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REFLECTIONS ON AN INSPECTION DRIVEN MAINTENANCE SCHEME

BY

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1. BACKGROUND

In the 1980's Durban City Council held the permit to supply electricity within an area of 1540 square kilometres surrounding Durban.
The electrical system consisted of a small 275kV system and extensive 132, 33 and 11/6,6kV systems and the associated LV networks.
A total of 82 major substations operating at primary voltages of 33kV and above and ± 6700 distribution substations operating at primary voltages of 11kV and below were involved.
6 District Works Sections were established, based at depots situated throughout the supply area. Such Section staff carried out all maintenance , constructions and fault repairs throughout their specific geographical area of responsibility on the 11/6, 6kV systems and associated L.V. networks.

Prior to the introduction of the inspection driven scheme, maintenance was generally carried out in isolation within each Section. Such maintenance consisted of dispatching maintenance crews to particular areas to carry out inspections and maintenance work as they deemed necessary. Thus, on leaving the depot, the maintenance crew had no knowledge of the type or volume of work that would be required during the day. It was therefore almost impossible to be correctly prepared in terms of equipment and material. Due to varying degrees of priority being attached to maintenance by the different section managements, very considerable variations in the progress and level of maintenance carried out existed between sections. There was also the expensive tendency to over-maintain equipment since the work required could easily be "expanded" to fill the time available (i.e. the length of outage which was normally one working day).

Thus some areas were being maintained every 5-6 years while other areas, with similar equipment and environmental conditions, were only being maintained every 10-12 years.
In the early 1980's increasing difficulty was experienced in providing adequate staff to maintain equipment on the above basis and this resulted in the employment of consultants to investigate staffing requirements, methods of operations etc.

The principle of inspection driven maintenance was established from the consultants recommendations. The original innovation thus stems from the consultants rather than from my organisation but I like to think that the implementation of such a principal was not without its' innovative aspects.

2. IMPLEMENTATION OF THE SCHEME

In early 1982 the decision was taken to implement what was, in effect, an on-condition maintenance scheme where, instead of exotic computerised monitoring equipment, our condition monitoring equipment was the eyes and ears of our inspectors supplemented by such mundane instruments as binoculars, hammers and the occasional thermometer.
The initial implementation of the scheme involved only our 11/6, 6kV and L.V. systems.

The required inspection staff were recruited, largely by internal transfer, and placed under the direction of a newly formed Work Programming Division. Thus responsibility for the inspection process was entirely divorced from responsibility for carrying out the prescribed maintenance/repair work: the latter continuing to rest with the District Works Sections.

In common with all maintenance schemes the first prerequisite is a complete and up to date inventory of all equipment requiring maintenance.
In our particular case this inventory was computerised and based on a unit of a substation. All items of equipment situated at the substation, together with the associated circuits were shown on the relevant substation inventory together with dates of last inspection etc. where appropriate.

The following two inspection processes were introduced : -

Distribution Inspection

A relatively cursory inspection to identify any hazardous condition and all tree cutting requirements.

Maintenance Inspection

A detailed inspection leading to specification of all necessary maintenance work and the estimated labour and material requirements.

a) Distribution Inspection

A group of 8 Distribution Inspectors were scheduled to carry out largely visual inspections of all equipment on a six monthly cycle and to report any hazardous conditions perceived and any tree cutting requirements.
Where feasible, inspectors were expected to remedy minor defects themselves r rather than report same (e.g. replace statutory notices, light bulbs, door locks etc.)

The scheduling of such inspections was carried out on a geographic basis via computer programs based on our equipment inventory, and batches of substations to be inspected were listed on DI inspection forms. Such forms had the dual function of listing the substations to be inspected and acting as a basic inspection report form.

Distribution Inspectors did not attempt to specify the necessary action but only to identify a hazardous condition, thus no time or material estimates were given. However, an indication of the perceived urgency of the job was given.

b) Maintenance Inspection

A group of 6 Maintenance Inspectors carried out detailed inspection on a 4-yearly basis and were required to specify the maintenance work necessary to keep the equipment in satisfactory condition for the next four years (i.e. until the next inspection).

Such inspectors were accompanied by two labourers, at least one of whom was competent to carry out testing of wooden poles according to a standard instruction sheet .This on-condition monitoring involved sounding of wooden poles by hammer, taking of core samples (Using Mattson Borers) and general visual checks, with the aid of binoculars where necessary.
The scheduling of such inspections was carried out via computer programs, which resulted in the printing of the necessary inspection forms.

In the case of certain items of equipment such as switchgear and transformers, an external visual inspection is obviously inadequate to ensure satisfactory condition. In this case a scheduled maintenance function was specified in addition to any items which may stem from the Maintenance Inspector's visual inspection. These scheduled maintenance requirements were indicated on the inspection form prior to the inspector visiting site and were an admission that our on-condition monitoring techniques were not entirely satisfactory in those instances.

The following standard forms were used where appropriate :

1) **Hazardous Condition Repair Request** (see Figure 1)

Used by both Maintenance and Distribution Inspectors where appropriate, with specified priorities (e.g. immediate, 7 days, 30 days).

2) Tree Cutting Request (See Figure 2**)**

Used by both Maintenance and Distribution Inspectors where appropriate, with specified priorities of 30 days or 3 months.

3) Substation Maintenance/Repair Request (See Figure 3)

Used only by Maintenance Inspectors as an inspection report form. Subsequent to completion of the inspection, the form effectively became a job request. A period of four months from date of inspection is allowed for completion of the requested work.

