Application of R.C.M. type Maintenance Methodology within Eskom Distribution

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Abstract:

The implementation of an R.C.M. type maintenance strategy within the context of skill shortages. The equipment to be analysed being decentralised and the skills centralised. The results of centralised R.C.M. studies being applied decentralised. A skills transfer of experienced staff to new staff. A successful implementation strategy for R.C.M. strategies within Eskom Distribution.

Introduction:

The South African National Electricity Regulator (N.E.R.) has adopted as part of its licensing requirement the following document, ***National Maintenance Policy for Electricity Networks NRS 082.***

This document states the following:

The maintenance practice adopted for each plant item shall have been determined by a structured process such as RCM (Reliability Centred Maintenance) or similar and the results documented.

Paper:

Eskom which is situated in South Africa is Africa's largest Electricity Utility. It has 5 divisions, which are the following: Generation, Transmission, Distribution and Eskom Enterprises and Corporate Services.

Eskom Distribution is divided into 6 Regions covering all of geographic South Africa. Each Region is divided into a number of geographic areas where area staff makes use of a computerised maintenance management system to implement maintenance strategies. Within Eskom there is a lot of staff movement at this level and therefore a skill shortage as well as experience is in short supply.

There are approximately 4000 High Voltage Substations from 132kV to 33 kV spread around South Africa. The Substations contain approximately 4500 Transformers with 99 different makes and types of Tap Switches. 45000 Circuit Breakers of 400 different makes and types. 10500 M.V and H.V. lines. Eight different voltage categories are used from 132kV down to 3,3kV.

An initial pilot site for the implementation of RCM strategy was identified. Brackpan North a substation close to Johannesburg, was identified. The RCM study and implementation at the pilot site was done using the “pure” and traditional RCM methodology.
After the study was completed, the results of the study were compared to the normal maintenance strategy employed at the substation at the time and it quickly became clear that following the RCM principals would lead to a considerable maintenance cost saving during the life cycle of the plant without lowering and in most cases improving the reliability of the equipment.

The study of the pilot site itself took approximately 4 weeks to complete and included the local staff of the substation as well as equipment specialists for the various types of equipment found at the substation. This substation was close to Johannesburg where most of these skills are readily available keeping the costs of the study itself reasonable. By extrapolating these costs to remote and rural substations spread around the country it quickly became obvious that the cost saving achieved through following the pure RCM methodology was completely negated by the cost of the studies themselves as it would require specialist to travel to each site around the country.

With 4000 H.V. substations in the 132kV. to 33kV. category spread around South Africa and equipment specialists only being available in the bigger centres the time frame for implementation using traditional R.C.M. concepts would be unacceptably long and impossible to achieve. The time frame would be in excess of 40 years.

A solution had to be found giving Eskom Distribution the advantage of using R.C.M. as a maintenance strategy but simplifying the R.C.M. analysis as well as a simplified implementation. With the skill shortages experienced within the geographic areas of Eskom distribution, the majority of the equipment decentralized, the equipment specialists centralized, a method had to be found allowing the inexperienced decentralised staff to use their local knowledge together with the knowledge of the centralised specialist to determine the optimum maintenance strategy.

