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RISK ASSESSMENT OF OVERHEAD LINE HARDWARE ON THE ESKOM DISTRIBUTION BUSINESS

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A research report submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Engineering.

Johannesburg 2014

DECLARATION

I declare that this research report

RISK ASSESSMENT OF OVERHEAD LINE HARDWARE ON THE ESKOM DISTRIBUTION BUSINESS

is my own unaided work. It is being submitted to the Degree of Master of Science in Engineering to the University of the Witwatersrand, Johannesburg. The sources that I have used or quoted have been indicated and acknowledged by means of complete reference.

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(Signature of Candidate)

<u>27</u> **day of** **<u>August</u>** **year** **<u>2014</u>**

ABSTRACT

This research report describes a holistic view of the impacts that ESKOM Distribution is currently facing due to poor quality overhead line fittings supplied by local and international manufacturers. Overhead line fittings are components/hardware used to connect power lines to function as a network. The purpose of this research report is to develop an effective overhead line fitting evaluation methodology which will encompass technical requirements to qualify manufacturers of overhead line fittings to supply ESKOM.

The report describes, supported by case studies, poor manufacturing processes contributing to overhead line fitting failures. A Microsoft Excel evaluation spreadsheet was developed to evaluate fittings from the technical point of view and ensure compliance to ESKOM's technical requirements. The evaluation is conducted on submitted documentation and later samples are inspected at the manufacturing premises. The final result of the evaluation is determined by calculating a weighted score for each item. An acceptance score of more than 70% qualifies manufacturers.

ACKNOWLEDGEMENTS

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Without the suggestion and constructive criticisms of the abovementioned persons, the research report undertaken could have not been completed on time. Last but not least, a word of thanks goes to my family and friends for their support.

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LIST OF SYMBOLS

Aerial Bundled Conductor	*ABC*
Accelerated Supplier Growth Initiative for South Africa	*ASGISA*
Cross-Linked Polyethylene	*XLPE*
Distribution	*Dx*
Eberhardt Martin	*EBM*
Electricity Distribution Industry	*EDI*
Gross Domestic Product	*GDP*
Generation	*Gx*
High Voltage	*HV*
International Standard Organisation	*ISO*
Joule	*J*
Kilometer	*km*
Kilonewton (1000 N)	*kN*
Kilovolt (1000 V)	*kV*
Kilowatt-hour	*kWh*
Life Cycle Costing	*LCC*
Low Voltage	*LV*
Medium Voltage	*MV*
Net Present Value	*NPV*
Overhead Line	*OHL*
Procurement and Supplier Chain Management	*P & SCM*
South African Bureau of Standards	*SABS*
South African National Accreditation System	*SANAS*
South African National Standards	*SANS*
Supplier Development and Localisation	*SD & L*
Single Wire Earth Return	*SWER*
Transmission	*Tx*
Ultra-Violet	*UV*
Volt	*V*
Watt	*W*

NOMENCLATURE

OHL fitting	: Components/hardware used to support and connect the phase conductor to insulators and insulators to the tower. By doing so, it enables electrical energy to be transmitted at a distance from the energy supply point.
Single-phase	: Alternating current electric power that is distributed in a system in which all voltages of the supply fluctuate in harmony. Single-phase distribution is used when loads are mostly lighting and heating, with few large electric motors.
SWER	: Single-wire transmission line which supplies single-phase electrical power from an electrical grid to remote areas at low cost.

OBJECTIVES

To measure the overall need for risk assessment of poor quality OHL fittings, a number of incidences including fatalities have to be investigated to get to the root cause and assist in mitigating risks associated with failures. In this research report, load, energy, electricity and power are used interchangeably.

The objectives of this assignment are:

a) Develop a framework for effective risk assessment by considering asset management, life cycle cost, quality management system and value engineering;
b) Develop a methodology for effective overhead line fitting evaluation which will encompass technical requirements;
c) Provide recommendations so that ESKOM distribution can align itself with the intention that future failure can be mitigated.

1 INTRODUCTION

South Africa is a developing nation with significant heavy industry, which is by its nature energy intensive. This energy intensive largely relies on indigenous coal reserves and the infrastructure for its driving force. The power utility, ESKOM is the primary supplier of electricity in South Africa, providing approximately 95% of the electricity consumed. The power utility has gradually developed from the past since it became operational. Technology was one of the important factors that made them grow into a more cost effective and productive away. An overview of the ESKOM electricity value chain is depicted in figure 1.1 to illustrate this driving force.

