errors are expressed in terms of the thermal meter referred to the corresponding integrating meter.

Consumer Reference No.	Reading on Thermal Meter	Reading on Integrating Meter	Percentage Error
1	272,0 kVA	279,0 kVA	2,6 –
2	316,8 kVA	328,8 kVA	3,7 –
3	326,4 kVA	337,6 kVA	3,3 –
4	1 080,0 kVA	1 090,0 kVA	0,9 –
5	1 500,0 kVA	1 560,0 kVA	3,8 –
6	109,2 kVA	92,4 kVA	18,2 +
7	220,0 kVA	240,0 kVA	8,3 –
8	340,0 kVA	360,0 kVA	5,6 –
9	265,0 kVA	236,5 kVA	12,1 +
10	380,0 kVA	408,0 kVA	6,9 –

TABLE B

The average error for the remaining 8 consumers where the loads are not as "peaky" as consumers 6 and 9, was 4,4% slow.

Except for associated timing devices the limits of error specified by South African Bureau of Standards at ± 3,5% is liberal but probably exceed those usually prescribed in by-laws.

Modern thermal polyphase demand meters using rectifiers appear to have more merit than others as they register the arithmetic sum rather than the vector sum of kVA and harmonic components which is to the undertaking's advantage.

According to this analysis it would appear that selection of the type of demand meter is virtually a personal decision influenced by such factors as the undertaking's definition or interpretation of maximum demand, the time interval, cost of meters, testing facilities, cost of testing etc.

5.6 **Special Meters for Demand control**

Attempts have been made in more recent times to design tariffs and meters to cater for variations in demands without measuring the maximum demand in the usual manner. As far back as 1940 Dr Unz (9) proposed a sliding scale meter for the purpose and subsequently H L Lovegrove (10) and J Thomson (11) referred to the ashour (amperes squared) meter. Such a meter registers a quantity related to the demand but does not indicate the maximum demand. It is intended to be used in conjunction with a kW.h meter.

It is claimed that the ashour meter together with the kW.h meter indicates the variability in the load placed on the supply by any consumer which is not done by conventional demand meters. Furthermore, the ashour meter would cost no more to produce than a kW.h meter and is less complicated, cheaper and easier to test than demand meters, and would possibly offer an increased incentive to the consumer to shed load with such a system of metering and charging.

The so-called "White" tariff meter or excess consumption meter is not the same in principle but could be regarded as a means of controlling load factor. These are generally two, or more, rate meters.

6. TESTING OF METERS AND ASSOCIATED TRANSFORMERS

6.1 Notes on the Code of Practice South African Bureau of Standards 01 - 1953

When the Code of Practice for the Testing of Electricity Meters was published during 1948 it was anticipated that the Electricity Control Board would adopt it and make it compulsory for all suppliers in terms of the Electricity Act. Although not so yet it is advisable to follow the Code in preparation for possible eventual enforcement as was the case in the United Kingdom when its Meters Act came into being during 1936.

The methods and limits prescribed in the Code are largely based on a survey made during the post world-war period up to 1953 of the methods used by the larger South African undertakings equipped with meter testing facilities. It is not necessary nor the intention to discuss the details of the Code in this paper. However, in the light of experience gained since the Code was revised during 1953 and as the 1971 amendment was mainly concerned with metrication and updated terminology, consideration should again be given to at least further amendments.

Meters are quite rightly required to be adjusted as close as practically possible to zero error at all loads, but the limits are plus or minus 2,5% for a.c. meters. Some distinction should now be made in respect of meters to be used on major supplies of electricity, such as to cities, etc., i.e. to line up with IEC or BS classification e.g. Class 0,5, Class 0,2 since errors of the order of 2% can mean a lot in cost to the consumer. Likewise the existing limits of plus or minus 3,5% for demand meters, which incidentally are not necessarily attachments, should also be reconsidered.

Furthermore, the requirements for timing devices associated with integrating demand meters need to be revised, particularly with regard to synchronous clock types and supply frequency variations. Some reference to electronic timing devices is also needed. Every a.c. meter is required to be tested in a circuit with a voltage having a wave form closely approximating to a sine wave form. In view of the variety of devices in use, particularly high power solid state rectifiers which distort the supply voltage waveform, more specific details of tolerances in this respect should be given in the relevant South African Bureau of Standards Code of Practice. This may be necessary to cater for instances where consumers dispute accuracy of the meters on which their accounts for electricity consumed are based.

6.2 Meter Testing Techniques

As a result of staff difficulties which are often due to remuneration or what a physician once described as illusion of routine, coupled with the demand for tested meters, various schemes have been conceived and tried for reducing monotony and increasing output. Stroboscopic and other optical applications have been used but with the development of modern electronic components and devices the position has changed and improved considerably. Automation is now applied on a large scale using these devices and related systems and by careful design of test benches.

In the case of new single-phase meters which are usually ordered in batches of many thousands at a time, Cape Town's specifications now have three clauses included which are intended to overcome the tedious procedure of testing each meter delivered. This not only meets staff shortages but relieves more meter testers for the repairing and overhauling of old meters particularly polyphase meters which are expensive to replace today.

Briefly, the requirements of these three clauses are as follows:

(a) The supplier must furnish batch test certificates with all meters supplied together with details of the standards authority against which the manufacturer's test equipment was calibrated.

(b) The periphery of the meter discs to be marked with 100 divisions, the major divisions being numbered 1 to 10.

(c) Meters supplied are subject to a random 10% sample test on each consignment received. Should any meter in a random 10% batch be found faulty or outside the specified limits of accuracy a further batch of 10% will be selected. If any meter in the second batch is found faulty or in error the complete consignment will be rejected.

These requirements have so far produced favourable results. Fig. 7 shows the escalation in the price of single-phase meters since 1970. Since the mean escalation rate over the last 5 years is 21% per annum it is now almost imperative that old meters removed from service be thoroughly overhauled, bearings i.e. jewels and pivots cleaned and, provided any necessary spares are available and obsolete ratings are not inadequate, reconditioned meters should be tested and put back into service since, despite the current trend in wages, such a policy is economically favourable.

6.3 Metering Transformers

The various methods used for the testing of current and voltage transformers, including phase shifting transformers for kVA metering, have not changed significantly in recent years and are fairly well known, most of them being referred to in text books on electrical measurements. The popular method used in Cape Town is due to Petch, a null principle which measures both ratio and phase angle in terms of standard transformers together with a vibration galvanometer. This method has replaced another null method previously used, namely that due to Shotter using a two-element wattmeter connected as a differential indicator.

Phase shifting transformers used in conjunction with kW demand meters for kVA metering are seldom used nowadays. Testing was simple but comparatively a lengthy process. The restricted power factor range kVA meter has for many years been more popular among many supply undertakings. They are less expensive and less panel space is required by eliminating external phase shifting devices. The only advantage of these transformers in the past was the multirange facility which was usually provided making it unnecessary to change the meter when the consumer's power factor changed or was corrected.

The more recent developments in kVA meters incorporating rectifiers for summating polyphase currents for accurate measurement irrespective of the value of the power factor in both lagged and integrating types, has now made external phase shifting devices obsolete and redundant hence it is not necessary to discuss the relevant testing methods in this paper.

7. THE CLASS A METER TESTING STATION

7.1 Purpose

The requirements for Class B and Class C meter testing stations as outlined by the South African Bureau of Standards when it published the relevant Code of Practice during 1948 are well known to most electricity undertakings and it may therefore be of interest to make some reference to Class A stations on which the performance of the other classes depend. Such a station is required to be equipped to undertake the testing of all sub-standard apparatus used for meter testing as well as the testing of all types of kilowatt-hour and ampere-hour meters. The revised version of the code is an extension of the earlier one to provide for maximum demand meters and additional requirements for rotary sub-standards.

7.2 Standard and Sub-standard Equipment

The standard d.c. potentiometer with its relevant accessories is the most important apparatus to be found in the laboratory of a Class A station. It is significant that no reference is made in the Code to a.c. potentiometers which are usually universal instruments of either polar or co-ordinate types. This may be due to the problem of providing a steady a.c. supply in respect of both magnitude and frequency and frequent returning of the associated vibration galvanometer. The calibration of dynamometer wattmeters and galvanometers on direct current against potentiometers has been practised for a long time as they are reliable transfer a.c./d.c. instruments and consequently a.c. instruments are successfully tested against these dynamometers.

7.3 **Alternative Standard**

Developments in electronics have produced devices of solid-state design which may be used as differential or digital voltmeters. The greater the degree of temperature compensation or control, the better the accuracy. Such instruments have become available with accuracies of 0,005% of input on d.c. measurements making them comparable with d.c. potentiometers. The South African Bureau of Standards has agreed that these instruments may be used for standardizing now provided that they are checked regularly against Weston standard cells.

The use of at least three Weston standard cells is advisable and these cells should be checked against each other regularly and any discrepancy investigated. Before the war these cells were usually returned to the maker's in England for attention and certification by the National Physical Laboratory. Now the cells may be sent to the National Physical Research Laboratory of the CSIR Pretoria.

7.4 **Power Supplies**

Furthermore, the advances in electronics have made it possible to replace obsolete secondary batteries with acceptable stabilised mains power supplies for potentiometers, which the South African Bureau of Standards Code of Practice provides for.

7.5 **Time standards**

Accurate timing and frequency measurements are now carried out with electronic counters or clocks. However, the pendulum clock is still satisfactory provided that it is checked regularly against accurate time signals.

8. LEGAL ASPECTS AND CONSUMER RELATIONS

8.1 **Acts and By-laws**

Adherence to a sound fixed policy for changing and maintaining meters by an electricity undertaking goes a long way towards protecting its revenue and securing the confidence of its consumers.

In a discussion on a paper by A Evans (7) relating to the Meters Act in Great Britain, one of the critics intimated that had all the relevant undertakings been properly provided with meter testing equipment and personnel from the beginning, that country may have been spared any legal intervention. He regarded the Act as evidence of failure on the part of the engineer, presumably in regard to relations with consumers since this is what led to the legislation. These statements seem harsh and sweeping but if there is any substance in them there is a lot to be said in favour of South African electricity undertakings and their engineers concerned with metering since similar legislation has not been considered necessary in this country. It is interesting to note, however, that meters subject to special agreement between supplier and consumer are exempt from the Meters Act in Great Britain.

However, in view of the large number of consumers, most electricity undertakings have to serve, the only way to satisfactorily protect both consumers and undertakings is to introduce some form of control having legal backing and to this end by-laws are framed. It is hoped, however, that a national by-law will soon be available to replace existing local by-laws. Such a by-law should include references to the Wiring Code and the Meter Testing Code etc.

The by-laws confer certain rights on the parties concerned and are particularly advantageous when, for example, the accuracy of a meter and an electricity account is involved. In this connection it is important to refer to the evaluation of an overall error of a meter particularly when it becomes necessary to amend an account.

8.2 **Interpretation of Meter Errors in relation to Accounts**

The South African Bureau of Standards and BS 37 give limits of errors at various loads but no reference is made to an average. This is usually included in a by-law or an agreement and it is usual to define the error of a meter for this purpose as an average in terms of the errors at light, medium and high loads. Even if the rating of the meter is appropriate to the consumer's requirements it appears that such an average error is seldom equitable. Various suggestions have been considered but one (8) which appears to be acceptable results in an overall, rather than an average percentage error as follows:

0,1 x light load % error	= e1
0,7 x medium load % error	= e2
0,2 x high load % error	= e3

where e1 + e2 + e3 = overall percentage error in terms of the separate weighted errors. For meters with normally shaped error curves there is practically no difference between the two methods of evaluation but where the curve has a pronounced droop at the light load end, which frequently occurs when the bottom bearing is badly worn or a jewel is fractured, then an adjustment based on the weighted overall error will be to the consumer's advantage. Fig. 7 illustrates examples of weighted errors. Fig. 8 shows a typical average annual domestic consumption characteristic and a basis for adjustments.

8.3 **Meter Dimensions and Accommodation**

Standards and specifications for meters and associated equipment, particularly in respect of dimensions, have been found to be conducive to favourable consumer relations. Although the dimensions of only single-phase meters are covered by BS 37, the majority of makes of polyphase meters are of similar dimensions, and specifications can be framed accordingly. Thus meter accommodation, for which the consumer has to pay, can be kept to a minimum in respect of both space and costs which is appreciated by all concerned.

9. CONCLUSIONS

Considerable improvement is evident in respect of design, construction and testing of electricity meters over the last 40 years. Ratings, dimensions and even carrying handles which are desirable for moving meters, have generally been standardized which has proved to be both advantageous and convenient. Polyphase meters with very few exceptions employ single-disc rotors, the problem of mutual interference between elements having been overcome. This factor is largely responsible for the relatively small overall dimensions of modern polyphase meters.

Prices of these standard meters are generally similar making adjudication of tenders somewhat difficult at times. Occasionally lower priced meters are offered, but these usually do not comply strictly with the requirements of the relevant specification.

Testing methods have to a large extent been automated and more time may therefore be spent by the personnel on reconditioning used meters.

Systems of metering have barely changed except in measurement of kVA demand, summation and telemetering.

10. ACKNOWLEDGEMENTS

The author expresses his appreciation to the Association of Municipal Electricity Undertakings of South Africa for being invited to present this paper and to the City Electrical Engineer of Cape Town for permission to do so and for the use of Departmental data where necessary.

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APPENDIX

It is well known that developments in electronics engineering during the last 30 - 40 years extended to the field of electrical measurements for many applications but it is only during the last few years that the accurate measurement of electrical energy by such means became possible and acceptable.

The outstanding features of this new application compared with induction energy meters is the high degree of accuracy obtainable and the very low burden these static meters impose on associated instrument transformers. Also both import and export metering facilities are possible with one instrument.

Earlier attempts to achieve a static meter were based on the Hall effect but were not acceptable to metering engineers on account of the general instability of the semi-conductors used at the time.

Favourable developments in stable components including devices such as Zener diodes, trigger circuitry etc. have now resulted in the development of solid state electronic energy meters of high accuracy. The main disadvantage is the present high cost – over R1 000 for a class 0,2 accuracy meter. However, these meters are now attracting the attention of electricity suppliers particularly where supplies to large cities etc. are concerned. Further, the adoption of static meters on a large scale is likely to alter the usual conception of testing and maintenance. However, the use of these meters on domestic supplies is a long way off but metering engineers will be watching developments in this regard.