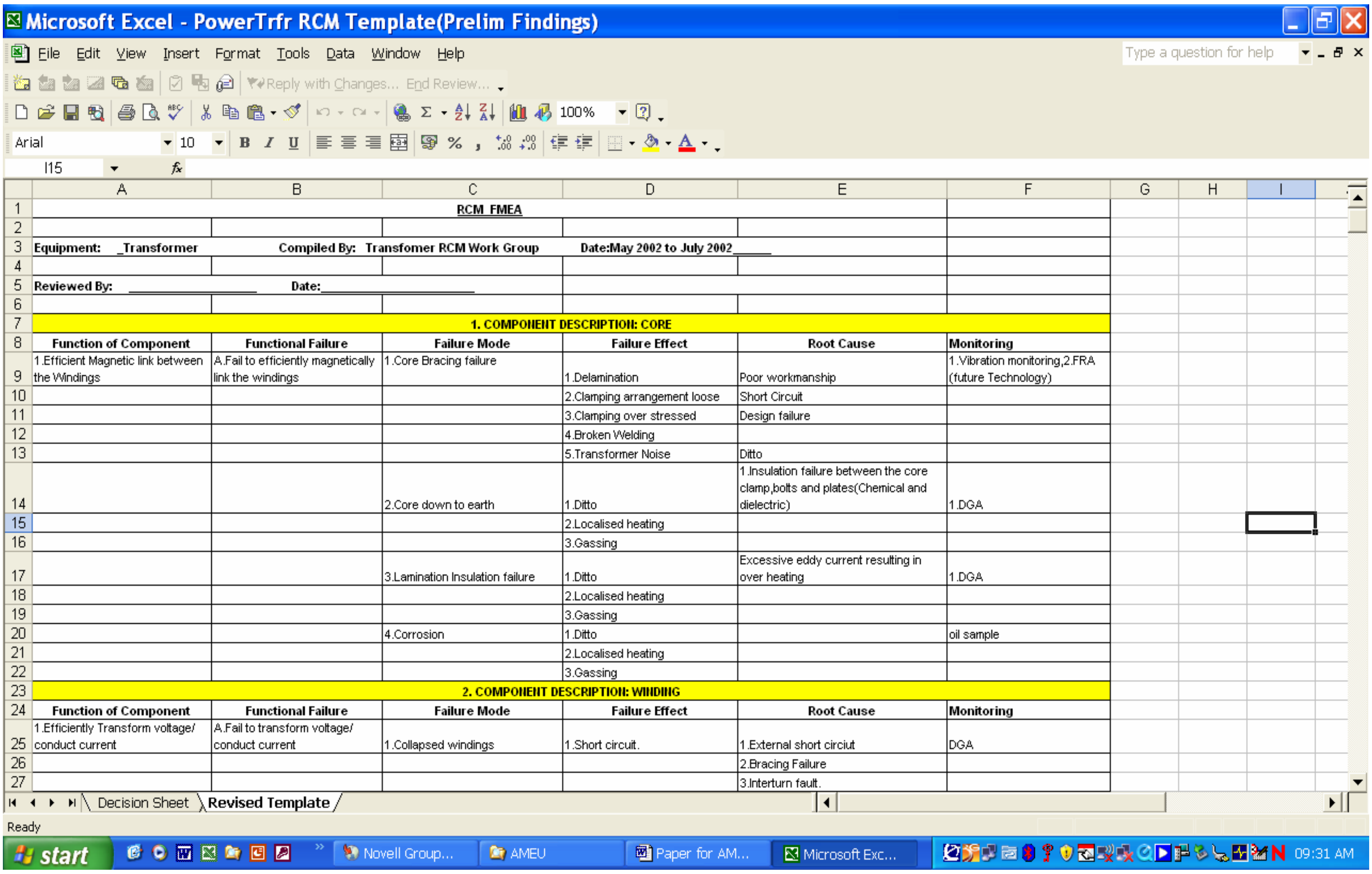
As there had been previous unsuccessful attempts to implement R.C.M. philosophies in Eskom Transmission and Distribution it was decided to run the implementation as an internal project.

The project consisted of the following.
Identification of equipment to be analysised.
R.C.M. training of all staff involved in the R.C.M. project.
Managing of all work groups required for all R.C.M. studies as well as time frames.
Soft ware data base development.
Regional implementation of the R.C.M. studies.

Equipment types were divided into various categories following the skills profiles of the specialists.
Transformers and Tap Switches, Circuit Breakers, D.C. systems, H.V. M.V. Lines, Cables, Instrument Transformers, Isolators, L.V. etc.

Work groups were formed for each of the following:
The equipment specialists as well as all regional staff that were members of the work groups were sent on R.C.M. courses so that all were aware of the R.C.M. methodologies as well as failure modes and effects analysis.
These work groups were assembled at a centralised venue where they then analysed their respective equipment types using the RCM methodologies. Each work group contained equipment specialists as well as regional staff who knew the local conditions that equipment must operate under.

The FMEA (Failure Modes and Effects Analysis) as well as the R.C.M. Decision Diagram which were done and recorded by the Distribution Transformer R.C.M. work group are shown below.