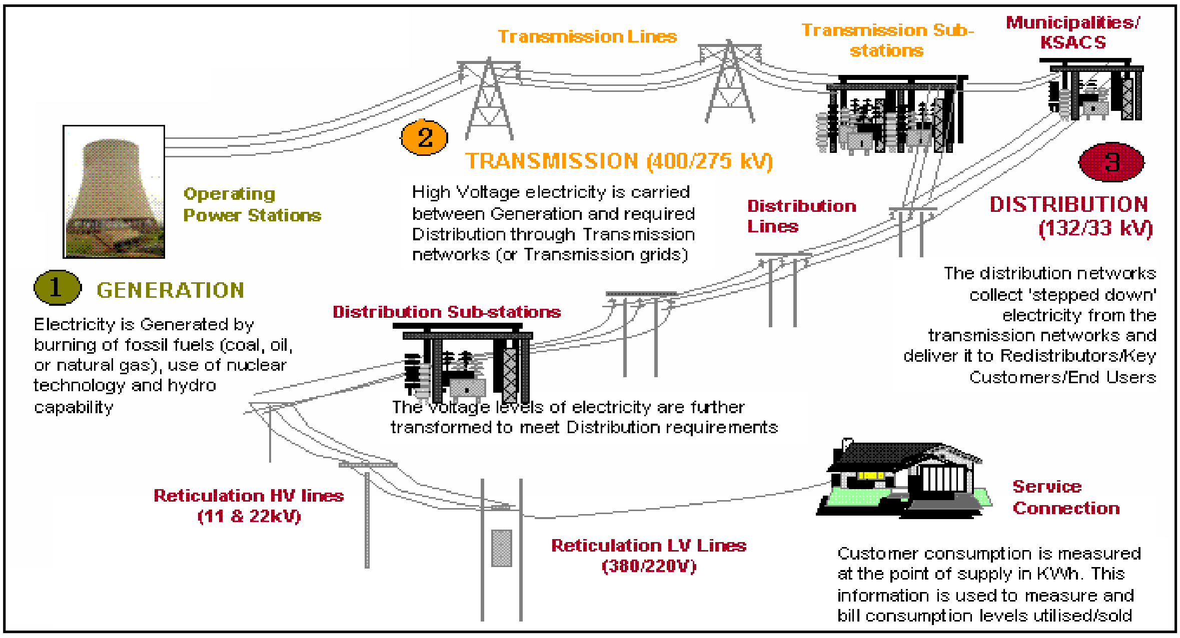


Figure 1.1 ESKOM electricity value chain (Eskom, 2013)

Generation (Gx) produces the needed power from coal carried into the plant on conveyor belts, crushed into fine powder and burned under controlled conditions in modern boilers to produce high-pressure steam. The steam drives turbines that generate electricity. When electricity is generated from power stations, it has to be transmitted to load centres. Much research has shown that this is best done by sending the power over high voltage overhead lines. As it leaves the power station, the electricity is boosted by a device called a step-up transformer to voltages such as 132 kV, 400 kV or 765 kV. When the electricity reaches its destination (a substation near a load centre), it is "stepped down" to voltages used for distribution (Dx) to customers.

Electricity Distribution Industry (EDI) is a vital link between supplier, usually ESKOM and customers (including major wholesale customers in municipalities, aluminium smelters and railways) that buy and use electricity. A Dx operation constructs and maintains equipment that transforms the power supply to the type that meets the customer's needs, provides the appropriate billing and collects the payments. ESKOM Dx has a distribution network of 320 035 km of line and approximately 3.6 million customers (ESKOM, 2013).

1.1 ESKOM Distribution Power Lines

In order to understand the challenges faced by ESKOM Dx due to poor quality overhead line fittings, it is important to understand how overhead power lines are classified in ESKOM. Overhead power lines are classified by the range of voltages they carry and they are namely, High Voltage, Medium Voltage and Low Voltage. Although underground power cables are used to distribute electricity, they are beyond the scope of this research report thus, it will be covered in less detail.

1.1.1 High Voltage lines

High Voltage (HV) lines distribute 44kV, 66kV, 88kV and 132kV. They are used for long distances and very high distribution of bulk quantities of electricity and are connected to very large consumers. HV conductors are not covered by insulation and the conductor material is always an aluminium alloy, made into several strands and reinforced with steel strands.