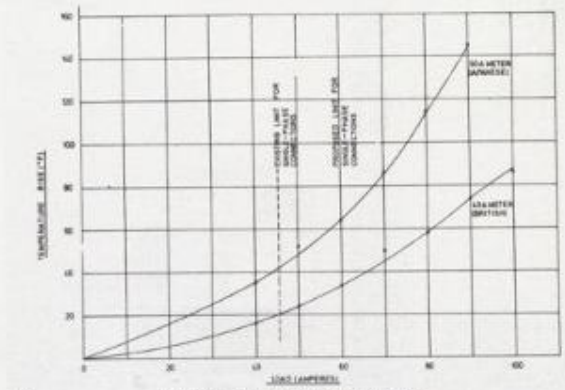

FIG1 TEMPERATURE RISE OF SINGLE-PHASE METERS

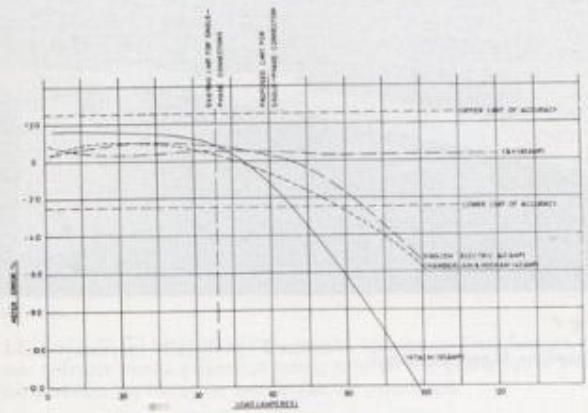

FIG2 PERFORMANCE OF SINGLE-PHASE METERS – M.C.R. SERIES

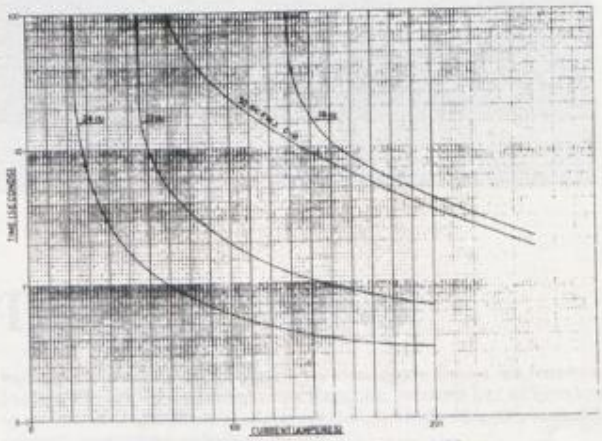

FIG3 FUSING CHARACTERISTICS OF TINNED COPPER WIRE & TRIPPING CHARACTERISTIC OF MINIATURE FWU CIRCUIT BREAKER

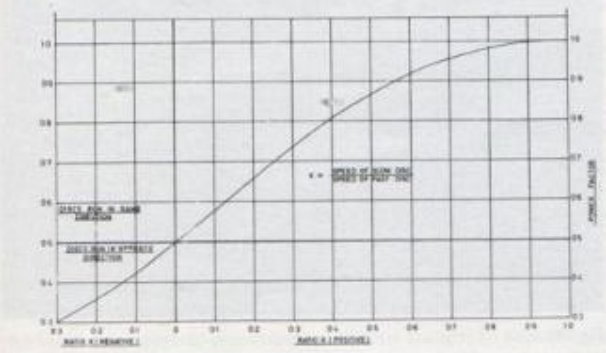

FIG4 TWO-WATT METER PRINCIPLE: POWER FACTOR

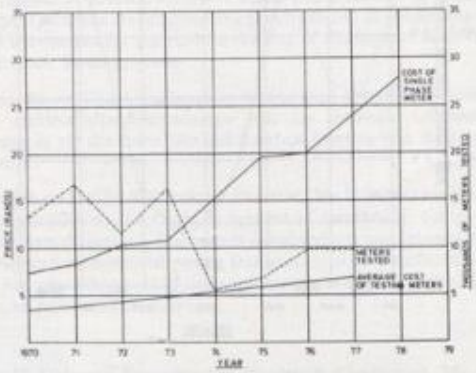

FIG5 COST OF METERS AND TESTING

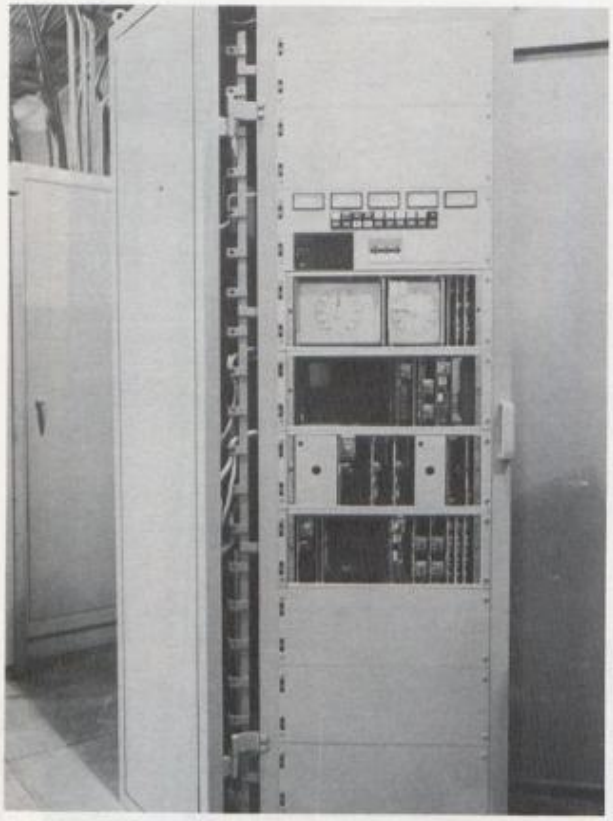

Fig 6

— Load Control Monitor/Computer

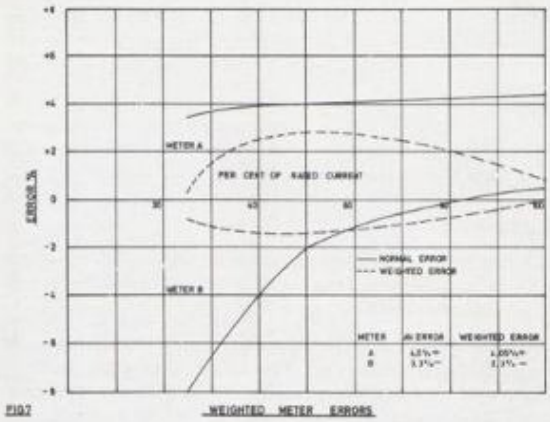

FIG7 WEIGHTED METER ERRORS

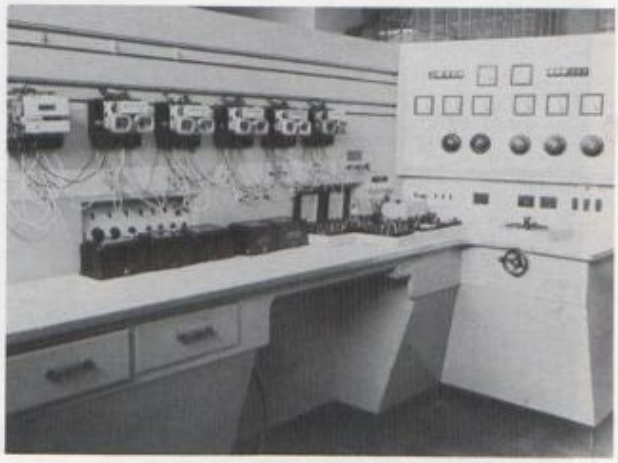

Fig 9

Polyphase Meter Test Bench

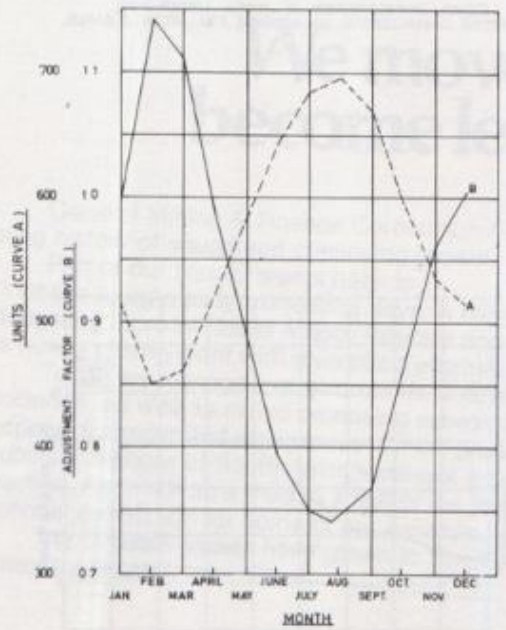

FIG 8 AVERAGE DOMESTIC CONSUMPTION AND ADJUSTMENT FACTOR

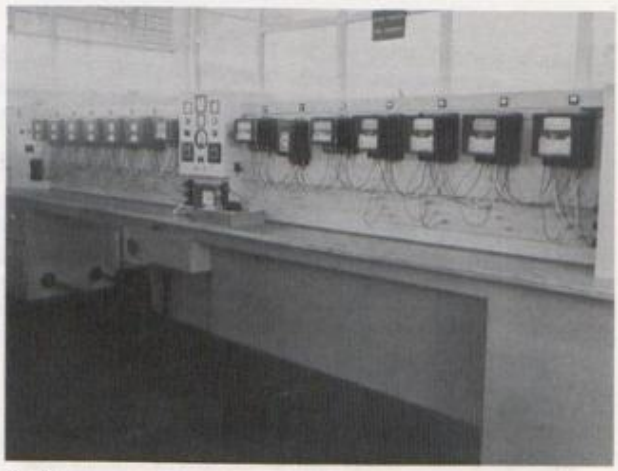

Fig 10

Single and Polyphase Meter Test Bench

Fig. 11

Instrument Transformer and Relay Testing Facilities

BESPREKINGS/DISCUSSIONS

MR K.G. ROBSON: PRESIDENT

Mnr. Heydenrych sal u asb. die bespreking inlei oor mnr. Gilmour se referaat.

J.E. Heydenrych: Middelburg (Transvaal): Meneer die President, ek wil mnr Gilmour hartlik gelukwens met sy referaat wat getuig van sy intieme praktiese en teoretiese kennis van die onderwerp.

Vergeleke met die twee referate wat gister gelewer is, is die tema van hierdie referaat in die geheel gesien, 'n meer wetenskaplike een met duidelik neergelegde riglyne en doelstellings en bevat dus nie soveel aanvegbare stellings en subjektiewe benaderings wat tot meningsverskille aanleiding kan gee nie.

Soos Mnr Gilmour tereg aangedui het, is die akkurate meting van elektriese energie die belangrike plig van elke voorsieningsowerheid en afwykings van hierdie beginsel kan verreikende finansiële implikasies vir verbruiker sowel as voorsiener inhou.

With regard to the use of single phase meters on three phase four wire metered supplies, it has been our experience that, notwithstanding the additional mounting space and administrative work involved, single phase meters are preferred because they provide automatic detection of open circuited voltage coils or short circuited current coils by virtue of zero consumption being indicated when meters are read. Similars errors on polyphase meters may go undetected for long periods because the remaining metering elements still produce a reading. There is also a cost advantage in the use of single phase meters compared to polyphase meters.

While on the subject of cost, I cannot resist the temptation to question the alarming escalation in the price of single phase meters. The average increase over the last 5 years of 21% per annum quoted by Mr Gilmour seems extravagant when compared to the national inflation rate over the same period.

Although coin operated prepayment meters are losing their popularity as standard electricity supply meters, they are invaluable in preventing abuse of cooking or heating appliances in public kitchens. Due to the high load of these appliances however, three phase meters are required, but as these are unobtainable in the Republic, recourse had to be taken to the use of single phase prepayment meters which were mechanically coupled to standard polyphase meters.

The principle of weighted errors in determining the overall accuracy of meters has certain merit and has been discussed by the Highveld Branch of the AMEU. It would however probably not find universal acceptance because the method would be to the disadvantage of those consumers whose load characteristics do not comply with the average load pattern and also because of the general use of standard range meters to meter all consumers within the range of 10 to 80 amps. In the Transvaal the Standard Electricity Bylaws provide that the average error of the four tests specified in SABS 01-1953 shall not exceed 5% and the weighted error principle can therefore not be applied in that province.

Mr Gilmour only touched briefly upon the subject of telemetry and then only in respect of demand meters. I would therefore like to enquire whether Cape Town has investigated the practicability of employing telemetry for kWh-meters for the remote reading of consumers' meters and, if so, what their findings were.

Die vereistes vir Klas A-toetsstasies is geheel en al buite die vermoë van kleiner elektrisiteitsondernemings wat op erkende toetsoutoriteite aangewese is vir die toets van substandaardmeters wat deur hulle gebruik word.

In his notes on the SABS Code of Practise, Mr Gilmour suggested further amendments to the Code in respect of tolerances, timing devices and waveform distortion. The recent development and introduction by a South African company of power transducers with maximum errors of ±0.5% has now also created the need for the inclusion in the Code of a section on power transducers.

J. L. F. H. Delport : Edenvale: Mr. President, Gentlemen, Mr. Gilmour must be congratulated on his valuable and comprehensive paper which I have read with great interest. He has covered the field of modern electric metering practice fairly extensively, although it is considered that

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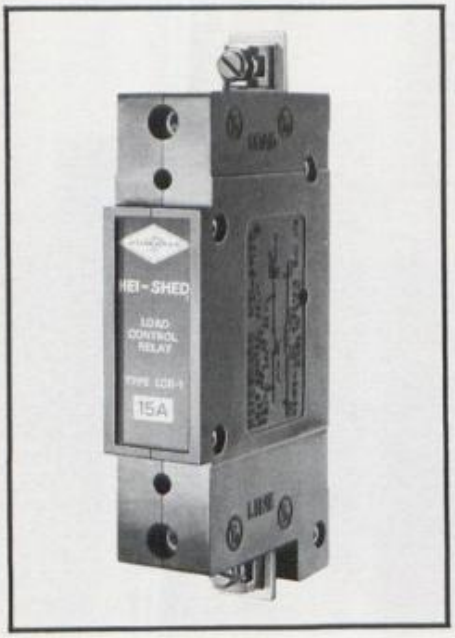


HEI-SHED LOAD CONTROL RELAY TYPE LCR-1

FEATURES

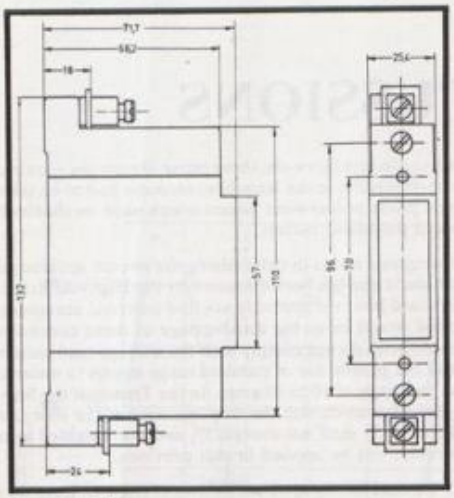
- ☐ Uses hydraulic magnetic principle of operation.
- ☐ Accurate trip points irrespective of ambient temperature.
- ☐ Quick reset when primary circuit is switched off.
- ☐ Clip in or surface mounting
- ☐ Attractive appearance.

The new HEINEMANN Load Control Relay has been produced with energy saving in mind and to meet the fast growing need for control devices of this type, which — by their operation — help directly to reduce peak load.

With known world energy sources slowly dwindling the "save it" campaign is already well established with actual consumers looking more closely at their costs for electricity consumed and Municipal Authorities and Supply Undertakings becoming ever more anxious to reduce peak demand without severe inconvenience to the customer.

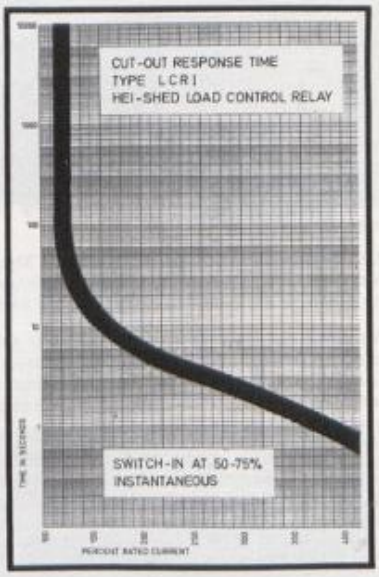
The Hei-Shed LCR-1 unit, if fitted as a rule,on large City and Municipal development could contribute effectively to stability and control of supply at peak hours. It could thus help to prevent the major black-outs, such as have begun to occur due to overloading of systems when generating capacity is stretched to its limits

The automatic operation of the Hei-Shed can be pre-planned by the Engineer or Consultant to fit admirably into his plans for economic design of installations due to its effect on diversity of load under peak or other defined conditions of supply.



Operating characteristic

1. Calibrated to switch off the controlled circuit at 125% of Main Circuit Rating chosen. Max. time delay 2 mins.
2. Unaffected by "Hot" or "Cold" start, or ambient conditions.
3. Automatically switches controlled circuit back on at 50 — 75% of Main Circuit Rating chosen.
4. Immediate re-switching of controlled circuit at Zero Main Circuit Load.



Construction

The Hei-Shed Load Control Relay is soundly based on the well proven Hydraulic Magnetic principle and the device is therefore generally free from characteristic change due to ambient variation. It is also able, due to the Hydraulic Magnetic principle, to differentiate accurately and swiftly to sudden load change, so that there is no thermal inertia delay involved.

The hydraulic magnetic design monitors directly through its series connected solenoid the current in the main circuit such that at a pre-selected point the hermetically sealed magnetic core moves against a spring along the dashpot to the top of the solenoid. At this stage the magnetic reluctance has reduced sufficiently so that the armature is attracted to the solenoid and it is this armature which operates an adjusted lever to switch off the controlled circuit. The dashpot itself is filled with carefully selected oil, thus providing the product with the well known time delay characteristic accompanying this type of design.

Reduction of the Main supply below the preset tolerance band of current allows the magnetic core to return to its original position thus releasing the armature and allowing the Controlled Circuit switch to reclose.

The propriety switch used to interrupt and restore the controlled circuit is carefully selected for its reliability and performance and is supported by the well established HEINEMANN guarantee arrangements.

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the inclusion of a section on summation metering would have been a useful addition.

Referring to his remarks regarding friction torque of meters, it should be noted that the friction of modern magnetic bearings is not claimed to be less than that of jewelled bearings, and may even be higher. However, the pressure on the guide pins is of the order of 0,1 kg/mm², compared with approximately 100 kg/mm² for jewelled bearings. There is therefore no noticeable wear on the rustless steel pins or graphite ring journals after millions of revolutions.

Mr Gilmour touches on the problems associated with distortion of the current and voltage wave forms. His comments on the provision of metering for high harmonic content loads, associated with thyristor control, will be appreciated. Under these conditions the induction type meter has a rapidly increasing positive error for cut-off angles exceeding 90°, especially when supplying a lagging power factor load.

With regard to meters associated with instrument transformers, most engineers are familiar with the difficulties encountered when an error is introduced due to a blown P.T. fuse or incorrect wiring. Adjustment to accounts can seldom be made to the satisfaction of both parties. In order to alleviate the first-mentioned problem to some extent it is standard practice in the undertaking with which I am associated, to install 15 watt 220 volt pigmy type indicating lamps on the secondaries of metering potential transformers. This enables maintenance personnel and meter readers to detect a blown fuse at an early stage. Neon type indicating lamps were found to be unsuitable for this purpose. The wiring on every metering installation involving demand metering, or where instrument transformers are used, is inspected by staff of the test department. This inspection includes polarity checks and continuity tests. The test report has also proved to be a valuable means of checking the correctness of metering constants.

The author stresses the importance of proper sealing and regular inspection of meters. The difficulties of obtaining convictions for tampering are well known. Meters with maximum demand indicators which can be reset from the outside of the case present a further problem, and one wonders why meters with maximum demand indicators which can only be reset by a special key are not available. The introduction of the cumulative demand register meter is considered to be of great importance. Not only does the register provide a much needed check on the meter reader, but it also enables detection of any tampering with the demand indicator by the consumer. In view of its considerable advantages this is now the only type of maximum demand meter purchased by the Germiston City Council.

A problem which is frequently encountered with whole current maximum demand indicating meters with integral timers, is that loss of the supply on the phase from which the timer motor is supplied prevents resetting of the demand indicating pointer drive, causing the demand indicator to over-register. Where the supply interruption on the one phase is lengthy, the pointer will be driven off scale. For shorter interruptions the over-registration may go undetected, to the consumer's disadvantage. This situation would not arise if the clutch on the pointer drive were to disengage on loss of supply, as the pointer drive would then remain stationary during this period.

It would appear that in service, selective, or sample testing of meter accuracy after a certain period of service has advantages for small as well as large electricity undertakings, and could avoid unnecessarily early removal for overhaul. The author's views on this matter would be of interest.

As far as the use of overhauled old meters is concerned, such meters may give a better performance than when new. This is because the magnets have had a longer time to age, and the stresses present in the materials used in the manufacture of the new meters have been relieved.

In Edenvale het ons ook eksperimente uitgevoer met soortgelyke metertoerusting en by 30 verbruikers, wie se maksimum aanvraag wissel van 61,2 tot 1392 kVA.

In 29 of these cases, Mr. President, we found that with the thermal or lagged meter up to 42% more than the integrating meter, the bigger differences were registered on the lower loads. We have found the thermal meter is advantageous on heavily inductive loads and this we put down to the fact that the thermal meter is operative on the full zero lag to zero lead power factor range.

Apart from the advantage mentioned, we found that current transformers of a lower V A rating can be used, which results in a saving on capital as well as in space.

Die termiese meter is ook beskikbaar met 'n kWH-registreerder wat dit moontlik maak met een meter instede van twee (die maksimum aanvraag-en-energiemeter), wat gebruik moet word wanneer die integrerende toerusting gebruik word. Behalwe die finansiële besparing is spasie altyd 'n probleem waar twee meters gebruik moet word.

Mr. President as a "meter man," I must admit that I do have a soft spot for the integrating meter but, in my present occupation, being in charge of an electricity undertaking where the capital expenditure and the revenue must follow the same pattern, when graphs are produced of these commodities, the operation of the thermal meter along its logarithmic curve warms my heart.

Mr President, in conclusion, I would like to thank Mr. Gilmour for having prepared this paper, which is a fine addition to the proceedings of this Association.

I. Boyack : Pretoria: The author has made reference to various sources of metering errors and to the interpretation of meter errors in relation to accounts. The following figures which cover the repair and recalibration of some 15 000 single phase meters over a period of two years may be of interest:-

TYPE OF FAULT	PER CENT OF TOTAL
Voltage coil	3,35
Gear mechanism	1,13
Damage due to overload	0,94
Magnet	0,58
Bearings	0,54
Current coil	0,15

It is noted that the author advocates sample testing of new single phase meters. In this respect all new meters in Pretoria are tested in accordance with the SABS Code of Practice. Tampering with meters is minimal and is less than the figure of 0,1 per cent quoted.

For the detection of meter errors, reliance is placed on the meter readers reporting faults and on routine changes. Where demand metering is used an interpretation of the monthly reading is made by the technical staff together with a monthly print out of the load factor.

The method of dealing with meter errors in relation to accounts has always been a problem and in our case consumer relations are enhanced by installing a calibrated test meter on the premises and operating this meter and the consumer's meter for a period of four to six weeks, thus providing an average error associated with the particular type of loading.

With regard to demand metering the author has compared the thermal and integrating meter. A disadvantage of the thermal meter is that the scale is non uniform and can lead to complaints of inaccurate reading when the metering constant is large. For this reason the practice in Pretoria is to use thermal demand meters using the rectifier principle for metering constants up to 12 000 and integrating demand meters for metering constants above this value. For particularly large consumers where it is necessary to summate a number of supply feeders, impulse metering schemes using solid state pulse generators and print out facilities are used. These schemes incorporate check meters and with a view to reliability, it would be appreciated if the author could provide further information regarding the long term stability and accuracy of solid state type meters.