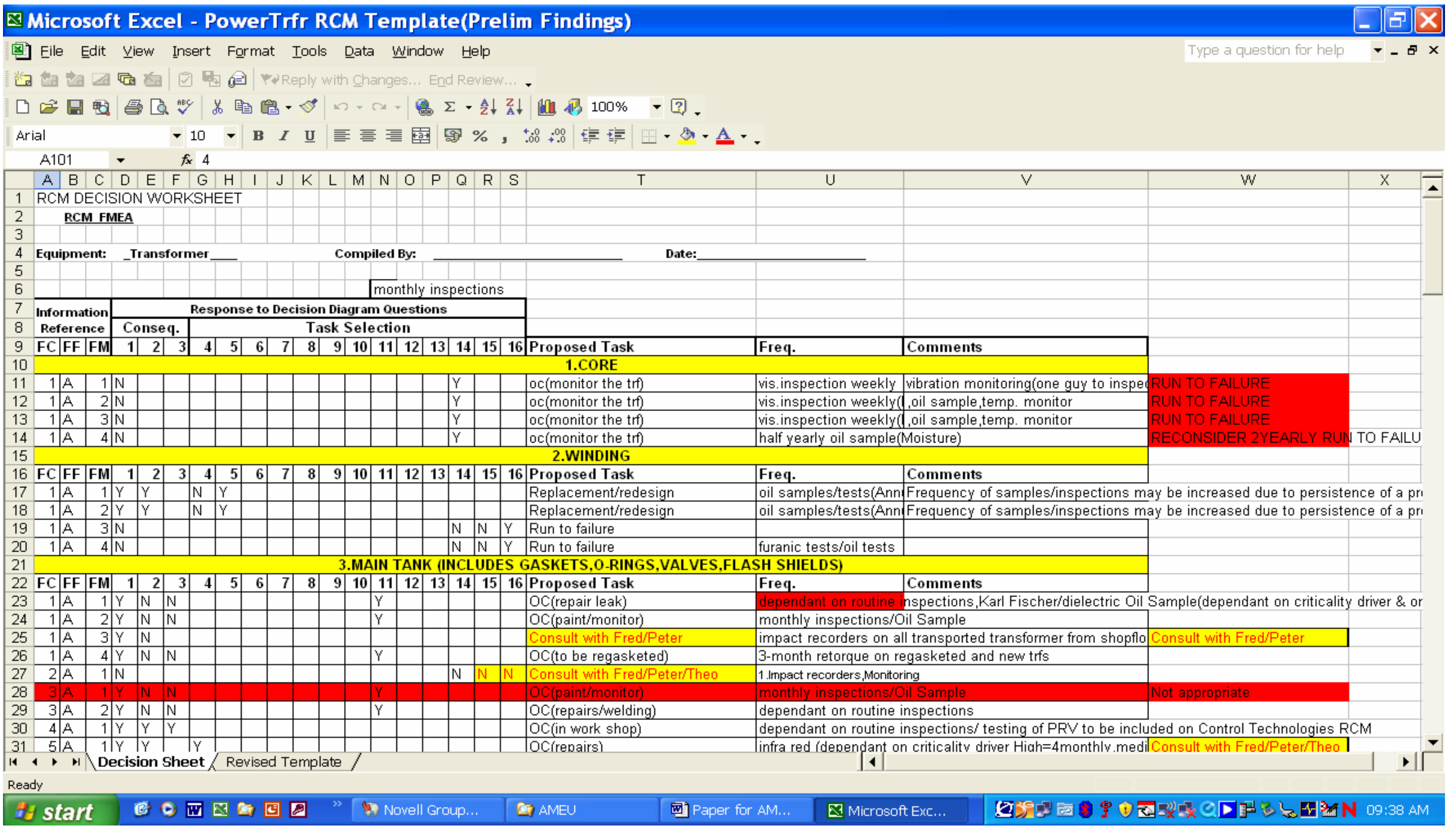


RCM FMEA

Equipment: _Transformer **Compiled By:** Transfomer RCM Work Group **Date:**May 2002 to July 2002_____