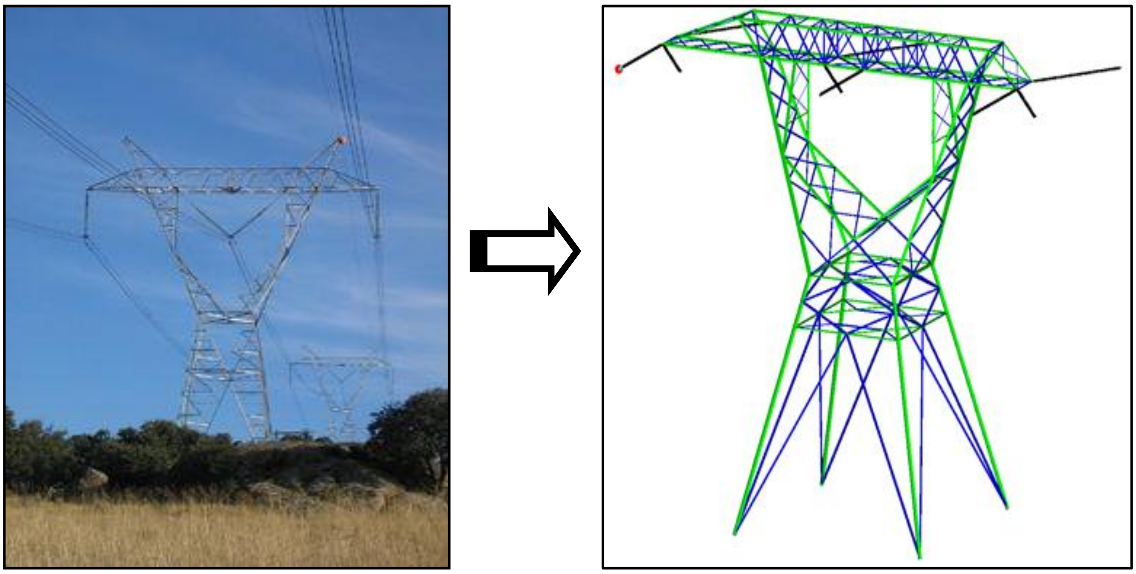


Figure 1.2 High Voltage power lines (ESKOM, 2013)

A typical HV power line has three phase conductors to carry the current and transport the energy, and two grounded shield conductors to protect the line from direct lightning strikes. The usually bare conductors are insulated from the supporting towers by insulators attached to grounded towers or poles. These lines are built with long-rod composite insulators. HV fittings including cross arms are larger in size and because of this, safety concerns and insulation requirements are a priority when constructing these lines (ESKOM, 2013).

Most HV lines, specially trained personnel use so-called "live line" techniques to allow hands-on contact with energized equipment. In this case the worker is electrically connected to the line but thoroughly insulated from the earth so that one is at the same electrical potential as the line. Since training for such operations is lengthy, and still presents a danger to personnel, only very important HV Dx lines are subject to maintenance while live.

1.1.2 Medium Voltage lines

Medium voltage (MV) lines as shown in figure 1.3, distribute 11kV, 22kV and 33kV which are mostly used for distribution in urban and rural areas. MV philosophies like Single Wire Earth Return (SWER), single-phase and phase-to-phase systems are often more appropriate, especially when dealing with small, dispersed loads.