4) Circuit Maintenance/Repair Request (See Figure 4)

As 3) above

5) Non-District Works Maintenance/ Repair Request (see Figure 5)

Used largely by Maintenance Inspectors to identify work required to be carried out by groups other than the District Works Section (e.g. repairs to private substation buildings) with specified priorities of 7 days, 30 days or other suitable period.

On completion of the inspection the relevant inspection forms were returned to the Work Programming Division for recording and subsequent issue to Works Sections. At this stage the inspection forms effectively became job requests listing what work needed to be carried out together with the estimated labour and basic material resources required. If, in the process of completing any job request, Works Section staff identified additional necessary work, they were required to carry out same and indicate on the job request accordingly. Thus a partial check on quality of inspection is available in addition to the sample checks carried out by the Inspectors' supervisors.
Monthly reports were issued showing details of work issued, completed, outstanding and overdue in the various categories of work.

Both sets of Inspectors were equipped with radios and, in addition to their routine inspection duties, were involved in the investigation of faults which occur from time to time, even on our system. Also many ad-hoc inspections emanating from reports from the public etc. were carried out.

The major areas of difficulty are listed below : -

1. **The ability of the inspectors to adequately inspect overhead line equipment from ground level.**

   Over many years, it has been found that such ground level inspections are certainly adequate on lines operating at 11kV and below. Very few instances of inadequate inspection have been forthcoming in spite of an initial "keeness" on the part of Works Section personnel to find such inadequacies.

2. **Lack of agreement on estimated times.**

   In the absence of official O & M times, there was initially considerable disagreement on many of the estimated times. However, after much negotiation, I believe that the estimated times used are not in major contention. Such estimates do incorporate Inspectors' discretion and on occasions are inaccurate where, for instance a cable is found to need replacement rather than repair in-situ or vice versa.

3. **Scheduling of substation inspections**

   Scheduling of maintenance was originally carried out on a geographical grid basis. This led to repetitive switching operations where HV circuits run through more than one grid reference.

4. **Difficulty in attracting suitable maintenance inspection staff**

   Such Inspectors need considerable background knowledge together with the "new" ability to use judgement and discretion in specifying the maintenance work required. In addition they must be able to work in isolation and unsupervised for considerable periods. Such staff are in somewhat short supply.

With the introduction of the scheme the following advantages accrued:

1. Works Section maintenance crews received clear job requests prior to leaving their depots and were thus able to carry all necessary equipment and material to site. This largely avoids return trips to the depot to collect necessary items, a situation which often occurred when no prior inspection was carried out.

2. An estimated on-site time for completion of the job was given which :

   a) allowed more efficient scheduling of crews by the respective foreman

   b) indicated to the crews the time period within which the job is expected to be completed. This aspect has been reduced in importance with the introduction of an incentive bonus scheme using agreed O & M standards.

3. A common maintenance level can be established via the Work Programming Divisions Inspectors', irrespective of the Works Section involved.

4. Any changes of maintenance policy can be quickly and easily implemented via the inspectorate staff.

5. A clear indication of progress of both the inspection function and the completion of the resultant works requests is available on an ongoing monthly basis.

3. CHANGES

Since the original introduction of the inspection driven scheme a number of changes have occurred.

1) Structure Changes

In 1992 the structure of the organisation was changed and the original Work Programming Division was disbanded and its functions devolved to the Planning Divisions of newly established Regional Departments. I believe this made it difficult to maintain a consistent maintenance approach throughout the whole Service Unit.

2) Computerisation

Since 1992 further computerisation of the process has taken place which, after considerable teething problems, allows better control. However, the loss of hard copy inspection reports which then became the job request has introduced further possibilities of error in transcription on the computer. The loss of highlighted colours of Hazardous Request Reports is another minor disadvantage.

3) Changed Inspection Techniques

It is important that inspection techniques are continually reviewed, monitored and updated where necessary. An example of such change is the testing of poles (vast majority wood). Such pole testing is now carried out by contractors and includes rather more exotic remedial treatment than the original coat of creosote.
Fault current monitors are now available on certain switchgear allowing a more realistic assessment of when such equipment requires maintenance.

4) Increase of Maintenance Inspection Period

After several successful maintenance cycles the original four year period was extended to five years (except for certain specific problem switchgear installations). No adverse effects have been identified and it may be that this period can be extended further in certain areas.

The Distribution Inspection cycle remains at 6 months.

5) **Inspection Scheduling**

Inspections are now scheduled in electrical “rings” rather than geographically. This leads to a reduction of switching for planned outages and a resultant time/cost saving.
An aspect that needs to be carefully accommodated is the updating of the inventory data base when circuit modifications (such as substation “cut ins”) are carried out. It is obviously essential for all equipment to be identified re last inspection dates and scheduled accordingly in rings. This can lead to some premature inspection/maintenance which is kept to a minimum but which is more acceptable than under inspecting.

4. CONCLUSIONS

Over the approximately 20 years of operation, the inspection driven maintenance scheme has proved to be a very satisfactory process for the specification and control of maintenance of an electrical reticulation system at least cost.
Changes have taken place in the structure of the organisation and some changes of inspection techniques have been introduced.

The attraction and retention of suitably qualified and experienced inspectorate staff (and contractors) remains a problem and requires considerable training resources. To allow more flexibility across inspection cycles the combining of the Maintenance Inspector and Distribution Inspector posts is being seriously considered.

With continued introduction of the most efficient inspection techniques and critical assessment of required inspection periods, there is every reason to expect that this scheme can be utilised for many years to come.