Reviewed By: ____________________ **Date:**____________________

Function of Component	Functional Failure	Failure Mode	Failure Effect	Root Cause	Monitoring
1. COMPONENT DESCRIPTION: CORE					
1.Efficient Magnetic link between the Windings	A.Fail to efficiently magnetically link the windings	1.Core Bracing failure	1.Delamination	Poor workmanship	1.Vibration monitoring,2.FRA (future Technology)
			2.Clamping arrangement loose	Short Circuit	
			3.Clamping over stressed	Design failure	
			4.Broken Welding		
			5.Transformer Noise	Ditto	
		2.Core down to earth	1.Ditto	1.Insulation failure between the core clamp,bolts and plates(Chemical and dielectric)	1.DGA
			2.Localised heating		
			3.Gassing		
		3.Lamination Insulation failure	1.Ditto	Excessive eddy current resulting in over heating	1.DGA
			2.Localised heating		
			3.Gassing		
		4.Corrosion	1.Ditto		oil sample
			2.Localised heating		
			3.Gassing		
2. COMPONENT DESCRIPTION: WINDING					
Function of Component	**Functional Failure**	**Failure Mode**	**Failure Effect**	**Root Cause**	**Monitoring**
1.Efficiently Transform voltage/ conduct current	A.Fail to transform voltage/ conduct current	1.Collapsed windings	1.Short circuit.	1.External short circiut	DGA
				2.Bracing Failure	
				3.Interturn fault.	



RCM DECISION WORKSHEET

RCM FMEA

Equipment: _Transformer____ **Compiled By:** ____________________ **Date:**____________________

monthly inspections

Information Reference			Response to Decision Diagram Questions: Conseq.			Task Selection															
FC	FF	FM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Proposed Task	Freq.	Comments
1.CORE																					
1	A	1	N													Y			oc(monitor the trf)	vis.inspection weekly	vibration monitoring(one guy to inspe RUN TO FAILURE
1	A	2	N													Y			oc(monitor the trf)	vis.inspection weekly(|	,oil sample,temp. monitor RUN TO FAILURE
1	A	3	N													Y			oc(monitor the trf)	vis.inspection weekly(|	,oil sample,temp. monitor RUN TO FAILURE
1	A	4	N													Y			oc(monitor the trf)	half yearly oil sample(Moisture)	RECONSIDER 2YEARLY RUN TO FAILU
2.WINDING																					
FC	FF	FM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Proposed Task	Freq.	Comments
1	A	1	Y	Y		N	Y												Replacement/redesign	oil samples/tests(Ann	Frequency of samples/inspections may be increased due to persistence of a pr
1	A	2	Y	Y		N	Y												Replacement/redesign	oil samples/tests(Ann	Frequency of samples/inspections may be increased due to persistence of a pr
1	A	3	N													N	N	Y	Run to failure		
1	A	4	N													N	N	Y	Run to failure	furanic tests/oil tests	
3.MAIN TANK (INCLUDES GASKETS,O-RINGS,VALVES,FLASH SHIELDS)																					
FC	FF	FM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Proposed Task	Freq.	Comments
1	A	1	Y	N	N								Y						OC(repair leak)	dependant on routine inspections,Karl Fischer/dielectric Oil Sample(dependant on criticality driver & or	
1	A	2	Y	N	N								Y						OC(paint/monitor)	monthly inspections/Oil Sample	
1	A	3	Y	N															Consult with Fred/Peter	impact recorders on all transported transformer from shopflo	Consult with Fred/Peter
1	A	4	Y	N	N								Y						OC(to be regasketed)	3-month retorque on regasketed and new trfs	
2	A	1	N													N	N	N	Consult with Fred/Peter/Theo	1.Impact recorders,Monitoring	
3	A	1	Y	N	N								Y						OC(paint/monitor)	monthly inspections/Oil Sample	Not appropriate
3	A	2	Y	N	N								Y						OC(repairs/welding)	dependant on routine inspections	
4	A	1	Y	Y	Y														OC(in work shop)	dependant on routine inspections/ testing of PRV to be included on Control Technologies RCM	
5	A	1	Y	Y		Y													OC(repairs)	infra red (dependant on criticality driver High=4monthly,medi	Consult with Fred/Peter/Theo

Their results had to take into account all possible scenarios where this equipment may be used around South Africa. These had to include all network variables, environmental variables, design variables, fault levels, etc.

For example:

For Transformers the following variables were identified.
Whether the transformer had redundancy?
What is the size of the transformer?
What is the pollution level at the substation?
What is the criticality score of the customers or load?
What is the voltage level of the transformer?
What is the loading of the transformer?
Does the customer pay for a firm supply?
Does the bushing have a test pin?