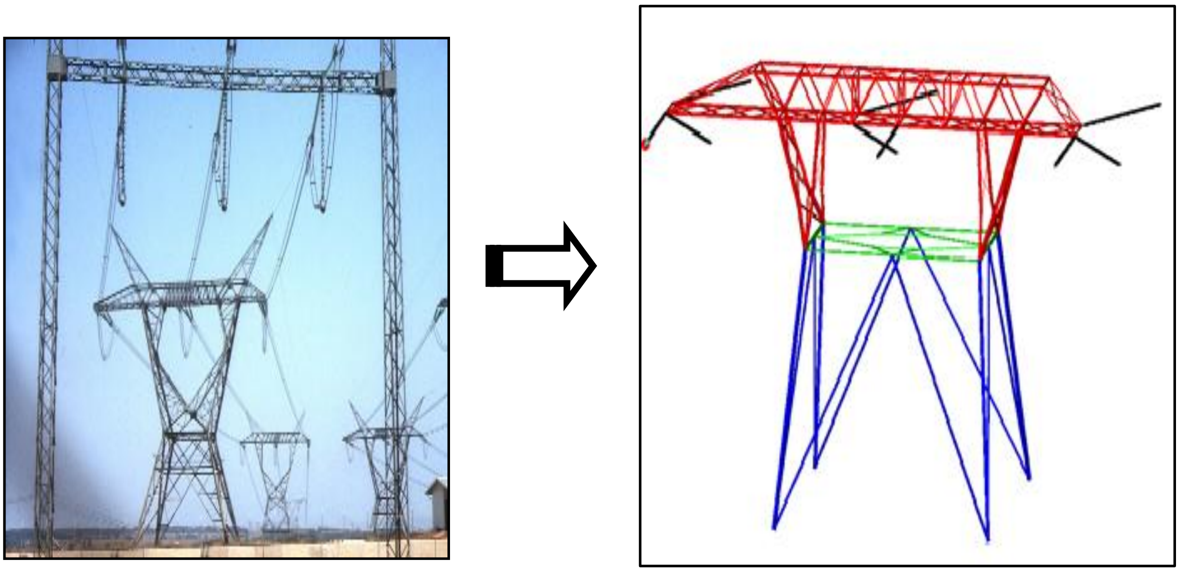


Figure 1.3 Medium Voltage power lines (ESKOM, 2013)

According to Maudu (2006), the main cost advantages of using these philosophies are:

- Used for low consumption, dispersed rural areas;
- SWER and two-phase MV systems require shorter poles or can provide longer span lengths than three-phase designs when using the same height poles;
- SWER and two-phase MV systems require less pole-dressing equipment.

1.1.3 Low Voltage lines

ESKOM typically uses Low Voltage (LV) lines with voltage levels of 230V and 420V. In fact, anything less than 1000V is considered LV. LV power lines are used for connection between residential or small commercial customers. It is characterized by carrying a substantial risk of electric shock and minor risk of electric arcs through the air. They normally use post insulators and in most cases conductors are covered by insulation as shown in figure 1.4.

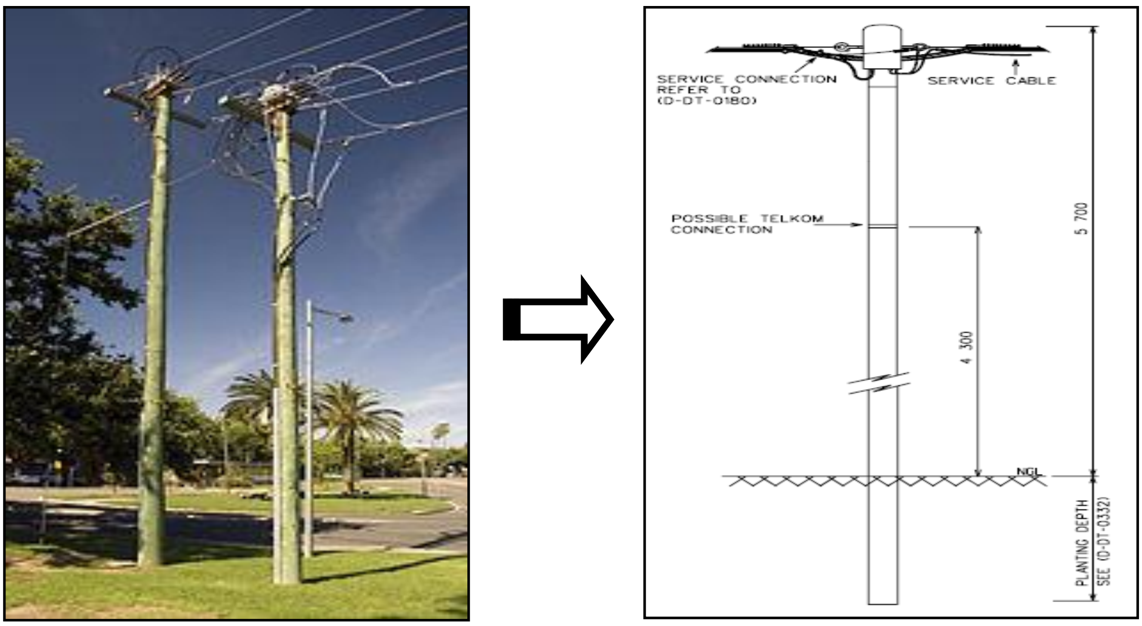


Figure 1.4 Low Voltage power lines (ESKOM, 2013)

Cost advantages (Maudu, 2006) for using LV philosophies are:

- Single- and dual-phase transformers are less costly than three-phase units and;
- Single- and dual-phase LV Arial Bundle Conductor (ABC) can be spanned up to 30 % further than three-phase ABC.

1.2 Underground Power Cables

Most cities use underground cables to distribute electrical energy. These cables virtually eliminate negative environmental effects and reduce electrocution hazards. However, they entail significantly higher costs and greater operational limitations. More recently solid cables have been developed using polyethylene-based insulation. The most common one is the cross-linked polyethylene (XPLE) cable shown in figure 1.5. All cables have an external metallic sheath to protect the cable should a fault develop. Rated voltages may range from 44kV up to and including 132kV.