I would like to thank Mr Gilmour for his interesting paper.

H. Frankle : GEC Power Distribution (Pty) Ltd: Mr. Gilmour is to be congratulated on a very interesting paper. I would now like to add a few comments.

The main and very significant improvements made in modern meters in recent years do, as suggested, hinge around the question of friction torgue levels. By the introduction of magnetic bearings and improved registering mechanisms using high performance moulded gears and stainless steel shafts, and by strict quality control of allowable tolerances, friction levels and rates of wear have been reduced considerably, resulting in accuracy at low loads being maintained for longer service periods, and overall the need for high driving torques has been reduced.

As Mr. Gilmour states, severe friction could be introduced if incorrect meshing takes place and this very important fact is recognised by reputable manufacturers who use specialised equipment such as a shadowgraph to ensure fully satisfactory meshing.

Another improvement referred to is in the design and materials of permanent magnets. Modern magnets are extremely stable and are little affected by South Africa's severe lightning conditions as was the case only a few years ago, when it was not uncommon to suddenly have a meter speed up by some 20% after suffering a lightning surge. On the subject of our severe lightning conditions, we have found that, by encapsulating meter coils, a big improvement in insulation levels is obtained and, on tests we have carried out in our own South African laboratories, we find that an impulse level of around 20kV on a 1/50 wave shape is achieved. B S S only lays down a level of 13kV which is based on allowable clearances of 2 kV per millimetre.

Concerning paragraph 3.5, harmonic distortion is an everincreasing

worldwide problem in distribution systems and this is being recognised by incorporating the appropriate tests in the new draft BS 37.

On the question of tampering raised in paragraph 3.9, this is a matter which is receiving more and more attention by supply authorities and manufacturers alike (and probably by would-be thieves as well) especially now that electricity costs are soaring.

Papers have been written on this subject before, the most recent being by A.P. Fleming presented at the I.E.E. "Metering Apparatus and Tariffs for Electricity Supply" Conference in London last November.

A useful deterrent now used to some extent in the U.K. is the fitting of tamperproof screws to the front cover and terminal cover. These screws just permit clockwise rotation and can only be removed by overtightening – which fractures the screw shaft across a specially reduced section. This immediately makes it evident that the meter has been tampered with.

Concerning recertification periods referred to in paragraph 3.10, practice in the U.K. at present provides for a duration of 20 years, which period has proved itself for pivot and jewel type meters. This was determined after tests conducted every 5 years over a 20 year period. The first 5 year survey on magnetic bearing meters already indicates an improvement over pivot meters.

Prices

Mr. Gilmour is of course quite right when he says that the cost of meters has risen sharply over the last 5 years, but the rate of increase does not compare unfavourably with other types of labour intensive products which have perforce been affected by world wide inflationary trends over the last few years. The import surcharge imposed in April 1977 also contributed to the escalation. It must be mentioned that the increase in prices does relate to the increase in costs and, in fact, profit is less than it was 5 years ago.

However, despite everything, it is generally agreed that the price, especially of S.P. meters, is still very good value for money when it is considered how much effort is put into design etc. to achieve the very accurate results now obtained. Mr. Gilmour's point is therefore taken concerning the question of old meters being reconditioned and put back into service and this of course **illustrates the need to buy proven long service life meters with low maintenance requirements in the first instance.**

In conclusion, Mr. Gilmour's remarks under paragraph 8.1 are very valid, especially in this day and age of rising electricity costs and, although the S.A. Code of Practice is not yet compulsory, it is in their own interests for all supply authorities to ensure that all their installed meters are checked and maintained on a regular basis.

W. Barnard : Johannesburg:

Tampering

The incidence of tampering is low, only 23 cases per 10 000 meters per annum, except in certain subsidised housing schemes, where special measures have had to be taken both in regard to tampering with meters and illegal re-connection of supply.

Handling and Maintenance

The cost of testing meters is given in Figure 5 as R7 per meter. Assuming that all facilities exist for other reasons, the cost will be less and, in Johannesburg, is between 50c and 60c per meter. However, the cost of changing meters, which may be included in the R7, precludes testing at more frequent intervals.

Comparison of Characteristics and Performance

The comparison of thermal and integrating demand meters quoted, gives some unexpected figures. Our rectifier kVA thermal demand meters are adjusted to within 0,6% of a substandard meter over the full operating range. Any error in excess of 1% of f.s.d. (let alone actual reading) would give cause for investigation. However, a 'peaky' load curve can cause readings in excess of those recorded by an integrating meter and the annexure gives some test results. It is difficult to understand the negative errors quoted in the paper. In the experience of Johannesburg, thermal demand meters have proved more stable and reliable than the equivalent integrating meters and the only disadvantage is that it is not possible to obtain a record of the demand related to time of day. Allied to this is the difficulty of telemetering the indication without a significant increase in the cost of the meter.

Metering Transformers

In Johannesburg the practice is to adjust the meter to compensate for errors in CT's and VT's. Details of errors are maintained in a card index system to facilitate determination of the replacement cycles of meters.

REPORT ON TESTS CONDUCTED ON BLOCK AND THERMAL DEMAND METERS TO DETERMINE THEIR RELATIVE ACCURACIES

1. **Conclusions**

(a) Under various load conditions, namely stepped load and linearly varying load, the thermal demand meter gave a reading which was considerably higher than that of the block demand meter. This is in favour of the supply authority. A unity power factor was used for the experiment.

(b) The thermal demand meter had a 15 minute rating and, with the constant load (maximum specified for the meter), gave a reading of 95% of the actual load after the 15 minutes.

For the block demand meter, which had a 30 minute rating, the reading was 104% of the applied load after the 30 minutes.

(c) It should also be noted that Escom uses a 60 minute block demand, which would give readings even lower than those obtained by a 30 minute meter. A 60 minute meter was not available for the test.

(d) The disadvantage with the block demand meter is that its reading is dependent on whether or not the load is started simultaneously with its 30 minute timer, and the conditions obtaining in practice are very seldom such as to give the highest reading. Ther thermal meter, however, gives the same reading regardless of the instant in time at which the load is applied.

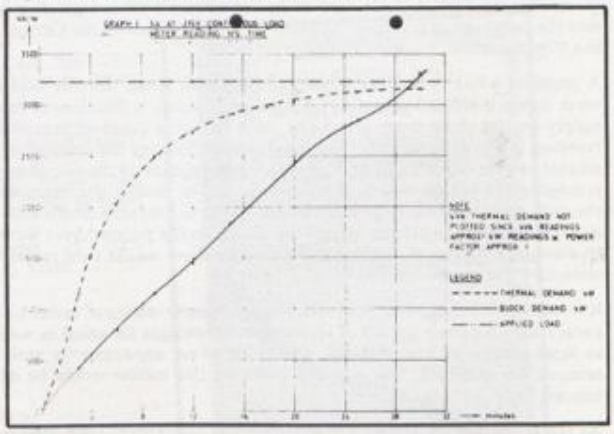
(e) The ratios of **thermal** demand to **block** demand are as follows:-
(i) Steady load: Average ratio is 1 : 0,68
(ii) Linearly varying: Average ratio is 1 : 0,53
(iii) Stepped load: Average ratio is 1 : 0,64
(iv) Linearly decreasing: Average ratio is 1 : 0,53

2. **Summary**

(a) Three load meters, a block (kW), a thermal (kW), and a thermal (kVA) maximum demand meter, were connected in series and applied to the same load conditions.

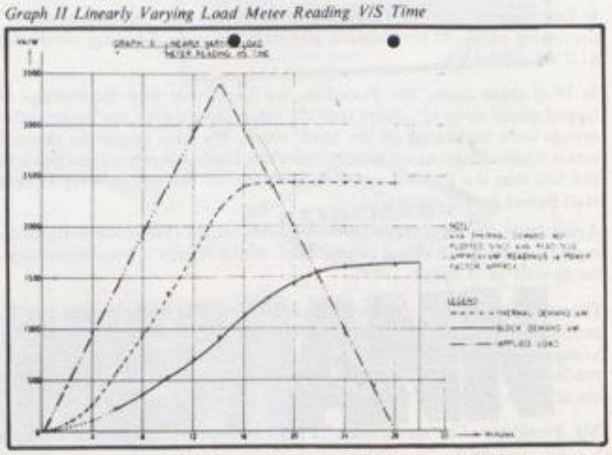
(b) Graph I shows the behaviour of each meter under a steady 5 A load.

Graph I 5A at 215V Continuous Load Meter Reading V/S Time



(c) Graph II shows the behaviour of each meter under a linearly increasing load from 0 to 5,2 amps lasting 14 minutes and then linearly decreasing from 5,2 to 0 amps over a further 14 minutes.

Graph II Linearly Varying Load Meter Reading V/S Time



Mr Frankle: Your remarks on the design and construction of meters and also on the escalation in costs, were noted with interest.

Mr Barnard: The incidence of tampering with meters i.e. 23 in 10 000 meters inspected or 0,23% compares favourably with the rate in Cape Town e.g. 0,1% during 1975 and predicted 0,4% during 1978 an average of 0,25%.

The remarks on token operated meters were noted with interest.

The cost of R7 for testing a meter as at 1977 is the overall cost of the whole operation i.e. wages and transport for the meter erector, wages for the meter tester and administrative costs etc. This would be the amount c rand given in my formula in Section 3.10 of my paper.

Thermal demand meters have disadvantages and advantages. As mentioned in the paper they may be more equitable from thermal loading considerations but the choice depends largely on the definition of demand in a tariff or agreement.

Only a recording demand meter can indicate when the maximum demand occurs. Cape Town has permitted consumers to be billed on such instruments where they have agreed to pay the difference in cost. All current transformers and 11 kV voltage transformers ar tested by Cape Town's Undertaking. There are no ehv consumers being supplied above 11 kV.

Mr Pretorius: A comparison of thermal and integrating demand meters has been made in the paper, taking into account the difference between steady and peaky loads.

Mr Trautmann: Facilities for replacing meter coils particularly voltage coils would be an advantage. This is something for the suppliers to note.

Mr Van der Velde: The comments on load and demand were noted but have been covered in the paper.

Councillor Lemmer: A purely electrical meter for kWh measurement appears to be answered by electronic developments. Analogue and digital principles are being used in electronic meters which will no doubt eventually display the consumption in LED readouts. As they are still too costly, it will be a long time before these meters will be used for domestic supplies. Meter testing techniques will change when this does happen.

The question of voltage drop on the accuracy of a meter is surely irrelevant if an installation is wired with the correct conductors and properly carried out.

Mr Gamble: Meters should of course be calibrated to register accurately at all power factors. However, low leading power factors can be troublesome not only in respect of metering but on the supply system also. Cape Town does not permit such power factors. Thank you.

Mr K.G. Robson: President: Mr Gilmour, may I congratulate you on behalf of us all on your presentation and the evident competence in your replies to the very many questions. I have the feeling that you could have talked to us for another ten hours non-stop. It is an indication, I think, of the content of your paper and I would warmly endorse Councillor Van der Velde's highly complimentary remarks about you and your obvious value to the Cape Town Electricity Undertaking. Your paper undoubtedly contributes a valuable updated addition to the technical proceedings of the AMEU and for this we are very grateful. Thank you for having accepted the invitation to present the paper.

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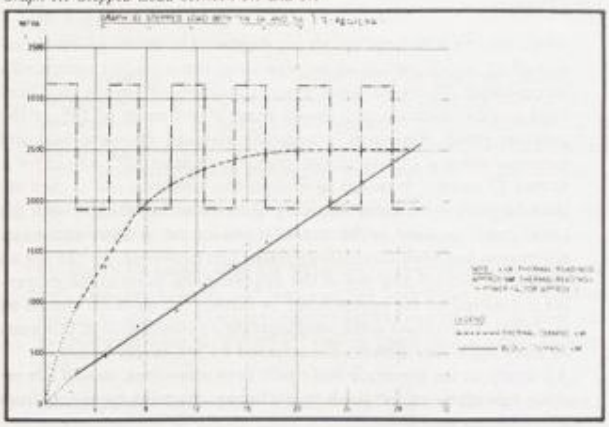
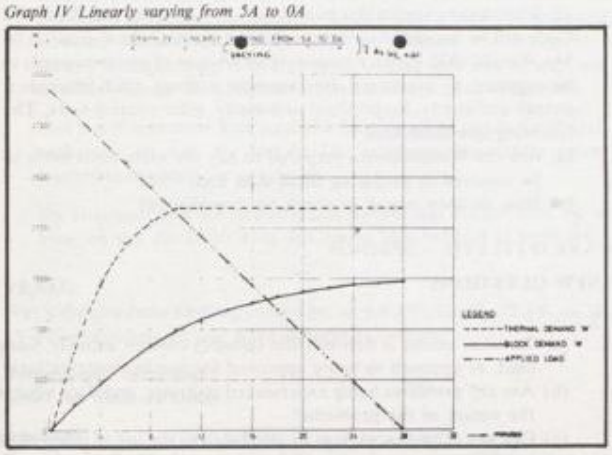
(d) Graph III shows the behaviour of each meter under a stepped load between 3 amps and 5 amps. There are 2,5 minute intervals between steps.

Graph III Stepped Load between 3A and 5A



(e) Graph IV shows the behaviour of each meter under a linearly decreasing load from 5 amps to zero load.

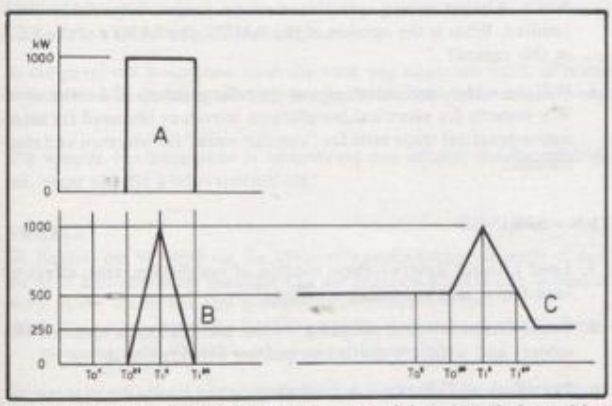
Graph IV Linearly varying from 5A to 0A



E. de C. Pretorius, Potchefstroom: Mr. Gilmour states (in par. 5.5) that thermal demand meters overregister on peaky loads. On this aspect I must cross swords with him and put it to him that what actually happens is that integrating meters under-register.

With a peaky load which registers say 500 kVA on an integrating meter and is supplied from a 500-kVA transformer one will probably find that the transformer will overheat.

The question of integrating demand meters versus thermal demand meters is a subject with many pitfalls but I should, nevertheless like to venture pointing out a serious shortcoming of integrating meters.



The three sketches above depict load curves of three installations with a peak load of 1 000 kW. Curves A and B are, admittedly, rather hypothetical but curve C is a reasonable approximation of what could be found in practice.

The integrating interval of an integrating demand meter metering the load is T_0-T_1. The demand that will be registered is dependent, and very much so, on the exact time when the integrating period commences, as is illustrated in the following table.

Load curve	Registered demand (kW)	
	$T_0' - T_1'$	$T_0'' - T_1''$
A	500	1 000
B	250	500
C	625	750

$$(T_0' - T_0'') = \frac{T_0 - T_1}{2}$$

On the question of using three single phase meters to meter a three phase supply I want to sound a note of warning: If the power factor is less than 0,5 (which, admittedly, is irregular but does occasionally occur in practice) one of the meters will run backwards which not only is very confusing to meter-readers and clerks but can play havoc on a computer!

E. Trautmann: Ladysmith: I would like to appeal to certain meter manufacturers to design the meters in such a way, that meter coils can readily be replaced.

In view of the high costs of meters, it seems to be a waste of capital to assemble the meters using rivets and molds, which do not permit the repair of the meters.

Cllr. Van der Velde: Cape Town: Mr President, it gives me pleasure to congratulate Mr Gilmour on a very excellent paper. It is nice to know, as a public representative of the people of Cape Town, that we have somebody of such skill looking after our affairs.

Many speakers have spoken of the differences under different load conditions that one obtains between the thermal and the integrated meter. My question is a very simple one, namely "Which is the correct intepretation of the load as far as the capital equipment is concerned?"

Cllr. C.M. Lemmer: Benoni: I am of the opinion that an electrical current cannot be measured mechanically. To measure it correctly it should be done electronically. A computerised mechanism should be used and the figures transferred over (via photocells or any such thing) to a mechanical meter independently connected, so that a readable figure can be seen in case of a power failure. This will also eradicate tampering.

J.S. Gamble: Greytown: Mr President, I am really a seeker of information in this case. I would like to ask Mr Gilmour if he had ever come across the problem of metering a consumer at a very low leading power factor and what sort of accuracy can be expected with a thermal demand type kilowatt-hour meter? This problem has arisen and it has got me in a spot, because the consumer comes under the Mines Act and I have no control.

Mr R.R. Gilmour: Cape Town: May I offer the following replies to those who have taken part in the discussion on my paper:

Mr Heydenrych: Three single phase meters in lieu of a polyphase meter have advantages from a technical point of view but not so administratively.

Prepayment meters have advantages and disadvantages. Token operated meters have advantages over coin operated meters, particularly in respect of break-ins which are reduced if tokens are employed as they cannot be re-used if stolen from a meter.

The Cape Town City Council abandoned these meters finally when those left in sub-economic dwellings were frequently rendered in-operative by cockroaches which entered the meters via the coin slot.

Mr Delport: It is not possible to predict accurately the relative merits of magnetic bearings compared with jewel/pivot bearings since meters with magnetic bearings have not been in existence long enough yet. Harmonics, or distortion, is an important consideration. A recent report was received from a domestic consumer to the effect that the mains waveform was badly distorted. An investigation confirmed this and the source was traced to a traction system fed from the same busbars as the stepdown substation concerned.

Steps were taken to have the matter rectified. However, it was established that the distortion had existed for many months and had the consumer disputed the accuracy of his meter, an embarrassing situation could have arisen.

As mentioned in the paper the choice of demand meter type is a matter of individual preference.

It is true that the magnets in old meters have been adequately aged.

LEDEFORUM

VRAE WAT OORGESTAAN HET VAN DIE TEGNIESE VERGADERING, 1976

1. Met die hantering van groot kontrakte blyk dit die algemene gebruik van munisipaliteite te wees om aansienlike retensiegelde plus sekuriteitsborge te vereis. Die retensies is soms 20% van die totale kontrakwaarde met sekuriteitsborge van 10% van die kontrakwaarde. Retensies verminder na afhandeling van die kontrak maar gewoonlik word 10% vir 'n verdere 12 maande agterweë gehou. Dit moet besef word dat tenderaars hiervoor voorsiening maak wat die uiteindelike kontrakprys sal verhoog. Daar kan geen rede gesien word om uitbetaling van die retensiegelde te weerhou sodra die toerusting afgelewer en getoets is nie aangesien die sekuriteitsborge dekking verleen. 'n Verdere volle betaling behoort gemaak te word sodra die toerusting opgerig en in werking is.

   Aangesien sekuriteitsborge minder uitgawe beteken as retensiegelde behoort hulle nie geheel en al uitgesluit te word van alle kontrakte en bestellings nie?