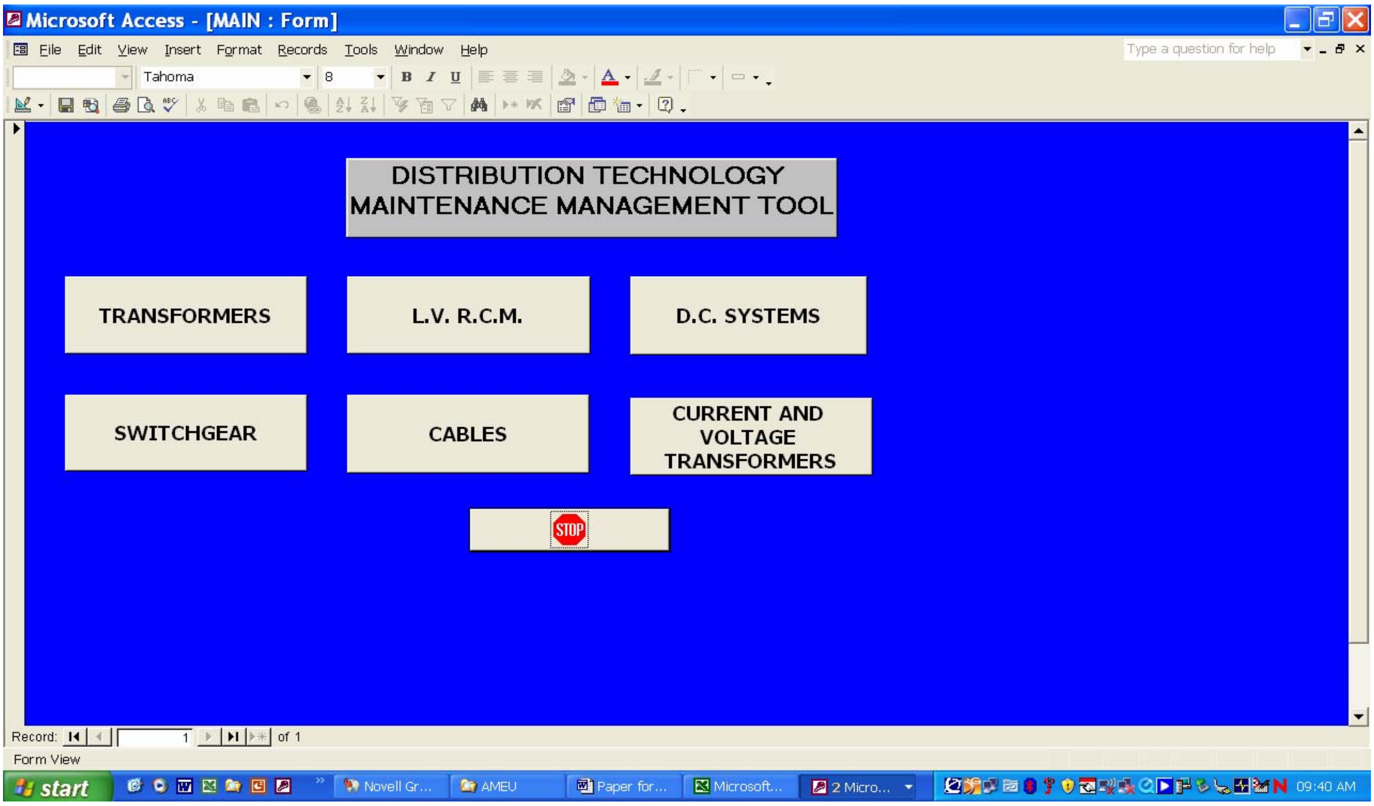
For Tap Switches the following variables were identified.
Whether it is an on-load or off-circuit tap switch?
What is the loading of the switch?
Is it used in star or line end configuration?
What type of design is the switch?
What is the criticality score of the customers or load?
What is the type of load?
What is the make and type of the switch?

The work groups had to find a maintenance strategy for each of their identified possible scenarios under which the equipment could be operated.