Figure 1.5 Cross-linked polyethylene cable (ABB, 2013)

Underground power cables can also assist in the distribution of power across:

- Densely populated urban areas;
- Areas where land is unavailable or planning consent is difficult;
- Rivers and other natural obstacles;
- Land with outstanding natural or environmental heritage;
- Areas of significant or prestigious infrastructural development;
- Land whose value must be maintained for future urban expansion and rural development.

The advantages for underground cables are as follows (Wikipedia, 2013):

- They are less subject to damage from severe weather conditions (mainly lightning, wind and freezing);

- They greatly reduce emission into the surrounding area of electromagnetic fields;
- Underground cables need a narrower surrounding strip of about 1-10 meters to install, whereas an overhead line requires a surrounding strip of about 20-200 meters wide to be kept permanently clear for safety, maintenance and repair;
- Underground cables pose no hazard to low flying aircraft or to wildlife, and are significantly safer as they pose no shock hazard (except to the unwary digger);
- Much less subject to conductor theft, illegal connections, sabotage, and damage from armed conflict.

The disadvantages for underground cables are as follows (Wikipedia, 2013):

- Undergrounding is more expensive, since the cost of burying cables at distribution voltages is several times greater than overhead power lines, and the life cycle cost of an underground power cable is two to four times the cost of an overhead power line;
- Whereas finding and repairing overhead wire breaks can be accomplished in hours. Underground repairs can take days or weeks, and for this reason redundant lines are run;
- Underground power cables, due to their proximity to earth, cannot be maintained live, whereas overhead power cables can be;
- Operations are more difficult since the high reactive power of underground cables produces large charging currents and so makes voltage control more difficult.

1.3 Current European Union Practices

It is of great interest to review the current situation of electricity networks (overhead lines and cables) in European countries according to the categories of networks in respect to their voltage: LV (200V to 400V), MV (10kV to 50kV) characterised generally as distribution networks, HV (60KV to 150KV) that are attributed in some countries as distribution and in others as transmission networks, and finally extra HV (220KV to 400KV) which constitute the main transmission networks for most countries (Commission of the European Communities, 2003).

1.3.1 LV networks (200 - 400V) and MV networks (10 - 50 kV)

The following tables 1.1 and 1.2 are based on information provided by (Commission of the European Communities, 2003) and present the length of "LV networks" and "MV networks" in a number of European Union countries and Norway, as well as the percentage of underground cables in these networks. It can be seen that most of the countries have achieved to underground more than two thirds of their Low and Medium Voltage networks, while the rest of countries have achieved quite important percentages of undergrounding. Furthermore, the rates of annual increase of undergrounding cables show that a serious effort continues by the countries to underground their low and medium voltage networks.

Table 1.1 Situation of European networks of LV

	Km of network	Length of network (m/habitant)	Percentage underground
Netherlands	145.000	8,9	100 %
UK	377.000	6,4	81 %
Germany	926.000	11,3	75 %
Denmark	92.000	17,6	65 %
Belgium	108.000	10,6	44 %
Norway	185.000	41,3	38 %
Italy	709.000	12,1	30 %
France	632.000	10,5	27 %
Portugal	112.000	11,9	19 %
Spain	241.000	6,0	17 %
Austria	65.000	8,0	15 %

Table 1.2 Situation of European networks of MV

	Km of network	**Length of network (m/habitant)**	**Percentage underground**
Netherlands	101 900	8,9	100 %
Belgium	65 000	6,4	85 %
UK	372 000	6,3	81 %
Germany	475 000	5,8	60 %
Denmark	55 000	10,5	59 %
Sweden	98 700	12,3	53 %
Italy	331 000	5,7	35 %
France	574 000	9,5	32 %
Norway	92 000	20,5	31 %
Spain	96.448	2,4	30 %
Portugal	58 000	6,1	16 %
Austria	57 000	7,0	15 %

1.3.2 High and extra HV networks

The following table 1.3 presents the situation of high and extra high electricity transmission networks in 8 European Countries, as well as in Norway and Switzerland, in a rather aggregate form in respect to voltages of networks.