MEMBERS' FORUM

QUESTIONS STANDING OVER FROM THE 1976 TECHNICAL MEETING

1. When dealing with large contracts, it appears to be the general practice of all municipalities to require large retentions in addition to surety bonds. The retention is often as much as 20% of the total contract price in addition to a surety bond to the value of 10% of the contract price. Retention is normally reduced once erection and commissioning is complete, but generally at least 10% is held for a further 12 months. It should be realised that tenderers add to their estimated price the cost of financing these retention monies with the consequent increase in the overall contract price. Once the major equipment has been successfully tested and delivered, we can see no reason for withholding any of the delivered site value as the guarantee is covered by the surety bond. A further full payment should be made for the erection and commissioning on completion of this work as once again any defects are covered by the surety bonds.
   As surety bonds are much less costly than retentions, should not serious consideration be given to excluding retention payments from all contracts and orders?

MNR./MR. P.P. CAPRA - GEC POWER DISTRIBUTION (PTY) LTD - GERMISTON

2. Die SABS-Kode vir Straatverligting is gebaseer op CIE-publikasie nr. 12. Met die hersiening van hierdie publikasie word aanvaar dat die SABS-Kode gewysig sal word. Soos ek aangedui het toe ek mnr. Wood se 1975-referaat geopen het, sal 'n aansienlike hoeveelheid bykomstige inligting deur tenderaars verskaf moet word.

   Die vraag ontstaan nou:
   (a) Is munisipaliteite bereid om die addisionele koste te betaal wat gepaard sal gaan om hierdie bykomstige inligting te verskaf?
   (b) Hoe beoog hulle om te bepaal of dit wel aan die vereistes voldoen?

2. The SABS Code for streetlighting is based on CIE Publication No. 12. With the revision of this publication, one assumes that the SABS Code will be revised. As I indicated when opening the discussion on Mr. Woods' 1975 Paper, a considerable amount of new data needs to be supplied by tenderers. For example average road luminance, overall uniformity, longitudinal uniformity, glare control mark. The following questions arise:
   (a) Are the Municipalities prepared to pay the extra costs likely to be involved in preparing these data and;
   (b) How do they intend to check for compliance?

MNR./MR. J.T. GRUNDY - PHOSWARE (PTY) LTD - SPRINGS

NUWE VRAE

3.
   (a) Tot watter mate word nie-metaal-(plastiek-) geleibuise werklik gebruik teenoor wat goedgekeur is vir gebruik deur munisipaliteite?
   (b) Word daar enige probleme ondervind met die gebruik daarvan, en indien wel wat is die aard van die probleme?
   (c) Kan enige ekonomiese besparings toegeskryf word aan die gebruik van hierdie tipe geleibuise?

4. (a) Tot watter mate word UPVC-kanale gebruik vir ondergrondse kabels?
   (b) Word enige probleme daarmee ondervind?

NEW QUESTIONS

3.
   (a) To what extent is non-metallic (plastic) conduit actually being used, as opposed to being approved for use in municipalities?
   (b) Are any problems being experienced in its use; and if so, what is the nature of the problems?
   (c) Can any economic savings be attributed to the use of this type of conduit?

4.
   (a) To what extent is UPVC ducting being used for carrying cables underground?
   (b) Are any problems being experienced in its use?

MNR/MR. N.C. SYMINGTON - AECI LIMITED - JOHANNESBURG

5. Tans word die mening gehuldig dat die standaard-bedradingspraktyk in Suid-Afrika waar oorwegend van draadwerk in metaalgeleibuise vir huishoudelike installasies gebruik gemaak word, verouderd is teenoor die nuwe bedradingspraktyke wat nou algemeen oorsee gebruik word en dat hierdie Suid-Afrikaanse bedradingspraktyk nie meer ekonomies geregverdig kan word nie. Wat is die sienswyse van die VMEO, die SABS en die EKV in hierdie verband?

6. Sal die wyer gebruik van nie-metaalgeleibuise en ander bedradingskanale vir elektriese installasies dit regverdig dat alternatiewe praktiese vaktoetse vir "buiswerk" vir draadwerkers en elektrisiëns ingestel word?

5. Apparently the view is presently being held that the standard wiring practice in South Africa where wiring in metallic conduits is commonly used for domestic installations is outdated compared to the new wiring techniques now generally in use overseas and that this South African wiring practice can no longer be economically justified. What is the opinion of the AMEU, the SABS and the ECA in this regard?

6. Will the wider application of non-metallic conduits and other wireway systems for electrical installations introduce the need for alternative practical trade tests for "conduit work" for wiremen and electricians?

MNR/MR. J.K. VON AHLFTEN - SPRINGS

7. Lasbeheerrelês - die metode van installasiekoste, invloed op die lasfaktor en verbruikersreaksie?

8. Onder-frekwensievragvermindering - wat is EVKOM se voorneme hiermee en wat word van munisipaliteite verwag?

9. Die effek van frewensievermindering op die maksimum aanvraag soos geregistreer deur EVKOM se meters?

10. Die wenslikheid al dan nie om aan te dring op 'n verbetering van die akkuraatheid van EVKOM se meters, tans 2½ persent?

7. Load Control Relays - their method of installation, cost, effect on load factor and consumer reactions?

8. Under-frequency load shedding - what are ESCOM's ideas on this subject and what are the municipalities expected to do?

9. The effect of a decrease in frequency on the maximum demand recorded by ESCOM's meters?

10. The desirability or otherwise of calling for an improvement in the accuracy of ESCOM's meters, at present 2½%

GOEIE HOOP-TAK

11. **Stelselaardfoutstrome:**

Inleiding:
In Boksburg is die stelselaardfoutstrome op die 11-kV-stelsel deur middel van aardweerstande tot 300 ampère beperk.

Op 'n gedeelte van die 11-kV-stelsel word toevoer van onlangs inwerkgestelde 132/11-kV-substasies, elk met twee 40-MVA-132/11-kV-transformators, in parallel, (vektorgroep Yyn O, impedansie 22%) verkry. Die berekende maksimum aardfoutstroom met die transformator se neutraalpunte solied geaard is ongeveer 17 280 ampère.

Op die 33-kV-stelsel is die aardfoutstroom deur middel van aardingskompenseerders tot 750 ampère beperk.

Op die 11-kV-stelsel skep die 300-ampère-aardfoutstroom probleme met beskermingsrelês met omgekeerde vertraging tot 'n bepaalde minimum wat onder sekere omstandighede nie in werking kom nie, byvoorbeeld waar sê, vier of vyf toevoergeleidings 'n substasie voorsien.

Aan die ander kant is daar weer besorgdheid oor die baie hoë aardfoutstroom wat as gevolg van die onlangse inwerkgestelde stelsel 'n aardfoutstroom van tot 17 280 ampère kan bereik.

Navrae dui daarop dat die stelselaardfoutstroom van plaaslike owerheid tot plaaslike owerheid verskil en verder dat daar 'n mate van onsekerheid bestaan omtrent die faktore wat 'n ideale of gewenste stelselaardfoutstroom bepaal. EVKOM (Randse en Oranje-Vrystaatse Onderneming) is ook genader en hier blyk ook 'n mate van onsekerheid oor die gewenste stelselaardfoutstroom te bestaan.

Hoë aardfoutstrome kan moontlik buitensporige skade aan kabelomhulsels en aan die stators van hoogspanningsmotore onder foutomstandighede tot gevolg hê.

Dit kom voor asof die stelselaardfoutstrome aan die een kant nie te hoog en aan die ander kant ook nie te laag behoort te wees nie.

VRAAG:
Wat is die gewenste aardfoutstroom by, sê, 6,6-kV-, 11-kV-, 22-kV- en 33-kV-netwerkstelsels en wat is die bepalende faktore?

Vergelykende Statistieke:
Groei van Stede en Dorpe:

Inleiding:
Die Master Builder's and Allied Trades' Association (Witwatersrand) publiseer jaarliks verslae wat die waarde van goedgekeurde bouplanne vir 'n sekere jaar aandui.

In Boksburg lê die Stadsingenieur 'n verslag in hierdie verband met inbegrip van die waarde van goedgekeurde bouplanne, oor 'n aantal agtereenvolgende vorige jare ter inligting en algemene belang, aan die Raad voor.

Raadslede, lede van die publiek, ens. heg baie waarde aan sulke statistieke, aangesien dit die groei en vooruitgang van 'n dorp aandui. Dit toon ook aan hoe 'n sekere dorp in vergelyking met 'n ander vooruitgaan.

Ek is die mening toegedaan dat statistieke van kragverbruik moontlik in kWh of kW of kV, net so betroubaar, indien nie veel meer nie, die groei en grootte van 'n dorp of stad aantoon.

In die geval van bouplanne moet die werk nog uitgevoer word, of is nog in hande, in vergelyking met die kragverbruik wat reeds werklik benut word.

Die waarde van bouplanne is onderhewig aan inflasie van die geldstelsel, maar nie die kWh-verbruik nie.

VRAAG:
(a) Beskou die VEMEO nie die kWh-verbruikstatistieke van stede of dorpe as 'n betroubaarder maatstaf van die groei en grootte van 'n stad of dorp as die statistieke van goedgekeurde bouplanne nie.
(b) Indien wel, behoort die VMEO nie sulke statistieke van lid-ondernemings van die VMEO jaarliks te publiseer nie?

Dit sal sekerlik tot die openbare beeld van die VMEO en die Elektrotegniese Ingenieur bydra.

GOOD HOPE BRANCH.

11. **System Earth Fault Currents:**

Preamble:
In Boksburg the system earth fault current on the 11 kV system is limited to 300 amps via earthing resistors.

On a section of the 11 kV system, however, the supply is taken from recently commissioned 132/11 kV substations each with 2 x 40 MVA, 132/11 vector group Yyn 0, with 22% impedance, transformers in parallel. The calculated maximum earth fault current with the transformer neutrals solidly earthed, is approximately 17 280 amps.

On the 33 kV system, the earth fault current is limited to 750 amps via earthing compensators.

The 300 amp earth fault current on the 11 kV system presents problems with IDMT protection relays becoming inoperative under certain conditions, where for example, a number of 11 kV feeders, say four or five, supply a substation.

On the other hand, there is some concern about the very high earth fault current that could result with the recently commissioned system where the earth fault currents could reach 17 280 amps.

From enquiries made about system earth fault currents, it appears that these vary from local authority to local authority and furthermore that there is a measure of uncertainty about the factors which determine the ideal or desirable system earth fault currents. ESCOM (Rand and Orange Free State Undertaking) was also approached and here also there appears to be a measure of uncertainty as to desirable system earth fault currents.

High earth fault currents are likely to cause excessive damage to cable sheaths and high voltage motor stators, under fault conditions.

It seems, therefore, that system earth fault currents should not be too high on the one hand or too low on the other.

QUESTION:
What are desirable system earth fault currents on, say, 6,6 kV, 11kV, 22kV, and 33kV systems and what are the factors which determine these?

Comparative Statistics:
Growth of Cities and Towns:

Preamble:
The Master Builder's and Allied Trades' Association publishes annual reports containing the value of building plans passed in a particular year.

In Boksburg, the Town Engineer submits a report in this regard, adding the value of building plans passed for a number of successive previous years, to the Council for information and general interest.

For the Councillors, members of the public, etc, these statistics are very meaningful, since they give an indication of the progress of one's town. It also shows how a particular town is progressing when compared with another.

I am of the opinion that statistics of electricity consumption probably in kWh or possibly kW or kV a show just as reliably, if not more so, the growth and size of a city or a town.

In the case of building plans, the work has still to be carried out, or is in the process of being done, whereas the consumption of electricity is a fact and has already taken place.

The value of building plans is also affected by the inflation of a monetary system, whereas the kWh consumed is not.

QUESTION:
(a) Does the AMEU not consider that kWh consumption statistics of cities or towns to be a more reliable barometer of the growth and size of a city or town, than statistics of building plans passed?
(b) If so, should the AMEU not undertake to publish annually, statistics of all the member undertakings of the AMEU.

This surely would add to the public image of the AMEU and the Electrical Engineer.

MNR./MR. A.H.I. FORTMANN - BOKSBURG

12. ACCOUNT ADJUSTMENTS RELATED TO METERING INACCURACIES

At the 90th meeting of the Highveld Branch a discussion took place on accounts adjustments following the discovery of metering errors which had existed for some twenty years. Consensus of opinion was that as the electricity supply regulations limited the period for which repayment can be made in the case of an overcharge to twelve months, this should apply.

At a meeting of the Good Hope Branch on the 23rd November, 1977, however, members pointed out that unde. the Prescription Act No. 68 of 1969 a consumer who has been overcharged can claim a refund over a period of three years, even if the supply regulations stipulate twelve months, because an Act takes preference over an Ordinance. This applies of course only in such cases where the amount overcharged or undercharged can be established absolutely, that is, is due to a connection error or a metering error. It would not apply in the case of poor metering accuracy.

At the 92nd meeting of the Highveld Branch consideration was given to the comments of the Good Hope Branch; some members felt that as the supply regulations were embodied in an agreement concluded between consumer and supplier, the parties should be bound by this agreement and that the twelve months period should apply.

Further, the various possible causes of the over-reading of the meter would complicate the issue, namely, wrong connections, blown fuses, wrong constants, slow or fast registers, etc. There was some doubt as to what constitutes metering.

What does the Forum think?

MR. R.W. BARTON – WELKOM

Messrs. Jules von Ahlften and John Morrison chairing the members' forum session.

Inleiding en Vraag 1/Introduction and Question 1

Mr K.G. Robson : President: En nou is ek bly om u aan mnr. Jules von Ahlften oor te gee vir hierdie sessie van die ledeforum. Mnr. Von Ahlften is een van die vraestellers. Mr John Morrison is the second quizmaster. These gentlemen have established a tradition in leading the forums at our Technical Meetings and I am sure that we have a pleasant morning's discussion ahead of us.

Mnr. Jules von Ahlften : Quizmaster: Dankie, mnr. die President. Menere, soos in die verlede stel ek voor dat ons die vrae bespreek soos hulle op die agenda verskyn. Ek wil 'n versoek aan u almal rig om deel te neem aan die forum.

Menere, ek stel voor dat ons twee van die vrae wat oorgestaan het van 1976 se forum, eerste behandel.

I will ask Mr John Morrison to take over the first question.

Mr John Morrison : Quizmaster: Mr President, Ladies and Gentlemen, it gives me great pleasure to ask Mr Murray Coutts-Trotter to open with the first question.

Mr. C.M. Coutts-Trotter : GEC Power Distribution (Pty) Ltd.: Mr Quizmaster, the question sets out the problem in some detail and I have done a little figuring to illustrate the basic issue. Looking at a fairly large contract say in excess of R100 000 where the manufacturing period is 6 months or so and the 10% retention is paid 12 months after completion or erection, I find that the average working capital is 35% higher than if there were no retention. Return on capital employed is the major yardstick for judging a company's performance. I also looked at one of our Divisions and found that retentions made up 15 to 20% of the capital employed.

From these figures you can judge what effect retention has on the finance of a business and therefore on the bid price.

I must also emphasize that electrical manufacturers do not normally receive progress payments and that payment only starts after completion of tests and inspection. Surety bonds are usually equal in value to the retention.

By requiring fairly large retentions for periods in excess of one year from delivery you are, I believe, unnecessarily raising the cost of equipment to yourselves.

Mr J. Morrison : Quizmaster: Gentlemen, here we have this problem which, Murray points out, viz that it is cheaper for the industrialists to raise a surety bond than to have retention. Can we have contributions from the floor?

Mnr. J.A. Loubser: Benoni: Mnr. die Vraesteller, by ons op Benoni het die Burgermeester 'n nuwe reël vir Raadslede wat in 'n Raadsvergadering oor 'n onderwerp wil praat, in werking gestel, nl. dat voor hulle begin praat, hulle eers duidelik moet stel of hulle vir die voorstel of teen die voorstel gaan praat. Dit dien natuurlik 'n goeie doel, want nou kan 'n mens ten minste seker wees wat die betrokke Raadslid probeer sê.

Uit die staanspoor wil ek dit dus nou duidelik stel dat ek ten gunste van die voorstel is.

Dit is ongelukkig so dat ons ingenieurs wat meer en meer bestuurspligte ook moet waarneem, naderhand betrokke raak in die sogenaamde "romp-slomp" en as sulks word dit dikwels van ons verwag om beslissings te vel in verband met items soos byvoorbeeld retensies, sekuriteitsborge en boeteklousules. Die meeste van ons voel egter dat ons tyd te veel in beslag geneem word deur argumente hieroor en gevolglik is dit sekerlik natuurlik dat ons dit sal wil uitskakel. Dit laat my nou dink aan die woorde van 'n vorige stadstesourier toe hy gesê het dat ons ingenieurs almal een spreekwoord het nl. "Let's cut out the red tape and get on with the job."

As ek egter nugter dink oor die saak, dan moet ek erken dat dit wel noodsaaklik is om die Raad en dus die belastingbetalers te beskerm teen moontlike wangebruike en ek dink die kontrakteurs teenwoordig, sal met my saamstem dat so iets wel nodig is. As retensies dan werklik 'n invloed het op die kontrakprys, dan is dit ons plig om die voorstel van Mnr. Capra te steun.

Ek wil dit egter ook duidelik stel dat die toestande nie heeltemal so donker is soos deur hom gestel nie. Die meeste van ons dring net aan op 10% retensie wat verminder word na 5% na voltooiing van die kontrak en die balans is dan betaalbaar 6 maande later.

Daar is egter iets in verband met sekuriteitsborge wat vir my nie heeltemal duidelik is nie. As ek byvoorbeeld as 'n privaat persoon 'n motorkar wil aankoop wat bestel moet word, met ander woorde, wat nie op voorraad is nie, dan word daar van my verwag om 'n bedrag te deponeer wat as sekuriteit vir my bestelling sal dien. As die Stadsraad egter sodanige voertuig per openbare tender aankoop, en die voertuig kan nie binne 14 dae afgelewer word nie, dan word daar van die **voorsiener** van sodanige voertuig verwag om sekuriteitborg te verskaf. Dit klink nie logies nie.

Mnr. die Vraesteller, u sal onthou dat die doel van die Niemand-kommissie eintlik is om die pryse van erwe te verlaag. Daar is nou al baie tyd en geld aan die vereistes van die kommissie bestee en ek en u weet dat dit voorwaar geen invloed gaan hê op die verkoopprys van die erwe nie. Die verantwoordelikheid word net meer op die skouers van die belastingbetaler geplaas en die wins van die dorpsontwikkellaar gaan net hoër wees. Nou wonder ek net; indien ons sou besluit om weg te doen met die retensie soos Mnr. Capra voorstel, gaan dit werklik laer pryse tot gevolg hê, of sal die wins wat die kontrakteur maak net hoër wees?

Ek steun dus die voorstel deur Mnr. Capra gemaak, met die voorbehoud dat die vermindering in koste in **werklikheid** oorgedra word na die verbruiker.

Ek dank u, Mnr. die Vraesteller.

Mnr. A.J. van den Berg : Krugersdorp: Munisipaliteite word soms in die verleentheid geplaas as hulle tenders ontvang van firmas wat heel dikwels die laagste tender vir 'n werk, en uit ervaring of van hoorsê is dit soms bekend dat 'n firma nie finansieel sterk genoeg is om 'n kontrak behoorlik te voltooi nie.