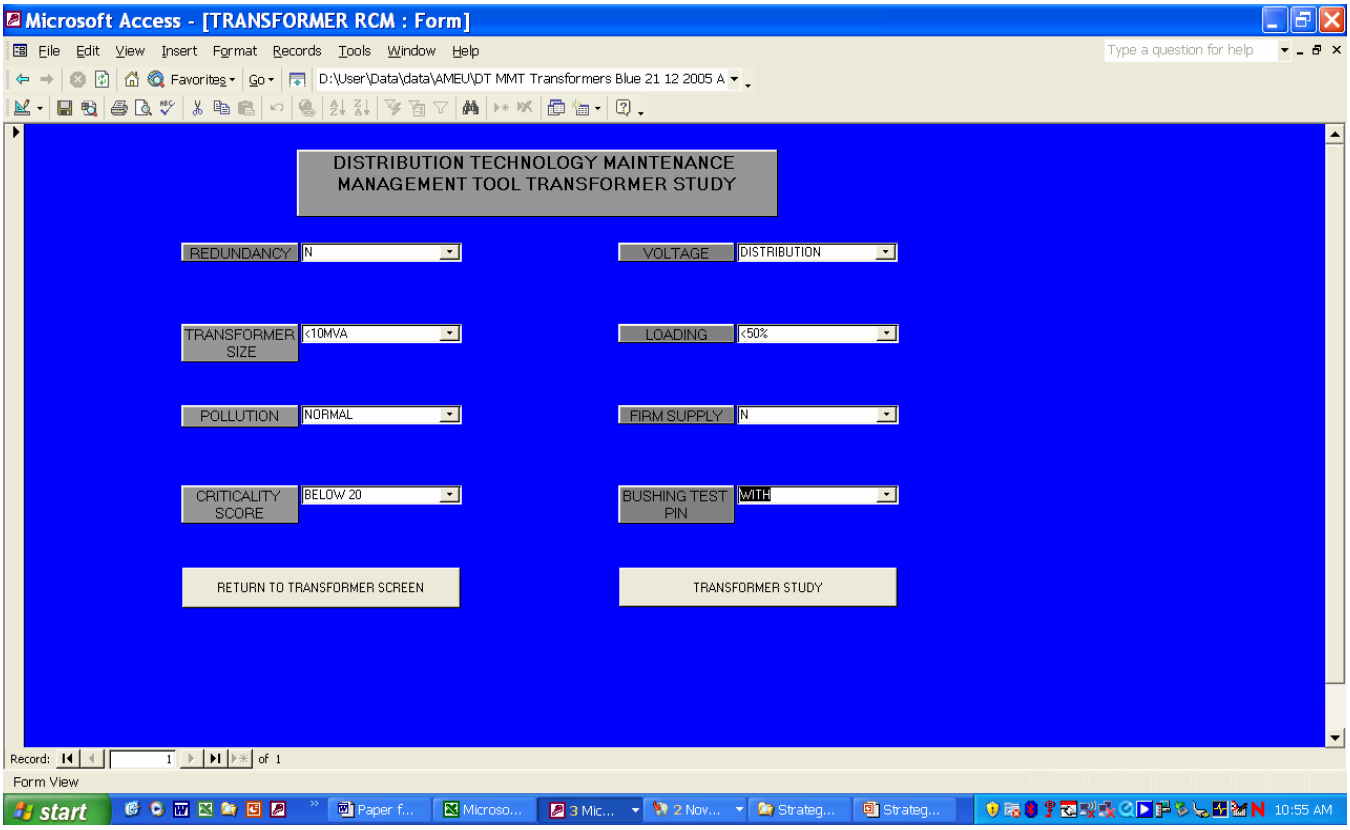
The next challenge was to empower decentralised staff that does not necessarily have the R.C.M. skill as well as not having the equipment specialist's skills to implement R.C.M. methodologies.

The commercial software market was investigated for a suitable software package where the studies done by the specialist's could be built into a data base to be used by de-centralised staff for their maintenance strategies.
No commercial software package was found to be suitable for this application where the experience of specialists is built into the soft ware package. The soft ware packages that were available in the market all required the operator of the soft ware to have R.C.M. skills as well as intimate knowledge of the equipment to be analysed. These were not suitable for application required.