Table 1.3 Situation of High and extra HV networks

	HV			**Extra HV**					
	60-90-110-150 kV			**220-275 kV**			**380-400 kV**		
	km of network	km of underground	%	km of network	km of underground	%	km of network	km of underground	%
Netherlands	6 457	905	14,0	648	6	0,9	1 979	0,4	0,02
UK	25 825	3 789	14,8	3 029	71	2,3	788	11	1,4
Germany	76 349	4 740	8,2	21 545	35	0,2	18 314	62	0,3
Denmark	8 005	1 673	20,9	5 578	375	6,5			
Belgium	5 172	396	7,6	267	-	0	883	-	0
Norway	19 825	624	3,2	6 049	64	1,1	2 316	36	1,8
Italy	36 677	449	1,2	13 641	387	2,8	9 751	9	0,1
France	50 513	1 984	3,9	27 890	813	2,9	20 794	2,5	0,01
Portugal	9 311	258	3,8	4 409	-	0	1 234	-	-
Switzerland	6 080	680	11,2	5 822	22	0,4	1 800	-	0

The following conclusions can be drawn from table 1.3:

- In HV networks the percentages of underground cables are medium to low. Four countries (Netherlands, UK, Denmark and Switzerland) have achieved percentages between 10% and 20%,while the rest of the countries have lower percentages. These HV underground sections are usually those in urban and semi-urban areas, as well as in environmentally sensitive areas. The relatively high cost of underground cables in respect to overhead lines of HV should be considered as the main reason for such medium to low percentages of undergrounding achieved in the various European countries.
- In extra HV networks the percentages of underground cables are very low, with average values around 0,5% for 380-400 kV lines and around 2,0% for 220-300 kV lines. Usually, the underground sections refer to special projects in urban areas or environmentally sensitive areas, where the construction of overhead lines is rather impossible. The considerably high cost of underground cables in respect to overhead

lines of extra HV should be considered as the main reason for such low percentages of undergrounding achieved in the various European countries.

1.4 Problem Statement

Electricity is taken for granted and it is only when lights go out and life comes to a standstill that ESKOM, industries and communities become suddenly aware of their total dependence on the integrity of overhead line (OHL) fittings. There are a number of poor quality OHL fittings manufactured locally and abroad finding their way into local South African suppliers. Most of these fittings are purchased by ESKOM Generation (Gx) , Transmission (Tx) and Distribution (Dx), municipalities and private organisations that generate their own electricity.

Once installed, the Dx network becomes subject to incidence of failure caused by defected fittings. This not only may cause power supply interruptions, but also, its destructive effects frequently extends to equipment's and other connected installations, with the possibility to impact the environment, cause personal injuries and the possibility of indemnities, penalties and fines. According to (Vrey, du Preez and van der Merwe, n.d.), the failure rate for various components for Dx lines as a function of age are indicated as follows in table 1.4:

Table 1.4 Component failure rate (Vrey, du Preez and van der Merwe, n.d.)

Components	Failure Rate
OHL fittings	0.96
Switch	0.37
Substation transformer	0.15
Underground cable	0.082
Circuit breaker	0.049
Distribution transformer	0.037

Statistically, the failure rate for OHL fittings is much higher than that of the other components. In fact, it is 6.4 times higher than that of substation transformers. Even allowing for regions with complex geological and severe climatic conditions, the fault rate for Dx lines is the critical factor determining the overall network reliability. Therefore, in order to minimise the risk of OHL fitting failures, it is necessary to ensure that each and every component is designed and manufactured to meet all the criteria set out in relevant ESKOM's standards and specifications.

1.5 Research limitations

Considering the above, it is important to indicate that this research report will have its own limitations and are as follows:

- This refers to access to information, support from ESKOM and suppliers. Most of the resources that will be consulted are a few months or years old, and does not contain the most relevant, up-to-date information. The author did, however, determine that one of the best ways to learn about this aspect is to study previous case studies throughout time. Gaining a historical context for current organizational problems and procedures is the strength of this research. A variety of literature will be consulted and also several technical specialists will be interviewed to aid in understanding of where the field currently is and where it is going;
- The main limitation of this dissertation is that no overhead line fitting evaluation was conducted before. Therefore, there are no established standards or defined processes for conducting this evaluation. However, while this can be viewed as a limitation, this particular aspect of research may also be its greatest strength. Because there has never been an evaluation, the author has the freedom and ability to fully immerse in research and development, and ultimately, create an effective evaluation methodology to better the field without being confined to a pre-existing format;
- In attempting to build an effective evaluation methodology model that fits the requirements of all overhead line fittings, the nature of the model could be so generalised that the link between asset management, life cycle costing, value engineering and quality management system may become tenuous;
- Although underground cables are part of the Dx network for distributing energy, a full discussion lies beyond the scope of this study;
- The research was limited to ESKOM Dx for practical reasons, such as logistics, response times and ease of access.