Sekuriteitsborge verseker dat die werk behoorlik afgehandel sal word en dek geen defekte nie. Dit gee die Munisipaliteit ten minste die versekering dat die tenderaar finansieel in staat is om die werk te doen.

Retensiegelde aan die ander kant dek die Raad teen enige defekte binne die neergelegde tydperk en verseker dat tenderaars hulle deel doen as daar nog geld uitstaande is.

Ons besef dat ons uiteindelik daarvoor betaal, maar aangesien dit op 'n eenvormige basis geskied word talle tenderaars eenders behandel.

Weens die bepaling wat in die Ordonnansie op Plaaslike Bestuur vervat is, is dit te betwyfel of daar enige steun is om enige een van genoemde sekuriteite afgeskaf te kry.

Mr. D.C. Palser : Cape Town: Mr Quizmaster

While fully appreciating and conceding that a banker's guarantee or surety bond should generally provide sufficient cover against the due fulfilment of contracts, I nevertheless consider that the retention system has certain distinct advantages. Firstly, it acts as an automatic and very effective stimulus to the contractor who is slow or tardy in meeting his contractual obligations. Secondly, it requires no direct action on the part of the municipality; one merely withholds payment.

I do agree with Mr Capra, though, that once all major equipment has been supplied, installed, tested and commissioned there is no need for further retention and that a banker's guarantee should adequately cover the maintenance period.

I would suggest, therefore, that all major contracts should provide for progress payments up to the time of official hand-over, with no retention beyond this stage, and that a banker's guarantee for an appropriate sum, say 10% of the contract value, be provided for the full contract period **plus** the maintenance period.

Mr. B. Jordan: Clinkscales Maughan-Brown & Partners: Mr Quizmaster, I would like to endorse what the two previous speakers said on this point, but I would like to suggest, as an alternative, that the surety bond could be repaid at the end of the official contract period before start of the maintenance contract, and that a retention of 5% and not 10% should continue to be held, with the possiblility that this amount could be put in an interest free account for the contractor. I do feel the retention amount being held by the client body is excessive and a reduction to 5% might alleviate the problem to some extent. My reason for wishing to keep the retention sum itself is that, in my opinion, it is easier to administer in that you are dealing directly with your contractor or supplier, where-as when claiming against a surety bond, a third party is involved.

I think that the surety bond serve a very useful purpose up to the end of the contract period, but there can be definite difficulties in obtaining redress from a contractor through a surety bond as opposed to the retention account.

I would like to raise another matter in regard to this question of retention. We are always told how much the contractor looses by the retention account. My experience shows that, if the contractor were more diligent in claiming his progress payments during the course of the contract, especially in reconciling the final contract account, a procedure which can drag on interminably, a lot of money, which is alledgedly standing on the retention account and thus capitilized in the project, could be used to better advantage by the contractor. I would like to conclude by saying that I personally feel that the practice of holding retention money should not be abandoned, but the method of holding it should be examined more closely. Thank you.

Cllr. A.K.L. Shepstone : Durban: To start off with I think we should know what we are talking about, because when one reads the question one is using words such as guarantees, sureties and retention. In the last paragraph the words "as the guarantee is covered by the surety bond" appear. Well, this is not possible. It is also stated that any defects are covered by the surety bond. There we are talking about quarantees and surety bonds and further down we say that surety bonds are much less costly than the contractual provision for holding retention monies. We are thus bringing in retention, surety bonds and guarantees.

Now I think before we make an assertion on this, we should know whether we are talking about surety bonds, guarantees or warranties. The surety bond as I understand it, is an amount which is lodged for the satisfactory completion of a contract. The surety bond should be paid immediately the contract is completed, because it is there in case the contractor, through insolvency or for other reasons, is unable to complete the contract. You then have that surety and you can get someone else in and have part payment of the contract. As I understand it the surety bond should only last for the duration of the contract.

Now I think a distinction should be made between guarantee and warranty. In many specifications you will find that these two words are confused. The word "guarantee" (ending with the letters "tee") denotes the person who is lodging the guaranty and the guaranty itself ends with the letters "ty". These are all things which appear in specifications and which appear to be used in the wrong sense. Also this morning one speaker mentioned the maintenance period. It is not a maintenance period, but warranty period. Contractors do not usually provide maintenance. I think in terms of a motor for example. If, during the retention or warranty period, that motor requires maintenance in the form of brushes wearing or such like, it is maintenance or normal wear and tear, which is not the responsibility of the contractor so, therefore, we must discriminate between our sureties, retentions, guarantees, warranties and the maintenance period. If those definitions of mine can be accepted then my views are that the surety bonds should be cancelled the moment the contract ceases. Any monies held thereafter are in respect of a warranty and not a maintenance period. I see the figure of 20% is quoted in the question. Well, in many contracts that I have handled, you don't make 20%, which means that by the time you have completed the contract, you are worse off than you were when you started off the period of the warranty. In a lengthy contract, and here I am talking about construction contracts as against a manufacturing contract, the warranty money, the retention that is, commences to be held the moment I recieve the first progress payment.

Once a consultant has issued the progress certificate, he releases a certain amount of retention money. Now if that contract goes on for two years and thereafter you hold a 12 months retention period, you are holding money for up to 3 years and therefore we try to ensure that the amount held is not unreasonable.

I think that the answer to this problem is to decide first of all whether the firm that you are dealing with is a reputable organisation. Is it likely to go insolvent? Likely to go bankrupt or anything like that? What is the probability of faults in that equipment? An example of the latter could be a high rise building with its complex lighting, ventilation and telephone systems. The total cost of the installation of that building might be something in the region of R200 000, but the components which may fail could be very small. It may be a light switch or plug and to hold R40 000, retention on a contract of that nature is, in my opinion, quite ridiculous. Also one must assess what the cost of the repairs is likely to be to the client. Is it likely that something can go wrong that will cost R40 000? I think that is unlikely and, therefore, I think these are the considerations one should make in assessing what retention to hold. By all means specify a maximum figure, but don't apply it. One should use one's experience and take into account whether or not, in a particular contract, one is dealing with a large reputable organisation. That is one aspect, the

other is what can go wrong and what will it cost to repair it. You may find that a retention of 3 or 5% is ample, but we will never consider 20%.

I would just like to conclude with one idea, viz that when one approaches a contractor and asks for the provision of a surety for the satisfactory completion of the job, the contractor is entitled to say, sure, but will you provide me with surety that I will get paid? So this cuts both ways. Thank you.

Mr J. Morrison : Quizmaster: Thank you, Mr Shepstone for your valuable contribution. We have spent 20 minutes on this question and I think we will now close the discussion. Speaking for industry, I may say that we all prefer a minimum outlay of money in the form of warranties. I think that the provision of a surety bond against the completion of the contract is acceptable. I would like to make a proposal that Councils jointly consider a standard practice by municipalities throughout the Republic of South Africa on these matters.

Vraag 2/Question No 2

Mr. Jules von Ahlften : Quizmaster: Gentlemen, I propose that we move on to Question No 2, which was posed by Mr John Grundy of Phosware who is unfortunately not present here to-day. Before we start I would just like to point to the two questions he posed. He refers to CIE document 12 and its influence on the street lighting tenders we are likely to receive. Let us have a look at Question (a). Are municipalities prepared to pay the extra cost likely to be involved in preparing these data. Now my question is : Why should the costs be increased to such an extent that it should cause a problem? The second question is how do we intend to check for compliance?

Mr. J.C. Waddy : Pietermaritzburg (Honorary Member): It is unfortunate that Mr Grundy is not here to pose the question himself, as you have mentioned. It has been in abeyance for two years and I do not know what has happened in the meantime. In the preliminary remarks here, Mr Grundy has mentioned that he assumed that, because CIE 12 had been revised, the S A B S Code would also be revised, or it may be that it has been in the meantime, but I think Mr Smit of the Bureau is here and he can tell us more about it later. So to the questions: Are municipalities prepared to pay the extra costs involved? Well, I am not going to say whether it should or should not be an extra cost. I am not in a position to say, but if there are extra costs, obviously the municipalities must pay them either directly or indirectly, but probably they will be included in the cost of the product.

The second question is: How do they intend to check for compliance? Well, I think the checks that will be required will probably be beyond the resources of the smaller municipalities and therefore it will be more satisfactory if the checking could be done by the Bureau. The types of fittings involved are not covered at present by a SABS Specification. I think there is a possibility of the specification providing for them and, if so, then presumably there will be a SABS mark that should be awarded to the manufacturers who are making fittings according to the specifications.

Mr. R.M.O. Simpson : Honorary Member: In the unavoidable absence of Mr. John Grundy on business overseas, I will endeavour to speak on the two questions posed by him at the 1976 technical meeting.

With regard to the first, who will "foot the bill" for the additional cost involved; I presume additional cost of the fittings must be covered in the cost of manufacture.

With regard to the problem of allocation of costs incurred by the manufacturer in submitting the information required by the purchaser and also the costs involved in checking that the fittings offered will in fact meet these requirements will to a great extent be dictated by the ammendments that the S A B S will have to make to their existing Code of Practice to bring it into conformity with the requirements of the CIE 12/2 Specification if, in fact, this is to be the policy of the Bureau of Standards.

It will be of value to hear Mr. Smit's comments in this regard.

Mr. J.W. Smit : S A B S: Mr Grundy states that he assumes that the SABS Code of Practice for Streetlighting will be revised to bring it into line with CIE Publication 12. He then goes on to ask questions on the cost of testing, etc.

I think Mr Grundy is putting the cart before the horse. We should not assume that our Code will be revised and then start solving problems which can be dealt with later. We should rather decide first whether we are in fact going to follow the CIE.

I discussed this problem at length during the Rustenburg Technical meeting and have discussed it again on subsequent occasions. I shall therefore just briefly restate our case.

CIE Publication 12 does not differ very much from our code in its recommendations. However it attempts to quantify streetlighting far too much. The result is that the code is supplemented by at least 150 pages of supporting literature in the form of technical reports, also issued by CIE. In order to apply Publication 12 intelligently, all this literature must be studied and applied.

The only real objection to the SABS code from practising engineers was that it is too complicated to apply. It requires some calculation which, it is claimed, is too cumbersome to make the code a practical document.

Compared to CIE Publication 12, however, our code is simple and I would therefore warn that a local code of practice based on CIE principles would not gain acceptance in this country.

Furthermore, I do not believe that such a code could produce any improvement in streetlighting installations designed to the present code.

Summarizing, I would conclude that the revision of SABS 098 would be so much wasted effort at this stage and, from this it follows that Mr Grundy's questions should be treated as purely rhetorical.

Mr. Jules von Ahlften : Quizmaster: Gentlemen, I think that we agree with what Mr. Smit has told us. I personally feel that there is no supplier who can afford the funds to apply CIE/12. Even the present Code under certain lighting conditions can be a problem to apply.

As I see street lighting, we have a standard set in this country and I feel that whereas CIE/12 is a novel piece of work giving high levels of illuminance, I cannot see us being able to afford any new or amended specifications. I think we should agree with Mr. Smit. He has summarized the situation very well; we even battle with our own code, which is simple.

Vraag 3 & 4/Question No's 3 & 4

Mr. John Morrison : Quizmaster: Gentlemen, we will now move on to the new questions and I will ask Mr Frankle to open the discussion of Questions No 3 and No 4 as Mr Symington is not here this morning.

Mr. M. Frankle : Duropenta (Pty) Ltd.: Listening to Mr Prins' paper brought back nostalgic memories as I spent most of my time in the Electrical Industry in the cable field, and I also recall the early resistance to acceptance of PVC cable and PVC conduit.

In answer to the questions asked:-

(a) Municipal approvals indicate approximately 90% acceptance of non-metallic conduit.
(b) The only problems are due to inferior installation practices and the tendency of contractors to skimp on certain important fittings, such as expansion couplings and correct saddles.
(c) Economic savings should be approximately 25 – 50% overall.

An example of conduit costs excluding fittings is as follows :

20 mm BLK M Steel on Reef R45 per 100 metres.

20 mm PVC on Reef R22 per 100 metres.

20 mm GALV M Steel on Reef approximately R60 per 100 metres.

At the coast the difference is bigger.

A striking example of the technical and economic advantages of PVC conduit systems has surely been seen at Mitchell Plain and all the other schemes being constructed at the moment. If members of the ECA are present they could possibly comment on the position regarding tendering.

(d) The use of UPVC (unplastised PVC – rigid) for underground ducting is fairly extensive, particularly for street lighting cables and service cables into buildings. It is also very extensively used by the telecommunication authorities for telephone cables.

VRAAG 3.

Mr. A.J. van den Berg : Krugersdorp: Probleme wat ondervind word met die gebruik van PVC-geleibuise.

(a) Ongeveer 30% plastiese geleibuis word gebruik teenoor wat goedgekeur is vir gebruik in die munisipale gebied van Krugersdorp.
(b) Die mees algemene probleem is dat die werk baie slordig gedoen word.

PVC-Klampe (saddles) breek baie maklik en die vervaardigers beveel aan dat nie van metaalklampe gebruik gemaak word nie. Dikwels word geen voorsiening vir uitsetting gemaak nie.

Daar word probleme met die buig van PVC-geleibuis ondervind.
(c) Indien dit enige ekonomiese besparing tot gevolg het, is dit 'n ope vraag of die besparing ooit verder strek as die sak van die aannemer wat die tipe geleibuis en toebehore gebruik.

Mr Quizmaster, I inspected one installation and found that the conduit

had pulled out of connection boxes. The conduit was saddled with steel clamps and no provision was made for expansion. Apparently the coefficient of expansion is quite considerable. The general appearance was untidy and trouble was experienced in pulling through conductors as the fishtape caught around cracked bends and openings that occurred at the end of conduit when this was not properly inserted into boxes. Thank you.

Mr. W.P. Rattey : Strand: Mr Quizmaster, I would just like to put our point over here to-day.

In the Strand we encourage the use of plastic tubing where this is installed on the surface of buildings, such as economic Coloured housing where we permitted its use extensively, but we would no more permit the installation of plastic tubing buried in walls, ceilings or floors than we would permit the laying of unarmoured cable underground, because we believe it is inherently unsafe in these areas.

Mr. D.C. Palser : Cape Town: Mr Questionmaster : We in Cape Town officially approved the use of plastic conduit, or more specifically, rigid non-metallic wireways, a little less than a year ago. Our requirements permitting the use of this type of wireway are based on the draft SABS Wiring Code now in the process of finalisation.

Contractors have already taken advantage of this concession and about a third of all installations undertaken in Cape Town today have plastic conduit.

No real problems have been experienced so far but, in view of our limited experience, it is perhaps a little too soon to be certain that there will be no problems. The only trouble that has so far been experienced has been due to bad workmanship.

Savings can definitely be achieved by the use of plastic conduit, but it would appear that not all contractors are passing on the full savings. From public tenders which have been invited for Council installations in steel conduit and alternatively in plastic conduit, it would appear that the plastic conduit installation has an overall price advantage ranging from around 3% to 12%, the higher figure being attributable to a firm that has had a fair amount of experience in plastic conduit installations.

Mr. A.H.L. Fortmann : Boksburg: In Boksburg the use of PVC conduit is permitted and widely used. The advantages are that it is light in weight – large quantities can easily be transported in light trucks and on roof-carriers.

The PVC conduit can be handled with ease in the roof space etc., as no threading has to be done and all work on the conduit can be done in the roof-space, ceiling and so on.

The economic saving is considered extensive both from a point of view of material cost and of labour cost.

With regard to Mr Van den Berg's concern, I would like to state that the problem of shabby and bad workmanship should be solved with the possible introduction of alternative or special training for the persons involved in doing this type of work.

This aspect is raised in Question 6 and, as the technique differs from that used in other systems, alternative training and possibly trade tests should be made available.

Mr. F.J. Prins : SABS: Mr Quizmaster, I discussed this aspect with our plastics division, which handles plastic conduit, to find out if they have had any experience on their side which could be usefull to relate here. Some points have been covered by previous speakers. Our plastics division stressed the point of correct storing by the suppliers of this type of conduit. If it is not stored out of the sun or if it is stored supported by say racks where it is not lying flat and it gets hot, it will become distorted and cannot be restored to its original form. They have had a few instances, and I saw some beautiful examples, where plastic conduit had been attacked by rats, and that is another possibility that one must bear in mind. Thank you.

Mr. D.H. Fraser : Durban:

Non-metallic Conduit:

(a) The Durban Municipality has approved the use of PVC conduit subject to certain conditions such as
   (1) the conduit must be saddled at intervals not in excess of 1 metre.
   (2) Crimpets are not permitted for the fixing of the conduit.
   (3) The conduit must be run vertically or horizontally where chased in brickwork.
   (4) PVC conduit is not permitted for exterior work where it is subject to ultra violet radiation.

   At present approximately 95 percent of domestic installations are being carried out in PVC conduit in Durban.

(b) Problems have been experienced where PVC conduit is used in concrete slab work, in particular where vibrators are used in the pouring of concrete. The conduit is easily damaged, resulting in expensive repairs and causing concern to structural engineers. Because of these problems and the labour involved in securing the PVC conduit to shuttering to ensure rigid fixing to prevent moving of the conduit when concrete is poured, contractors usually prefer to use metallic conduit. Consequently, consulting engineers generally specify metallic conduit on the larger buildings involving concrete decking. Where PVC conduit and metallic outlets are used requiring an additional earth conductor to be housed within the PVC conduit, care has to be taken that the prescribed maximum allowed number of conductors is not exceeded for the particular conduit dimension. Care has to be taken in drawing conductors through PVC conduit, particularly where bare copper earthwires are used, as bare conductors tend to cut through the conduit at bends. Some problems have also arisen where the adhesive recommended by the manufacturers has not been used, resulting in the parting of joints.

(c) PVC conduit has an obvious financial advantage in material costs and installation labour is reduced considerably. Current comparative prices in Durban are –

PVC	R22,00 per 100 metres
Black Screwed Iron	R47,90 per 100 metres
Galvanised Screwed Iron	R77,45 per 100 metres

Use of UPVC Ducting for carrying Cables Underground

Durban makes extensive use of 110 mm and 160 mm outside diameter UPVC ducting for road crossings and for bringing cables in and out of consumer's private substations which are situated well back from the road, using approximately 28 000 metres of the 110 mm O/D pipe and 14 000 metres of he 160 mm O/D pipe annually.

The pipes being used at present are jointed by means of the spigot and socket principle, with rubber sealing rings to prevent the ingress of fine soil. Separate double ended socket fittings are also available for jointing plain ended pipe off-cuts. However, short plain ended socket fittings are also available for this purpose. Alternatively, short plain ended pipes can be joined by inserting the end of one pipe into the end of the other which has been expanded slightly by heating with a gas torch. Another advantage of these pipes is that they can be slightly curved or bent so as to avoid obstacles such as other services found in the trench.

Because of the smooth internal surface, these pipes present very little resistance when drawing in jute, hessian and PVC served cables. Furthermore, the cables can, with a little effort, be withdrawn from the pipes after a period of service.

The pipes are normally laid in a trench on a bed of soft or riddled earth at a depth of 800 mm and then covered with further riddled earth to a depth of approximately 300 mm, which is then well rammed and this is followed by coarse fill taken from the excavation, which is well consolidated by ramming as back filling progresses.

To date this Department has not experienced any collapsed or fractured pipes as a result of loading.