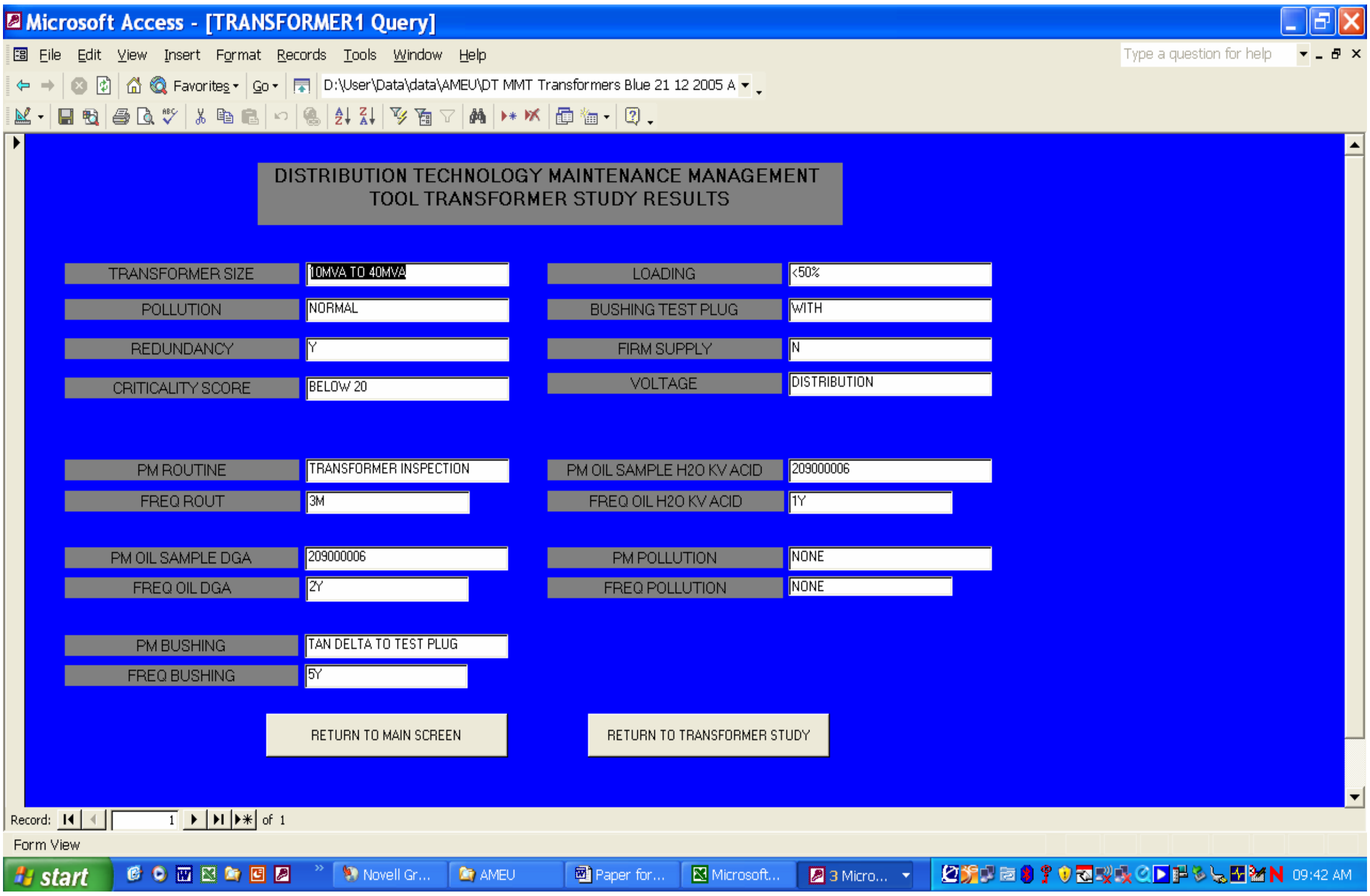
As Microsoft office is used as a standard software package by Eskom it was decided to write a software package in house using the Microsoft Access data base program.