2 OVERHEAD LINE FITTINGS

In South Africa, the standard reference used by most power utilities for the design of OHL networks is the South African National Standard Code of Practice: SANS 10280:2004 titled, *“Overhead power lines for conditions prevailing in South Africa”*. This standard essentially deals with the design and mandatory safety requirements of tower structures, insulators, conductors and the associated fittings. OHL fittings forms an integral part of ESKOM’s Gx, Tx and Dx networks. OHL fittings, by definition, are components/hardware used to support and connect the phase conductor to insulators and insulators to the tower. By doing so, it enables electrical energy to be transmitted at a distance from the energy supply point.

OHL fittings covers a range of components from connecting the conductor to the tower or protecting the conductors from vibration damage, to making the line more visible to low flying aircraft. There are others used for electrical continuity connections such as aluminium compression dead-ends and mid-span joints. OHL fittings can be divided into two groups, namely, load bearing and non-load bearing fitting.

2.1 Load Bearing Fittings

Load bearing fitting typically comprises shackles, yoke plates and other components subjected to continuous mechanical loading during operating life. Some examples of load bearing fittings that can be defined as subject to continuous mechanical loading are shown in table 2.1.

Table 2.1 Load bearing fittings (ESKOM Power Series, 2005)

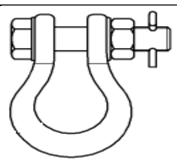
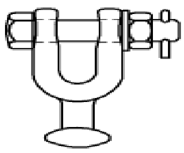
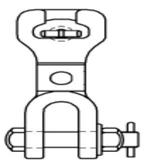
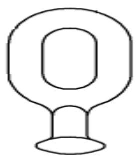
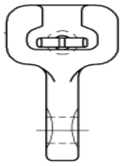
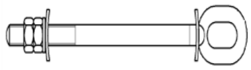
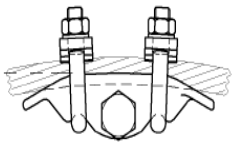
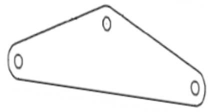
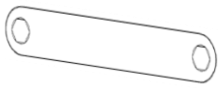
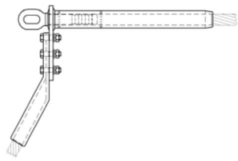
Description	Drawing	Description	Drawing
Shackle		Ball clevis	
Socket clevis		Ball oval eye	

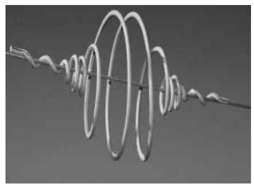
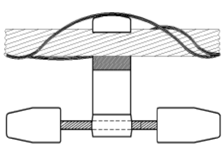
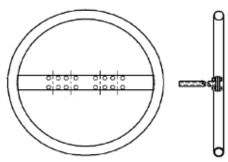
Table 2.1 Load bearing fittings (ESKOM Power Series, 2005)

Description	Drawing	Description	Drawing
Socket tongue		Eye bolt assembly	
Suspension clamp		Yoke plate	
Extension link		Compression dead end	

2.2 Non-load Bearing Fittings

Non-load bearing fitting depicted in table 2.2 includes items such as vibration dampers, corona rings, aerial warning spheres, bird diverters and other components, not necessary subjected to continuous mechanical loading.

Table 2.2 Non-load bearing fittings (ESKOM Power Series, 2005)

Description	Drawing	Description	Drawing
Aircraft warning spheres		Bird flight diverters	
Vibration dampers		Corona rings	

OHL fittings have specific functions and together they form a reliable electricity network. These specific functions result in special designs and characteristics that need to be tested before the component can be safely used on the network.

2.3 Strength Requirements and Overhead Line Fitting Grouping

The strength requirement for OHL fittings is calculated based on their relationship to the conductor and ground wire to which they are attached. The strength classes used by ESKOM for OHL fittings is the standard insulator strength classes that is, 40 kN, 70 kN, 120 kN, 210 kN, 300 kN, 400 kN and 500 kN (ESKOM Power Series, 2005). The following groupings indicate different types of OHL fittings currently used by ESKOM:

- Conductor clamps (CC) - used for suspension of conductors (e.g. pistol grips);
- Galvanised pre-fabricated steel (GPS) - support structures (e.g. steel cross arms);
- Strain nuts, strain bolts and forgings (SN, SB & F) - couplings (e.g. socket clevis);
- Bolts, nuts and washers (B, N & W) – fasteners (e.g. clevis bolts) and;
- Stay steel components (SSC) - steel wire, rope or rod working under tension, connecting a point of support to a separate anchor (e.g. stay rods);
- Threaded rods (TR) - fastener (e.g. galvanised threaded rods).