End caps are available for sealing the ends of vacant pipes so as to prevent ingress of earth, until used.

Our experience with this ducting has resulted in its preferred to the many other types available for reasons of economy and ease of installation.

Cllr. A.K.L. Shepstone: Durban: We have allowed the use of plastic conduit in concrete provided someone is in attendance at all times during pouring of concrete.

We find that its light weight makes it particularly useful for use above suspended ceilings.

Mr. J. Morrison : Quizmaster: Just to tie up this question, it does seem as if this material is well accepted. The problem is one of installation control and I have been told by Mr. Frankle that there is a booklet issued on this now and it could well be worthy of circulation among installation contractors and municipalities to let them know there is a code of procedure for the installation of plastic conduit and trunk ways. Thank you.

Vraag 5 & 6/Question No's 5 & 6

Mr Jules von Ahlften: Springs: Gentlemen, there is a lot of pressure being brought to bear on suppliers to accept new wiring systems, especially as far as low cost housing is concerned. The NBRI together with the building users federation have investigated this whole problem, but up to date they have not been able to convince either the Department of Labour or the suppliers that these new wiring systems will be cheaper or would in fact be able to be used in this country.

The fact is that in many of the low cost housing schemes these wiring systems would be used under completely different conditions from those which obtain overseas; the consumers will be of a different type from those who are already accustomed to the use of electricity and it is a moot question as to whether there will be savings in employing any new wiring techniques. There are many new systems being used overseas.

Then the question arises as to whether the wireman overseas still does any wiring work in conduit. In other words, he has used these, to us, new wiring systems over many years, while our wiremen in this country are still doing conduit wired work. In fact question No 6 refers to the same problem i.e. the present trade test for electricians and wiremen is based on conduit work. I think it is important to find out from the meeting whether there are any views on this problem and whether it is felt that our present wiring system employing metallic conduit are out dated. Are there really any savings to be found in new wiring systems and, if so, where can they be applied? I can quite see that this may apply in low cost housing, where total cost is very important, especially in all the plural housing schemes to be wired. Unfortunately, the Department of Labour is not represented this morning, nor is the ECA, which is directly involved, but I wonder if anybody from the floor could give us some guidance on this problem.

Mr. M. Frankle : Duropenta (Pty) Ltd: I have not come across any problems, but have books available if anybody requires them.

In answer to Mr Symington's questions, conduit systems especially in PVC, are not outdated although there is a tendency overseas to use power trunking in many areas. There is also a tendency to use underplaster harness type wiring systems which have distinct limitations, particularly when rewiring.

The wider application of PVC conduit will not need much change; in practical trade tests for conduit work it only needs a slight change in technique.

Other wireway systems could, of course, alter accepted practices.

Mr. J. von Ahlften : Quizmaster: Thank you, Mr Frankle, I think we will take up your suggestion and see what we can do. We are represented on the Wiremen's Registration Board and I think we will put this view forward and see what comes out of it.

Mr. J. S. Gamble : Greytown: I would like to mention something that is perhaps more of historical interest. About 40 years ago, also in a hot damp climate like Durban's, only worse, the use of conduit was impossible because of condensation and the answer was to use TRS. It was embedded in the plaster of the walls. This practice was used for many years and, as far as I know, still exists, except that they have now gone over to PVC. Thank you, Mr Quizmaster.

Mr. E. Trautmann : Ladysmith: The new wiring practice overseas, using a flat double or triple conductor tape, similarly constructed to the flat F M aerial conductor, cannot easily be adopted in South Africa. The reason is that in South Africa we use thin cement plaster, and it would be uneconomical to increase this to the required thickness of 20 mm.

In Europe a thick lime plaster is generally used, which is much cheaper and smoother.

I doubt that we will be able to persuade our builders to change their building practices to accommodate the flat double or triple conductor tape.

Mr. J. Morrison : Quizmaster: Gentlemen, on the question of new wiring systems I would like to inform you that the NBIR in conjunction with the AMEU and CSIR are conducting a pilot scheme at Lenasia right now using three different wiring systems and presumably, based on the inspection of these by various authorities, will make certain recommendations. If any of these systems are accepted, we will have to modify our Wiring Regulations to embrace them and I believe that the Bureau of Standards and the Wiring Regulations Committee has this in hand.

Mr. Jules von Ahlften : Quizmaster: Thank you, John. I think that you are quite right as far as Question 5 is concerned. We will have to wait and see what transpires in the future.

Regarding Question 6, if other wireway systems are adopted, a problem will arise in so far as the section of the trade test for Wiremen covering conduit work is concerned. Unfortunately Mr Hare of COTT is not here this morning. Neither is there anybody from the ECA. I believe Mr Milton Frankle would like to say something on Question 6.

Mr. M. Frankle : Duropenta: The wider application of PVC conduit will not need any or much change in the practical trade tests. It would only need a slight change in technique, but I would like to appeal to the AMEU to ask COTT or any other of the trade test organisations to include the installation of PVC conduit systems in their curriculum and I think this will go a very long way towards avoiding any problems in future.

Mr. Jules von Ahlften : Quizmaster: Thank you, Mr Frankle. I think we will take up your suggestion and see what we can do. We are on the Wiremen's Registration Board and will put this view forward.

Vraag 7/Question No 7

Mr. K. J. Murphy : Somerset West: Mr. Quizmaster, because of the ever rising cost of demand charges, we in the Cape are examing all ways and means of improving our system load factors.

Many of our towns with their MCB tariffs already have such reasonable load factors that investment in injection load shedding equipment cannot be justified.

In Somerset West, where we have an MCB tariff we have recently introduced the following measures to further improve the system load factor, viz:

1. In all new dwellings or on request an automatic load control relay is to be connected in the stove circuit to cut off the geyser when a predetermined load is reached.
2. As the demand charge payable by the consumer is determined by the Municipal MCB on his distribution board, which is accessible to him, this enables him to apply for a lower rating and thus to save himself R1,25 per month for every 5 amp reduction in peak load.
3. All downward MCB changes are made free of charge whilst a charge of R5 is made for changes upward.
4. It will be noted that the aforementioned measures do not preclude the use of injection or ripple control relays as well - provided we do not control the poor consumer out of hot water!

What we are interested in knowing is how many other undertakings are making use of these load control relays, what their experience has been and what their consumer reaction has been.

Mnr. A. J. van den Berg : Krugersdorp: Mnr die vraesteller, ek neem aan ons verwys hier spesifiek na termiese of soortgelyke apparaat wat reageer op werklike las soos op die perseel ondervind word. Ons gebruik die lasbeheerrelê in Krugersdorp direk op die stoofbaan in die 15-ampèregrootte en dit skakel die warmwatersilinder af wanneer die stoofstroom ± 20% meer as 15 ampère is.

Ons het in sekere gebiede probleme gehad waar mense twee geysers geïnstalleer het, en dan gebruik ons 'n 25 tot 30 ampère lasbeheerrelé in die hoofstroombaan wat die tweede geyser afsny, of indien daar nie 'n tweede geyser is nie, 'n sauna of ondervloerse verwarmingbeheer.

Ons gebruik 'n standaard-60-ampère-aardlekrelê en 'n 80-ampèreminiatuurstroombreker. Die lasbeheerrelêkoste beloop naastenby R6.50 per eenheid en word deur kontrakteurs geïnstalleer teen ± R25.00. Die lasbeheerrelés is verpligtend vir alle nuwe huise. Waar daar lasprobleme ondervind word, het die Stadsraad 'n besluit geneem dat ons hierdie tipe relés aanbeveel en dit word gewoonlik sonder teenstand ingesit.

Ons het ondervind dat die vervanging van 'n dienskabel weens lasprobleme verhoed kan word deur van die relés gebruik te maak.

Ons ondervind geen teenkanting van die publiek nie en ondervind ook geen installasieprobleme nie.

Mr Quizmaster, we tested a load control relay rated at 15A intended to switch off the first geyser when the stove load exceeded the 15A mark.

The results obtained were interesting, namely:

(a) With 13 amps passed through the relay for 30 min., the geyser stayed on;
(b) With the current increased to 18 amps, the geyser switched off in 2 minutes;
(c) With the current decreased to 13 amps, the geyser switched on in 2 minutes.
(d) With the current increased to 50 amps and held for 15 minutes, the geyser switched off within 8 seconds, after the 50 amps was applied.
(e) With the current then decreased to 13 amps., the geyser switched on after 25 minutes.

We solved overloading problems in areas where the designed ADMD was 4 kVA but where the actual ADMD was 6 + kVA. Thank you.

Mr. J. S. Gamble : Greytown: I have had experience in using FW relays (as stove/geyser relays) in various places with satisfactory results.

About 20 years ago they were installed in the Railway Township of Dett in order to keep the kVA maximum demand within certain limits which were imposed by the ability of Wankie Colliery to supply.

In 1970, they were installed in houses in Oudsthoorn, primarily to reduce the peak load on the municipal power station, but also to enable consumers to keep their loads within the limit imposed by 30A MCBs.

In 1974 they were installed in Howick to reduce the kVA maximum demand and to enable consumers to manage on 40A Curve 1 MCBs.

In 1977 they were installed in Greytown for the same reasons.

In all cases they were installed on the distribution boards.

The cost at present is under R10-00. The cost of installation varies considerably with the type of distribution board and whether or not there are spare ways.

For new installations the relay is issued to the contractor who puts it in as part of his work.

There has been no adverse reaction from consumers – they do not even notice that the relays are in service.

The effect is to reduce the kVA MD by about 10% in a residential area. Another way of looking at it is to say that consumers who had a 60A MCB now manage equally well on a 40A MCB.

Where there are two geysers in a house, either two 3 kW relays are used or, if feasible, one 5 kW relay is installed.

The most common rating of relay I have used is 15A – i.e. when the stove load reaches 15A, the geyser is switched off.

Other current ratings are available.

A side benefit is the reduction in load on transformers coupled with less voltage drop on the distribution system.

Mnr. E. de C. Pretorius: Potchefstroom: ? nr. die Vraesteller, ek wil net beaam wat die vorige spreker gesê het, nl. dat hierdie lasbeheerrelés werk en baie effektief is.

By my eie huis het ek die afgelope 7 jaar 'n maksimumaanvraagampèremeter geïnstalleer en dit is interessant dat voordat ek 'n lasbeheerrelê geïnstalleer het, het my maksimum aanvraag gewissel het tussen 40 en 58 ampère, 'n merkwaardige verskil.

Terwyl daar so baie ondernemings is met stroombrekertariewe, kan ek nie verstaan waarom die vervaardigers nie groter publisiteit aan dié lasbeheerrelés gee nie.

Mr. R. R. Gilmour : Cape Town: Presumably a distinction is intended between a centralized control system using mains borne signals, and load limiting devices designed to shed unnecessary loads within installations.

At the outset it can be mentioned that consumers generally tend to resist the efforts of a local authority to effect control of any sort. Although Cape Town at present is not using either of the abovementioned methods, it has in the past tried a form of control relay known as a Reyvaux unit and a ripple control system. Although the consumers resenting the presence of control devices in their premises were in the minority, their reaction was predominantly hostile when their hot water requirements could not be met due either to maloperation of relays or prolonged shedding periods.

The electricity by-laws give the Council the right to install apparatus and equipment on a consumer's premises for disconnecting the supply of electricity to water heaters.

Load control relays are cheaper than ripple or similar receivers. The price is around R10 each for load control relays but in any case by using these instead of a centralized system a large capital investment is avoided. The ultimate choice of a system depends of course on the relative reductions in system peak demands.

Experience seems to indicate that, whichever method is used, a reduction of the order of 17% may be expected by disconnecting water heaters during the system peak period.

Consider a system peak demand of say 500 MW for Cape Town of which one half say is supplied by Escom. Then 17% of 500 MW = 85 MW. Even if this reduction is split between the two sources of supply, at R5 per kW the saving in one month on the Escom bill is R4 2500 x 5 = R222,500.

Modern load control relays have generally been designed so that the dimensions are more or less within the limits of single pole M C B'S, and may be flush or surface mounted in distribution boards. They may be wired in a number of ways. Two important methods are:

a) The whole circuit passing through the main portion to operate the auxiliary circuit to control selected loads.
b) The stove circuit only passing through the main portion to control the auxiliary circuit usually consisting of the water heater only.

With regard to the load factor, this should obviously be improved when the water heater only is controlled since a virtually necessary load is transferred to a more quiescent portion of the system load curve, the kWh remaining the same, the cost to a domestic consumer charged on a flat single tariff rate being unchanged. This does not necessarily apply when other loads are controlled.

Mr. P. Wrigley : Salisbury:
Load control relays.

1. **Their method of installation**
   These relays are installed in domestic water heater circuits and in heating and airconditioning plant of larger consumers and also to control street light circuits on a full and half night basis in furtherance of energy conservation.

2. **Cost**
   In 1976 the cost of each relay was £42,00 and 23,500 units are presently installed in the Salisbury area, controlled by injection equipment. There are 18 units installed in 33/11 kV substations and each unit at the 1976 price costs £27,00 including switchgear and building.

3. **Effect on load factor**
   The load which can be shed is about 157 MW and this represents an improvement in the annual load factor of 7%. In terms of the tariff this is a saving of about £400,000 per annum to the Salisbury City Council in maximum demand charges.

4. **Consumer Reactions**
   The consumers react very favourably to this method of load control. There is an optional higher tariff if the consumer does not wish to have the relay installed, but to date there are no consumers on this rate. 49% of all domestic owners gave a relay installed.

Mr. P. Botes : Roodepoort (President Elect): Mr Quizmaster, there appears to be a great interest in load control and load management and I have arranged for a session on load control at our next Convention. I think that there will be active discussion and suggest that we leave this subject till then, Mr Quizmaster. Thank you.

Vraag 8/Question No 8

Mr. W. P. Rattey : Strand: The appearance of this question on the Forum arises from a letter received by the Secretary of the AMEU from the Commercial Manager of Escom and which appeared in the AMEU Bulletin No. 132 of November, 1977.

This letter referred to the prospect of the introduction of selective voluntary or indiscriminate compulsory load shedding, the latter if the former should prove inadequate.

The letter also mentioned that at this stage it is the intention of Escom to involve only mining and heavy industrial consumers and municipalities using large 'blocks' of power.

Now most municipalities can be considered as using large blocks of power, or does this refer to municipalities supplying large blocks of power to bulk consumers?

If the former, most Municipalities will be involved, if the latter, relatively few.

Mention is made of manual load shedding, but can manual load shedding effected after receipt of verbal instructions from Escom be considered as an effective measure to counter falling coltages if the cause is the failure of generating or transmitting plant, or does this suggest that Escom can foresee a shortage of plant to meet future maximum load requirements?

The AMEU is urged to give its 'fullest collaboration in this exercise' and if it is in the national interest to do so, I am sure we will.

Explicit and detailed instructions will be necessary before constructive criticism of the proposal can be offered but, in the meantime, I am perturbed as this is the first time in my experience that Escom has found it necessary to propose such an exercise and I would be grateful for the insurance that Escom is not planning for a national shortage of electrical energy.

An exchange of views from members present who are better informed would be welcomed by my colleagues of the Western Cape.

Mr. W. Barnard : Johannesburg:

1. As Escom's last remaining friend (although Mr Stoffberg says he doesn't know why he needs enemies with such a friend) and as chairman of the AMEU's Escom Liason Committee, I would like to give

you my understanding of the question and my understanding of the excuse Mr Stoffberg will make in reply.

2. In emergency Escom will shed load in steps by operating under-frequency relays which the Municipalities will install at their own cost.

3. On restoration no relief will be given by Escom for excess demand – apparently only Mr Hawkeswood will not have problems. Escom in replying to my representations have stated the Local Authorities must install equipment for combatting their demands such as ripple control. This matter must be taken further.

Mr. T.C. Stoffberg: Escom:

Under-frequency load shedding:

There are rare and infrequent occasions when low frequency load shedding is unavoidable.

The interruptions experienced yesterday in the Peninsula comprised a typically infrequent example of such unavoidable under-frequency load shedding.

The years 1975, 1976 and 1977 were difficult years when these rare occasions sometimes cropped up frequently. This was the result of a low margin of reserve generating capacity and teething problems with Cabora Bassa.

Under-frequency load shedding can often be done with more discrimination and less disruption by the consumer. Under-frequency tripping by Escom as the bulk supplier must necessarily be somewhat arbitrary.

The suggestion put forward by Escom that major consumers install under-frequency tripping to operate in advance of Escom's tripping in order to minimise disruption has been well received by the Chamber of Mines and by major industries, but may not be feasible to the same extent in the case of Municipalities.

The collaboration by the consumer is necessarily voluntary, for the very reason that it is not always feasible. There is no pressure on Escom's part.

If we are told that Municipalities cannot participate in a scheme for selective under-frequency tripping this will be accepted without question.

In some cases where water heater control is installed, such help may possibly be readily implemented. We ask only that you think about the problem and come forward with any suggestions which may be practicable.

There is no imminent crisis and no precitate decisions are being demanded.

Invloed van onderbrekings op geregistreerde maksimumaanvraag:

Dit was inderdaad so dat die las na 'n onderbreking hoër as normaal mag wees.

Hierdie verskynsel is egter minstens ten dele onder beheer van die Munisipale onderneming en Evkom se standpunt is dat munisipale ingenieurs aangemoedig moet word om te help om hierdie abnormale kruinlaste te bekamp.

As die munisipaliteit afhanklik is van sy eie kragstasies moet hy noodwendig stappe neem om te verseker dat die las na 'n onderbreking nie sy vermoë oorskry nie.

As dit 'n roetine sou word dat die kruinlas na 'n onderbreking buite rekening gelaat word, verloor ons hierdie hulp van die munisipale ingenieur om die totale las binne perke te hou.

In enige uitsonderlike geval sal Evkom vanselfsprekend die meriete van die saak met die munisipale ingenieur bespreek.

Mr. W. Barnard : Johannesburg: Mr Chairman, I would like to make two very brief comments.

First of all I am shocked to hear that Mr. Stoffberg expects this sort of abnormal demand to arise every month when he told us previously that he did not expect this ever to happen.

Secondly I think that as a matter of good faith Escom should adopt the principle that where the demand is excessive because of actions on their part, the consumer will not be penalized financially. I do not for one moment think that, if we had a national power failure such as they had in New York, Escom would attempt to restore the whole supply at the same time; they would still have to do it in stages. I think Mr Stoffberg is just hedging on the issue. Escom should in fact come out with a policy and say that "if your demand is excessive because of actions on our part, you will not be penalized", because this in fact just a penalty. It is not done te recover costs, because they have not incurred costs to meet that emergency.

Mr. D.C. Palser: Cape Town: Mr Questionmaster: Cape Town has an extensive computer-based under-frequency load shedding system and details of the system may be of interest to members.

Consideration was first given in 1966 to the introduction of under-frequency load shedding for two basic reasons, firstly because of the increasing magnitude of the load and the problems that might be experienced in taking a bulk supply from Escom in the near future and, secondly, because of the vulnerability of the long Escom 400 kV lines from the north.

Supply was eventually taken from Escom in 1970 and in 1974 a computer-based under-frequency load shedding system was installed and commissioned.