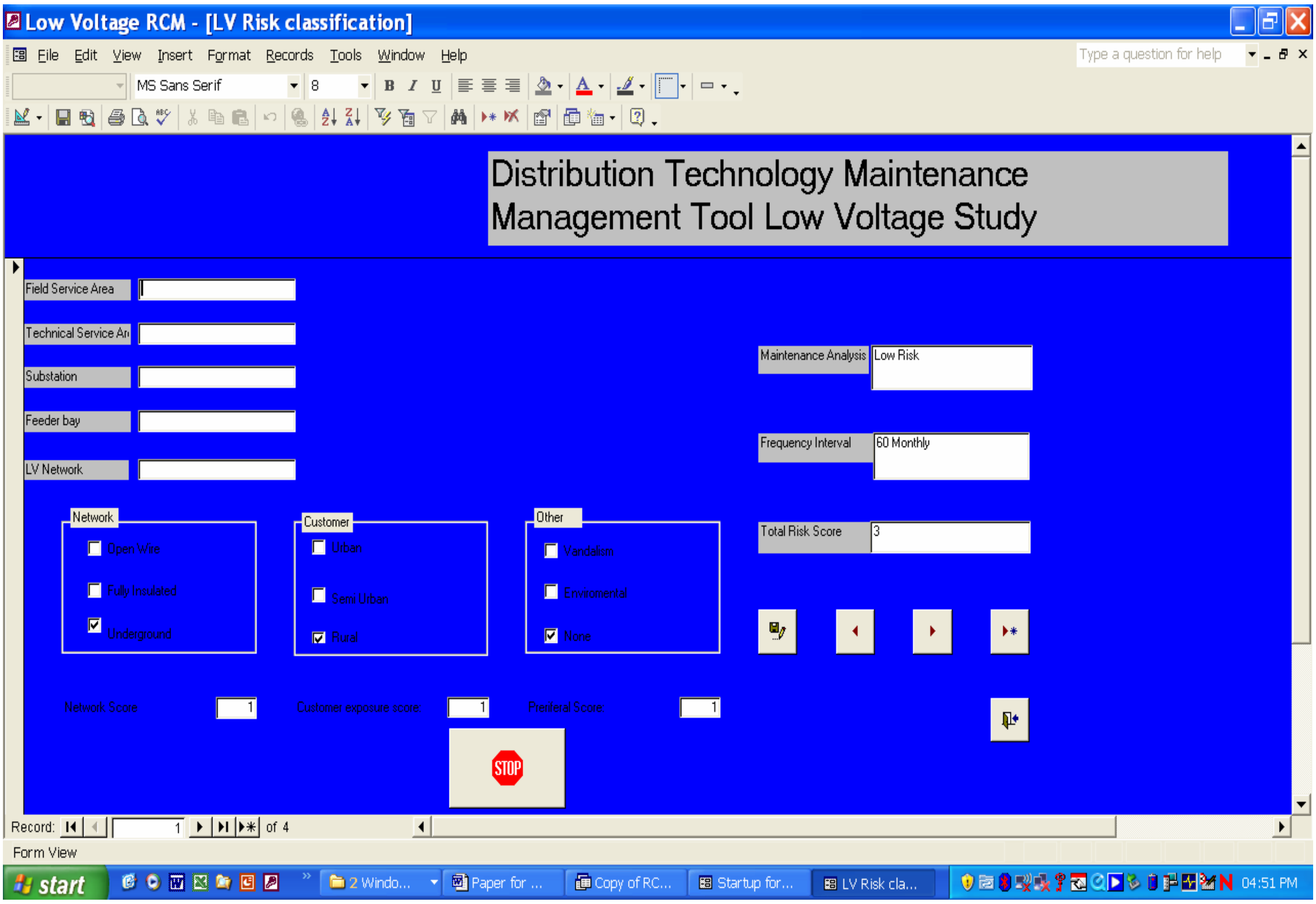
Transformers Input Form:



Transformer Results Form:



Low Voltage:



The program allows staff that does not necessarily have the equipment skill or the R.C.M. skills to determine the maintenance strategies using R.C.M. principles. All that is required is that the decentralised staff makes the necessary local condition choices and feeds these results via an input form into the database. A query runs through the tables and returns the result for which all choices made for the local conditions apply.
The returned results are than the analysis which had been done by the equipment experts and regional representatives in the centralised work groups using the R.C.M. principals.
The result contains the frequency whether time based or number of operations of every required maintenance intervention as well as a job plan no. The obtained frequency as well as the job plan no. is then inputted into the computerised maintenance management system.
The Transformers table for example contains 576 variables that were populated by means of the specialists R.C.M. analysis results.

As the success of the project lies in the implementation of the soft ware each region was visited by the implementation team. The software was explained and demonstrated to the regional staff. A software training program demonstrating the R.C.M. program was also created and distributed to regional staff.

The implementation is monitored via the Maintenance Strategy Work Group.

An additional benefit of this project was that knowledge transfer between the equipment specialists maintenance experience could be transferred to the maintenance planners via the software package. If equipment specialists should leave the company their maintenance knowledge remains within the company as it is captured within the software package.