This system effectively employed under-frequency relays to shed the load thereby reducing circuit breaker tripping times to an absolute minimum, but employed the computer to preprogramme and update at regular intervals the load to be shed on the basis of the import from Escom. Allowance was consequently made for varying imports from Escom at different times of the day, days of the month and months of the year.

After introduction of this system, Escom approached us and asked if consideration could be given to modifying our system to facilitate integration with their national load shedding programme to assist in the stabilization of system frequency under conditions of gradual frequency decline in times of national emergency.

A multi-stage under-frequency load shedding scheme was accordingly introduced towards the end of 1975. This updated system basically incorporated the original system to look after a rapid drop in frequency and an additional feature to progressively shed blocks of load on a slow decline in frequency. A further feature provided for the isolation of the City system from Escom in conjunction with reverse power at certain frequency settings at fixed time delays and for the islanding of the City's power stations as a last resort if all else failed.

In conclusion, I would mention that the system has operated successfully on twelve occasions over the past four years, the last time being yesterday, and has undoubtedly averted major disruptions in supply to Cape Town.

Mr. Jules von Ahlften : Quizmaster: Thank you very much for your detailed contribution, Mr. Palser. We will unfortunately now have to close the discussion of this question.

Mr. D.C. Palser : Cape Town: Mr Quizmaster, **On Question 9** : With the increasing dependence of municipal electricity undertakings on Escom, coupled with the recent steep increases in Escom's tariffs, it is considered that far closer attention should now be given to metering accuracy and all factors influencing metering accuracy in view of the corresponding increasing financial implications.

One factor influencing metering accuracy on a two-part maximum demand tariff, when the demand metering period of 'thirty consecutive minutes' is determined by a synchronous motor, is low frequency.

As we all are only too well aware system frequency is controlled by Escom and it would appear that low frequency is today a fact of life. At times it has been observed to drop as low as 49,2 Hz for relatively long periods. A figure as low as this represents an error of nearly 2% and would, in the case of frequency dependent demand metres, as currently employed by Escom, result in the metering period being lengthened proportionately with attendant overregistration of the maximum demand and consequent overpayment to Escom. In the case of Cape Town, for instance, where our purchased demand from Escom is of the order of 250 MW, an error of this magnitude at the time of maximum demand would represent, in any particular month, a loss to the city of around R25 000. In point of fact, we have kept a careful check over the past twelve months and have found the frequency to be low at times of maximum demand in nine of these twelve months. The net loss to the city on this account is estimated at R20 000 for the year.

Low frequency has often occurred on Escom's system in the past and will no doubt occur again on occasions in the future. Statistically speaking it is more natural to expect that the frequency will be low rather than high at the time of peak demand. Because of the magnitude of the financial loss that undertakings could sustain on this account, it is submitted that Escom should make every endeavour to ensure the accuracy of the "thirty consecutive minutes" metering period.

This accuracy can best be achieved through the employment of timing

devices independent of frequency, such as precision mechanical or electronic clocks. Such devices are readily available and reliable and their employment, particularly in the case of the larger undertakings, can be economically justified.

It is also worth mentioning that in Escom's First Schedule covering Standard Prices, the definition of "maximum demand" refers specifically to "thirty consecutive minutes" with no qualification as regards accuracy. It would be reasonable to assume, therefore, that the metering accuracy that Escom is contractually obliged to meet refers to the intrinsic accuracy of the metering device or system and cannot be taken as extending to include inaccuracies external to the metering circuit, such as those introduced by frequency deviations.

Another relevant point worth mentioning here is that according to the SABS Code of Practice covering the testing of electricity meters, the true time of the demand interval, when carrying out tests on a demand indicator, must be measured with a stopwatch. Furthermore, the accuracy of timing device associated with the demand indicator shall be within the limits of ± 0,5%.

It is evident, therefore, that through the use of metering devices employing synchronous motors, such as are employed by Escom at the moment, and with Escom's frequency varying as it does by up to nearly 2% downwards at times, this required accuracy of 0,5% is not being attained.

I would submit, therefore, Mr Quizmaster, that Escom should formally be asked to consider this matter with a view to improving demand metering accuracy, firstly by way of closer control of system frequency and, secondly, particularly in the case of the larger undertakings, by the employment of precision type clocks to determine accurately the demand metering interval.

Escom's standard metering accuracy is 2,5%, while in the case of larger bulk supply consumers, such as the larger undertakings, including Cape Town, the accuracy is currently 1%.

For normal bulk supplies to large consumers these standards of accuracy are possibly just acceptable, but for the larger consumers, such as Cape Town, where revenue runs into tens of millions of rands annually, I would submit that an even higher accuracy should be aimed at.

In view of the considerable sums of money involved in the purchase of electricity from Escom these days it is not unreasonable to expect Escom to pay particularly close attention to all factors and matters relating to metering accuracy and to increase their contractual accuracy limits.

Such improved accuracy would be to the mutual advantage of both Escom and the municipalities since it is just as likely that the error could be to the municipalities' financial disadvantage as it is that it could be to Escom's.

The cost involved in increasing metering accuracy is generally not prohibitive nor out of proportion to the revenue, or potential loss of revenue, involved. As an indication of the basic metering costs involved, the following figures may be of interest.

Accuracy (%)	Basic meter cost (R)
2,5	R50
1,0	R200
0,5	R1 000
0,2	R3 000

It may also be of interest to note that for Cape Town's second bulk supply point from Escom, both Escom and the Council are installing metering equipment of 0,2% accuracy.

I would propose, therefore, that Escom be asked formally to investigate the practical and economic implications of a general increase in its metering accuracy, particularly in the light of today's high cost of electricity and the considerable sums of money involved.

Mr. T.C. Stoffberg : Escom: Mr Quizmaster, I would like to deal with question No. 10 first, the question of the 2½% contractual metering accuracy. I would hate anyone in this hall to think that Escom's metering standards are generally within the very wide limits of plus and minus 2½%. It is indeed so that there is, in most Escom contracts, the 2½% limit beyond which, in the case of dispute, Escom undertakes to bear the cost of the test and if the meter is found to be within the 2½% the consumer pays for the meter test. You probably all have similar clauses in your by-laws. The standard that Escom sets for itself for metering accuracy is plus and minus ½% and I think in general this is attained. We pay a lot of attention to metering accuracy, also to the extent of site testing larger metering installations at something like 15 to 18 month intervals. Possibly there is a case to be made for narrowing even this contractual limit, but I would like you to be assured that the actual practical limit is in the region of plus and minus ½%.

There is a need to continuously update one's metering practices in line with technological developments. One of the soul searching questions that Escom is always confronted with is the apparent desirability to discriminate on the basis of the size of the consumer. We have very large municipal consumers indeed and we also have smaller municipal consumers and there was perhaps a time when the feeling was that what is good for one is good for the other. This is not a practical standpoint to maintain in view of modern developments, as Mr Palser has indicated, when very high accuracies in the region of 0,2 and possibly 0,1%, can be attained at a price. These meter installations cannot be considered economical for small supplies, but are quite justified for very large supplies. All this is being looked into. There happens to be an Escom Committee recently established to review and restate policy especially as regards demand metering and the type of meter to be used for loads of different sizes. Conclusions have not yet been reached and so I would not like to anticipate them here, but the question is being investigated.

I feel that the concern regarding the influence of frequency on the period of the maximum demand metering interval is a low priority item on the list of matters regarding metering which should be attended to. It is almost as if low frequency is a general or normal occurence. In fact we got to this state of thinking because of the two bad years, which we experienced and which I have referred to as 1976 & 1977, when there was a shortage of generating plant reserve. This is not a normal situation. What I am about to say now may sound like an excuse, but it is not, i.e. a drop in frequency has a significant effect on the load. On the total Escom system a 1% drop in frequency results in a 5% drop in load. This admittedly does not apply to all municipal loads but, because of the synchronous meter loads in mining and industry, we have this droopy characteristic. Nevertheless the drop in frequency in itself is a factor which, in this sense, contributes to lower demand registration; also the metering characteristic is sensitive to a drop in frequency.

A 1% drop in frequency typically would result in low energy registration to the extent of something like .2%. None-the-less what Mr Palser says is true. If you do have a half hour of almost continuous low frequency, it may have some significant effect on the recorded maximum demand during that half hour. It may also conceivably happen to be the maximum half hour recorded during the month. I think this would be exceptional. The solution is, of course, as Mr Palser has said, to find other timing devices where they are warranted. One may mention that thermal meters are not influenced by this timing problem. It is a frequency sensitive timing problem. I would like to leave you with the thought that Mr Palser's concern for this particular metering problem is over-stated and that the metering practices are under continuous review and that there is certainly no resistance to the exploitation of technical progress which permits the improving of metering standards. Thank you.

Mr. J. Morrison : Quizmaster: Thank you Mr Stoffberg, for the informative and detailed reply.

We will await further developments.

Vraag 9 & 10/Question No's 9 & 10

Mr. A.H.L. Fortmann : Boksburg: Mr. Quizmaster, it is surprising what impact these statistics have when printed in the local press, and I think that this other method put forward probably gives a better version of the facts.

Mr. A.A. Middlecote: SABS: Mr Fortmann's question is a very interesting one. I, for one, believe that the kWh growth curve is one of the finest indications of industrial or economic growth of a country, province or town. You may remember the paper I presented to the AMEU Conference in Umtali in 1969 where I indicated how kWh curves could be analysed and how a standard growth curve could be used to help predict the future growth. I might say that I have continued to study this matter, and the actual growth that has taken place in most municipalities over the past ten years has in fact coincided with the predicted growth curve using the standard curve. I would again recommend the use of my standard curve in predicting future growth of your electricity consumption.

To align this with actual economic growth requires further adjustment however. One must remember that electricity growth consists of two components:-

a) The growth of energy to match the economic growth;
b) the takeover of electricity from other existing forms of energy viz. coal, wood, oil.

This means that the rate of growth of electricity consumption will usually be 20% or so higher than actual growth, which is more closely indicated by the GNP growth curve, the total energy growth curve and the water consumption growth curve. The latter three correspond reasonably well but cannot be as conveniently accurately measured as the electricity growth curve. I would like to show you a set of actual curves for South Africa indicating the relationship of these different growth curves. For

an individual municipality, the local equivalent of a GNP cannot be easily obtained and total energy is also difficult. I would therefore recommend that city and electrical engineers get together and compare the growth curves for water and electricity and then present to their city fathers a **reliable** and true indication of long term growth. This would be a good chance for us engineers to cast off our parochialism and work together with other branches of the profession.

When one comes to building plans, one deals with a different problem. It covers a year's activity and not a supply of energy or water to what has been built up over all the previous years. The growth curve of buildings, expressed in constant money units, does also follow the long term growth curve, but is subject to a much larger annual deviation – according to economic conditions.

The curve I will show you clearly indicates this. The so-called fundamental "business cycle" of the building industry has a basic cycle of 17-18 years – not only here but as has been reported, also in the USA and other countries.

The origin of the large cycle which, incidently, is followed by other industries such as the motor car industry, is possibly easy to understand. It usually takes up to three years or so to complete a large project from the time when it is decided to start. Thus if one starts in an upswing period, one can overshoot the mark.

I am one of the few individuals who sincerely believe that fundamental business cycles could be reduced considerably in amplitude if there were more control on building activity to prevent overshoot. We don't like control, but I really believe that the benefits of more stable growth for the country or area as a whole fully warrant this.

I know our economist fraternity would superciliously throw up their hands in disgust at this suggestion, but I suggest that a little more imagination on their part and an appreciation of simple harmonic motion might let them see a simple engineer's point of view.

For this reason I commend to you all that you get together and analyse water, electricity and building plan growth in relationship to each other. You will not only help your municipality, but commerce and industry as well.

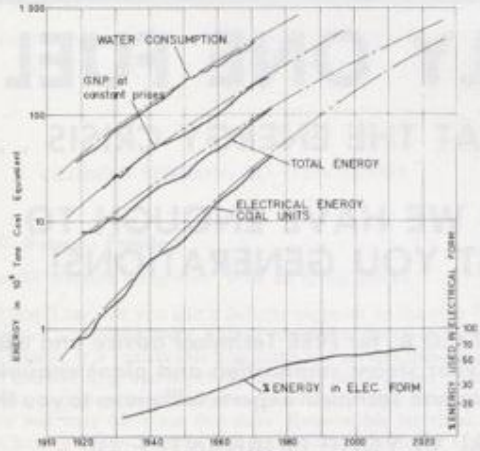
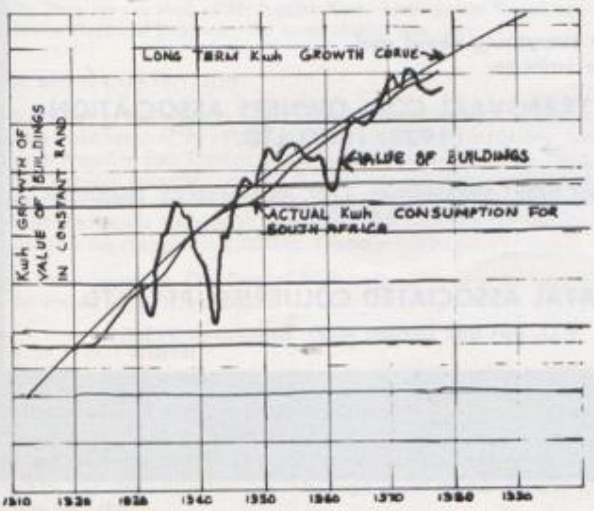


FIGURE 4 – ENERGY GROWTH IN SOUTH AFRICA



Mnr. E. de C. Pretorius : Potchefstroom: Mnr. die Vraesteller, ek stem volkome saam met mnr. Middlecote. Behoort die VMEO nie sulke statistieke van VMEO-lidondernemings jaarliks te publiseer nie?

Ek sien nie die nodigheid dat ons in duplikaat statistiek moet publiseer nie, terwyl ons dit reeds het in die Munisipale Jaarboek nie. Ek het in 1975 by die kongres in Durban daarvan melding gemaak dat dit eintlik jammer is dat die statistieke wat in die Munisipale Jaarboek verskyn so onvolledig is. Ek wil weer 'n beroep doen op alle lidondernemings om tog altyd daardie statistiek te voorsien, dit is baie waardevol.

Mnr. Jules von Ahlften (Vraesteller): Mnr. Pretorius, stel u voor dat dit voortgesit moet word in die Munisipale Jaarboek of moet die VMEO dit doen?

Mnr. E. de C. Pretorius : Potchefstroom: Mnr. die Vraesteller, ja my voorstel kom eintlik daarop neer dat ek nie die nodigheid insien dat in parallel met bestaande statistieke nog statistieke voorsien moet word nie, want die middele is alreeds daar. Ons VMEO-lede moet net toesien dat hulle daardie inligting verstrek en akkuraat verstrek. U weet mens kry somtyds in daardie statistieke dat iemand se stelselverliese bv. -1% is.

Mnr. A.H.L. Fortmann : Boksburg: Mnr. die Vraesteller, dit is reg so, maar ek voel dat ons lede dan daardie statistieke moet gebruik. Die Munisipale Jaarboek gee ongelukkig net die een syfer vir een jaar. Ons kan dan van tyd tot tyd miskien van ons eie ondernemingsstatistieke van 'n paar jaar voorlê vir algemene kennisname of aan ons stadsrade. Dit sal miskien die probleem oplos. Dankie.

Cllr. C.M. Lemmer : Benoni: I think that the statistics from building plans submitted are a true reflection of the town's growth, because it reflects good and bad times whereas the kWh consumption will remain more or less constant.

Mr. A.H.L. Fortmann : Boksburg: Mr. Quizmaster, actually I have written the question out to make it self-explanatory. I may add here that the problems are numerous, far more than what I have very briefly indicated. This morning an excellent example was mentioned; the care one must take against over-voltages in selecting the current, the shifting of the neutral which Mr. Wilson mentioned. So there are problems that really go hand in hand with this problem. If you restrict current, you might get over-voltages, if you have too much current you damage equipment. To get a happy medium is probably no easy task and I think that the ideal will be to restrict the current in relation to the load, i.e. each size of transformation equipment will have its size of earthing resistor or compensator. For local authorities this is not really practical or desirable.

A local authority needs a certain size of equipment that will restrict the current to a reasonable and practical limit. I would like to hear the comments and views on this. Thank you.

Mr. N. Kirschner : Reyrolle Parsons of S.A. Ltd.: When a system is earthed through a high reactance compensator, circuit breakers operating to clear earth faults can generate over-voltages due to restriking transients. This is aggravated by the effect of large earthed capacitances e.g. in cable networks. The over-voltages overstress insulation and give rise to failures of the weakest features of the system e.g. cable-crutches, cable joints and the like.

These overvoltages can be held to acceptable limits by either fitting surge arresters (which are of doubtful reliability) or by suitable neutral earthing.

In the AIEE Transactions, February 1955, authors Brever, Johnson and Lyon in their paper "Grounding of Sub-transmission Systems", state transient over-voltages due to switching of earth faults will be limited to 250% of normal line to neutral crest voltages if reactance earthing is used with X0/X1 less than 3 and R0/X1 less than 1

Where X0 = Zero sequence reactance
X1 = Positive sequence reactance
R0 = Zero sequence resistance

Alternatively they recommend resistance earthing with X0/X1 equal to, or less than 20 and R0/X0 equal to, or greater than 2.

Based on these criteria, Escom select Neutral Earthing compensators with ratings of either 2500, 1250 or 630 amps – all 10 second thermal withstand.

Rule of thumb British practice is to limit earth fault current to approximately full load of a single incomer to a system. Thus, in the Boksburg 132/11KV substations mentioned, a neutral earthing resistor would be connected to each transformer neutral to limit the earth fault current to about 2000 amps. Thank you.

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Mr. C.T. Carter : Cape Town: Mr Questionmaster, while the economic considerations of insulation level have a bearing on the earthing arrangements on 66, 132 and 440 kV systems, this is not the case for systems up to and including 33 kV.

It is accepted by the CEGB in Britain and in most other countries in Europe and America that the neutral of systems rated from 6,6 kV to 33 kV should be earthed through a compensator or resistance to limit the magnitude of the earth fault current. While hitherto there has been inconsistency in the neutral earthing practices of the various undertakings of Escom in South Africa for the abovementioned voltages, I understand that a head office policy decision has recently been taken that, where appropriate to the system, the neutral of each transformer should be individually earthed through a neutral compensator, largely resistive, to restrict the earth fault current to approximately between 300 and 400A per transformer, i.e. with two step-down transformers on load in parallel, the total maximum earth fault current would be of the order of 600 to 800A.

While, in general, earth fault currents have a magnitude in line with the system symmetrical fault rating, the earth fault current can in certain circumstances exceed the symmetrical fault rating by up to approximately 17% depending on ratio of source to unit impedance. The overall fault rating of 6,6 to 33 kV cables is accordingly often determined by their ability to cater for earth faults.

In such cases and also in the case of screened 11 kV cable and 33 kV cable in which only phase to earth faults can occur, it is surely logical to control the magnitude of these earth fault currents if this can readily and economically be done.

Having established in my opinion the desirability of earth systems in the 6,6 to 33 kV range by means of a neutral earthing compensator or resistance, the question arises as to what value of neutral resistor should be used. A primary factor in this is the sensitivity and selectivity of relaying. A too low value could result in insufficient earth fault current flowing in the remote areas of a system to operate the unit or back-up protection. At the same time, it is desirable to limit the earth resistance to a value such that transient over-voltage caused by switching does not cause a problem.

In Britain it is the practice for each transformer on the 6,6 to 33 kV systems to have its own individual neutral earthing compensator and resistance with a rating equal to approximately the full load rating of the transformer concerned. In Cape Town it is not the practice to install a neutral earthing resistor with each transformer, but to have a single neutral earthing resistor per step-down substation for the two to three transformers that may be installed. The rating of the neutral earthing resistors on the Council's present 11 kV system is 1600 A for transformers rated from 15 to 40 MVA and 2000 A on the 33 kV system for transformers rated at 80 MVA. These values of neutral earthing resistance have proved entirely successful in practice, no problems having been experienced, protection wise or due to system operating conditions.

In conclusion, it is considered that the allowable earth fault current should be as low as is commensurate with the associated system earth fault protection parameters, due allowance being made for a suitable safety margin.

Afsluiting van Forum/Closing of Forum

Mr. Jules von Ahlften : Quizmaster: Thank you, Mr Carter. Gentlemen, that brings us to the end of this Members' Forum and I would like to thank you all for your valuable contributions.

Mr. J. Morrison : Quizmaster: Thank you, gentlemen, for your support and contributions.

Mr. K.G. Robson : President: Gentlemen, may I say that I am sure you will agree with me when I express the opinion that this has been a most useful session. It may interest you to know that in this session this morning, there have in fact been 53 contributions and that, added to approximately 36 contributions yesterday, is an indication to me of how actively you have involved yourselves in this meeting.

May I thank you also for the questions. There has obviously been just the right number.

May I finally ask you to express your appreciation to our two Quizmasters, Mr John Morrison and Mr Jules von Ahlften, for having arranged and conducted the forum so very well.

CLOSING SESSION: SLUITINGSESSIE

Mr K.G. Robson : President

Baie hartlik welkom terug mev. West en al die dames.

Ladies, may I say that you add a definite elegance to the view from the platform as I see you up there, and we are glad to have you back for this closing session. It is remarkable how many and various things have to be done in this half hour and hopefully none will be forgotten. First of all I would like to draw your attention to these lovely floral decorations that we have had here for these two days. Responsible for them are the Town Clerk, Mr Gert Human and the Helderberg Flower Club.

I would also like to direct your attention once more to the murals on the walls. They are the work of Mr Jocelyn Kerr, the Somerset West Deputy Town Electrical Engineer. We congratulate you, Joss.

1979 AMEU CONVENTION

I would like at this stage to announce officially that there has been a change in the venue of the 1979 Convention which, if you remember, you were informed in East London was to be held in Port Elizabeth. Well, due to changed circumstances, the decision has now been made by the Executive Council that the venue for the 1979 convention will be 'Die Randse Afrikaanse Universiteit (RAU)" in Johannesburg. So will you please note the change as it is definite. The dates will be decided shortly.

May I now invite Cllr. Don Frost of Welkom to come up to the lectern, as he wishes to say a few words.

Cllr. D. Frost : Welkom

Mr President, Mr Mayor, Ladies and Gentlemen, on behalf of my Council I would like to invite the AMEU to hold their next Technical Meeting in Welkom in the OFS in 1980.

Mr Bob Barton, our Electrical & Mechanical Engineer has already applied for and obtained permission from our Council should you wish to accept the offer.

It would be quite a change to move from the oldest established part of the country to one of our newest cities for your next get-together. What we in Welkom lack in tradition, I hope we will be able to make up in hospitality and in the advantages we enjoy in a beautifully laid out city with all the modern facilities available for such a meeting.

Not that it will be easy to improve on the excellent organisation of the present one and I would like to add my congratulations and thanks to those of the other delegates who have enjoyed being here and have enjoyed the pleasures of your fair Cape. And, talking of pleasure reminds me of the Chinese Philosopher (obviously younger than the man referred to by Mr Barnard earlier) who once remarked that the pleasures of life consisted basically of food, wine and women – the food he said must be good, the wine old, but the women neither thereof! In deference to our ladies present here to-day, I hasten to add that that was an old Chinese outlook.

The last time the AMEU met in the Free State was 15 years ago in Bloemfontein and I hope, Mr President that you will be able to consider our invitation favourably.

Mr K.G. Robson : President

Thank you Councillor Frost for that very kind invitation; I am able to assure you that we will consider it at the Executive Council Meeting tomorrow and we will keep you informed well in advance.

There is another pleasant duty that I think it is necessary for me to perform and it is to formally, on your behalf, say farewell to engineers who will be attending their last national meeting of the AMEU in their official capacities. Could I ask those gentlemen to stand. I see Mr Jack Waddy and Mr Gawie Theron and Mr Cloete of Ceres. Well we are acknowledging your contributions, not only to the AMEU, but to Municipal Engineering generally in South Africa and Jack we salute you as a courageous human spirit and we thank you and Gawie as lustrous past presidents and distinguished Honorary Members of the AMEU. We thank you also Mr Cloete for your contribution over many years. This will be your last official attendance, but we live in the hope that we will see you many times as our Honorary or Retired Members. On behalf of us all here, I wish you a very happy and satisfying retirement and as it is your

birthday to-morrow Jack, may we wish you many happy returns of the day.

Mr Mayor, Ladies and Gentlemen, conferences and meetings like this don't just happen overnight. It takes a lot of work by many people and I think it is correct and fitting that we publicly acknowledge our thanks and appreciation to the various individuals and organisations that have played a part in what has been a most successful meeting. I say this with feeling, because I have really only had work to do since my arrival here, and had little to do before that as it had all been done by those persons who will be named as we conclude this meeting.

First of all to His Worship, the Mayor, Deputy Mayor and Town Clerk of Somerset West for their magnificent hospitality and also their involvement in here.

To the Mayoress Mrs West for her charming and gracious hospitality extented to our ladies and for her gracious presence throughout the two days, baie dankie. To the Town Clerk, Mr Human, also for his complete involvement in the running of the meeting and for his support of Mr Murphy. My wife has told me also of his care of the ladies as courier and guide on their morning tours, and I have no doubt that he has had the most satisfying time of us all. (Laughter).

A special and very sincere expression of appreciation to Mr Ken Murphy for his outstanding and willing work in the planning and organising of what you will agree has been a most impressive and memorable 7th Technical Meeting.

We acknowledge the contributions of the staff of the Electricity Dept., Town Clerk's Dept., and the Town Engineers & Traffic Depts. of Somerset West.

We record our gratitude to the sponsors of the luncheons :

Messrs Reyrolle Parsons (Pty) Ltd and Power Engineers (Pty) Ltd
Messrs Siemens S.A. (Pty) Ltd
Messrs Aberdare Cables Africa Ltd. Thank you.

Our thanks to Mr De Klerk of Sanlam for name tags and folders; to Siemens Africa Ltd for Note Pads, and to Mr Ivan Hess for his assistance as far as communications were concerned.

To neighbouring Municipalities – expressions of appreciation –

Mr Palser and Cape Town City Council for assistance in providing for transport to and from the airport, and to Strand and Gordon's Bay Councils for assistance whenever called upon.

Mr Murphy's personal thanks to the Good Hope Branch of the AMEU for their support and encouragement.

Our very warm appreciation to the Town Council and to Mrs Saayman and her helpers for a superb Cocktail Party last evening, they really did you proud Mr Mayor.

To the charming ladies who cared for our many and diverse needs at the Reception and Information Desks and to the ladies who provided the delicious teas during the meeting, we say thank you.

Thanks to Mr Stan Hawkeswood, Mr Felix Prins, and Mr R. Gillmour for impressive papers and to Mr John Morrison and Mr Jules von Ahlften for Quizzmastering our member forum session. Thank you too to the Discussion Leaders for accepting my invitations to introduce the discussions on the papers.

It is my particular privilege and pleasure to be able to give public recognition to a number of persons who made invaluable contributions to the smooth working of the whole of this meeting.
I now ask my wife, Maureen, to make presentations to the Mayoress, Mrs West and Mrs Ansie Murphy as a token of our gratitude and affection.

May I also call on Mrs Annatjie van der Walt to make a presentation. (Bouquet presented to Mrs Maureen Robson).

I now invite certain members of Mr Murphy's staff and of the Town Clerk's Department to receive some small tangible expression of our appreciation for the many duties they have performed in the months before and during this meeting:

Mr Jocelyn Kerr – Deputy Town Electrical Engineer – murals etc.
Mr Sakkie de Villiers – Asst. Town Clerk – Congress Secretary.
Mr Essmann – Public address systems.
Mr Childs – Transport.

Both Mr Murphy's and my thanks to our Secretary, Mr Bennie van der Walt, for his continuing influence in the work and activities of the AMEU and above all, for his support and friendship.

Many thanks also to the President Elect, Mr Piet Botes, for his support.

My sincere thanks to you all for your attendance, your really hard work and for the many, many individual contributions throughout the whole of our conference session which probably as much as anything has made this such an effective working conference.

Thus we have now come to the concluding moments of our meeting.

However, I have received a message that Mr Fraser wishes to say a few words.

Mr D.H. Fraser : Durban

Mr President, Mayor and Ladies and Gentlemen

The success and enjoyment of a meeting such as this depends largely on the ability and personal qualities of the Chairman.

Experience is of course helpful and our President has occupied offices of high responsibility in other spheres such as Chairmanship of N.O.S.A., in addition to controlling a full Convention and the activities of the AMEU for the past year.

But to my way of thinking, the more important requirement is the personality of the man!

What sort of personal qualities stand out in the man who has directed the business of these proceedings during the past two days?

I see in the first place conscientiousness and devotion to duty, complete reliability in all circumstances – something for which our Secretary is understandably grateful.

Further a sense of honour and a seemingly endless stock of stories for all occasions.

Of considerable importance is his tactfulness, subtly combined with a firmness and when circumstances demand, something bordering on ruthlessness in keeping his Executive Council to the point, in order to get proceedings over before lunch!

But, to my way of thinking, Ken Robson's most endearing qualities are his sincerity and humility, his faith in his fellow humans and in his Creator.

Assisted so ably by his charming wife, Maureen, and possessing these enviable qualities, Ken cannot but succeed in all he undertakes.

Ladies and Gentlemen, I am sure you will agree with me that the AMEU Technical Meeting has been an outstanding success. Without denying the importance of the tremendous effort put into the organisation behind the scene by Ken Murphy and his dedicated helpers and the wonderful hospitality of Somerset West, I am sure that you will also agree with me that this success is in a large measure due to the directions given by our President, Ken Robson.

On behalf of all of us who have enjoyed the benefit of your experienced, helpful and benevolent handling of proceedings, Ken, may I say 'thank you very much' and extend to you our very good wishes for the balance of your term of office as President of the AMEU.

Mr K.G. Robson : President

Thank you very much Mr Fraser and may I wish you all a safe journey home.

Ek verklaar hierdie Sewende Tegniese Vergadering van die VMEO afgesluit.

I declare this Seventh Technical Meeting of the AMEU closed.

The Mayor Cllr. A.J. West receives an AMEU tie from Mr. Ken Robson, President of the AMEU.

Messrs. Ken Murphy, Electrical Engineer Somerset West greeting the Mayor, Cllr. A.J. West, Ken Robson, President of the AMEU and Bennie van der Watt, Secretary of the AMEU.

Dames word op tee getrakteer deur Mev. West, Burgemeestersvrou.

Mrs. Joan Hess, Miss. Colleen Allison, Mr. W. Engelbrecht and Mrs. Susan le Roux enjoy them thoroughly in the relaxing atmosphere of the mayoral function.

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DE WET, L.D.M.: Posbus 15, Brakpan, 1540.
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Aliwal North, C.P.

B
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Benoni, Tvl.
Bloemfontein, OVS.
Brakpan, Tvl.
Burgersdorp, KP.
Beaufort-Wes KP.
Bethal, Tvl.
Boksburg, Tvl.
Bredasdorp, KP.
Bantoesake-Administrasieraad, Suid-Transvaal.
Bedfordview Village Council, Tvl.
Bethlehem, OVS.
Bothaville, OVS.
Brits, Tvl.

C
Cape Town
Carolina, Tvl.
Carletonville, Tvl.
Cathcart
Ceres, KP.
Carnarvon, KP.
Cradock, KP.

D
De Aar, K.P.
Duiwelskloof, Tvl.
Delmas, Tvl.
Dundee, Natal.
Dewetsdorp, OVS.
Durban.

E
East London, CP.
Ermelo, Tvl.
Evander, Tvl.
Edenvale, Tvl.
Eshowe, Natal.
Empangeni, Natal.
Escourt, Natal.

F
Fochville, Tvl.
Fort Beaufort, CP.

G
George, CP.
Gobabis, SWA.
Grahamstown, CP.
Germiston, Tvl.
Gordonsbay, CP.
Greytown, Natal.
Glencoe, Natal.
Graaff-Reinet, CP.

H
Heidelberg, Tvl.
Henneman, OVS.
Howick, Natal.

J
Johannesburg
Jeffreysbaai, KP.

K
Kakamas, KP.
Kenhardt, KP.
Kirkwood, KP.
Kokstad, Oos-Griekwaland
Kroonstad, OVS.
Keetmanshoop, SWA.
Kimberley, KP.
Klerskdorp, Tvl.
Komgha, CP.
Krugersdorp, Tvl.
Kempton Park, Tvl.
King Williamstown, CP.
Knysna, KP.
Koppies, OVS.
Kuruman, KP.

L
Ladybrand, OVS.
Louis Trichardt, Tvl.
Ladysmith, Natal.
Lydenburg, Tvl.
Lichtenburg, Tvl.

M
Mafeking, KP.
Meyerton, Tvl.
Mooi Rivier, Natal.
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Middelburg, Tvl.
Mosselbaai, KP.
Middelburg, KP.

N
Nelspruit, Tvl.
Newcastle, Natal.
Nigel, Tvl.

O
Odendaalsrus, OVS.
Orkney, Tvl.
Oos-Randse Bantoesake-Administrasieraad.
Otjiwarongo, SWA.
Oudtshoorn, KP.

P
Paarl, KP.
Pietermaritzburg, Natal.
Plettenbergbaai, KP.
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Potgietersrus, Tvl.
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Pretoria, Tvl.
Phalaborwa, Tvl.
Piet Retief, Tvl.
Port Elizabeth, CP.
Potchefstroom, Tvl.

Q
Queenstown, CP.

R
Randfontein, Tvl.
Robertson, CP.
Richardsbaai, Natal.
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S
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U
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Vanderbijlpark, Tvl.
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Vereeniging, Tvl.
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W
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Westonaria, Tvl.
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Square D (Pty) Ltd: P.O. Box 4212, Luipaardsvlei, 1743

T

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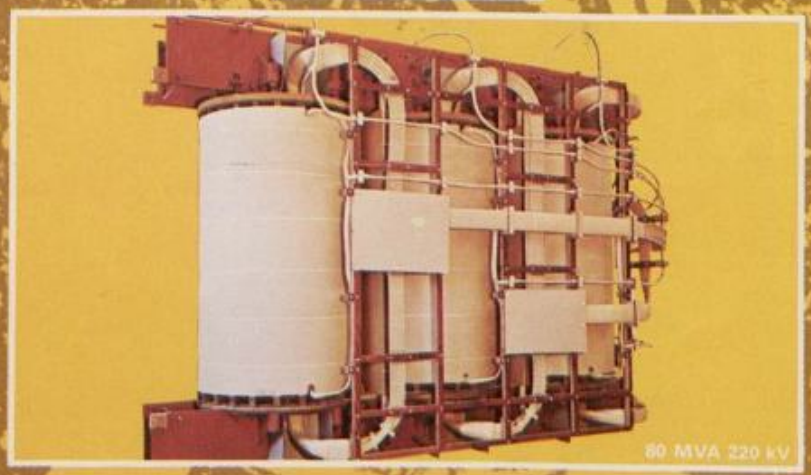

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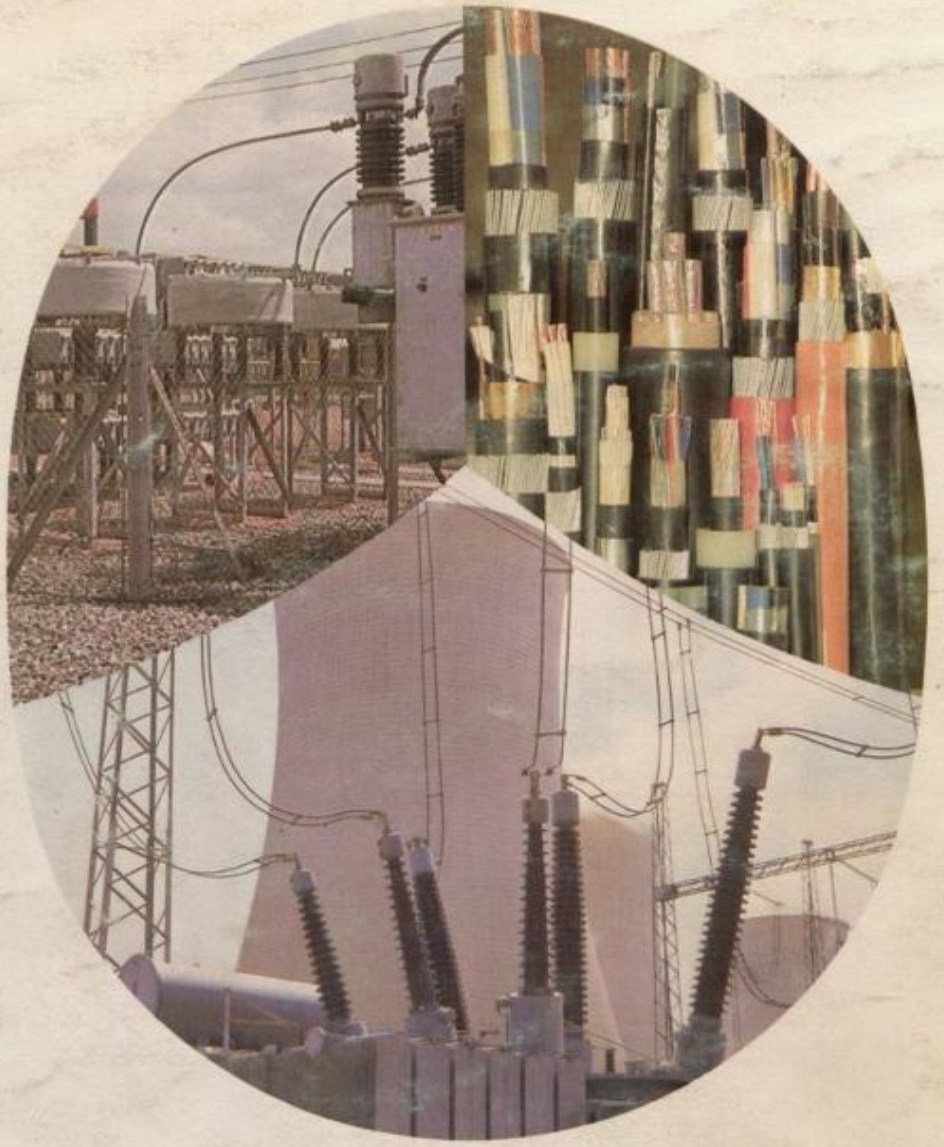

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