2.4 Framework for Strategic Overhead Line Fitting Analysis

Clear and concise communication has long being a goal of good governance. Technical jargon is probably one of the impediments to communication. While a certain amount is useful and necessary, overuse can interrupt the flow of understanding. There is a need for what may be termed an "anatomy of technology" (van Wyk, 1999). The essence of that is presented in figure 2.1 and 2.2.

2.4.1 Overhead line fitting description using nine cell functional classifications

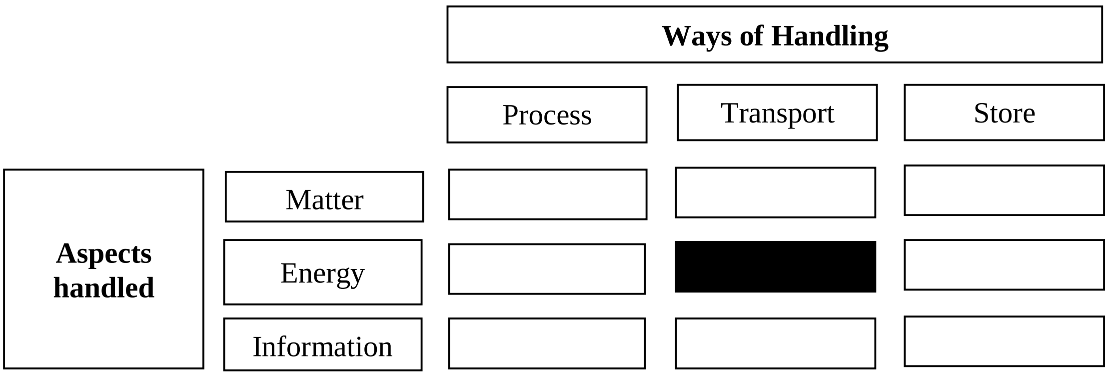


Figure 2.1 Nine cell functional classification of overhead line fittings

The primary function of OHL fitting is that of support however, as an auxiliary to the Dx network, it also plays an important role in enabling electricity to be transferred from one source to another. Based on this analogy, OHL fitting is classified as an energy transporter using the nine cell classification of technological functions.

2.4.2 Description of overhead line fitting using essential features of technology

The framework for identifying the essential features of technology is determined by 6 features as per the following strategic technology analysis block shown in figure 2.2.

FEATURE	QUESTION	RESPONSE
Function	What does the entity	Three nouns & verbs
Performance	How well does it do it?	Four measures
Principle	How does it do it?	Underlying science
Structure	How is it made?	Shape, build & complexity
Size	How big is it?	Micro, human & macro
Material	What is it made of?	Six materials

Figure 2.2 Framework for identifying essential features of overhead line fitting technology (van Wyk, 1999)

The technology being analysed is OHL fitting which is classified as an energy transporter according to functional classification in section 2.4.1

Function

OHL fitting is used to support and transport power from one point to another in an electrical network. It is utilised with other line fitting accessories to satisfy this function.

Performance

According to the South African National Standards; SANS 61284:1997 titled, *"Overhead lines - Requirements and tests for fittings"*, OHL fitting shall withstand the mechanical loads relevant to installation, maintenance and service, the designed service current, including short-circuit current, the service temperatures and environmental circumstances. It should operate within a minimum of the following parameters.

Table 2.3 Performance parameters for overhead line fittings

Performance Indicator (Dx only)	**Requirement**
Rated voltages	From 230V up to 132 KV
Mechanical loads/Strength rating	From 6kN up to 210kN
Temperature during continuous current rating	70 degrees Celsius
Temperature during the short circuit	200 degrees Celsius

Principle

Since OHL fitting are used for support and transporting energy (electrical continuity connections), the principle are as follows:

- Support - OHL fitting comes with a number of intricate shapes and sizes and thus it allows connection of conductors to insulators, and from insulators to towers possible. It is utilised with other fitting accessories to achieve this principle;
- Transporter of energy - To ensure that there is continuity of electrical energy, OHL fitting acts as a pathway for current to be transmitted from one supply point to the other (e.g. aluminium mid-span joints). Most of the OHL fitting are metallic in nature, the electrically charged particles move through the electrical joint. The movement of charges constitutes an electric current. The charge transport may be as a result of potential difference due to an electric field. The physical parameters governing this transport depend upon the material. The conduction is well described by Ohm's law which states that the current is proportional to the applied electric field. The conduction of electricity by metallic electrons will cause the electrical flow.

Structure

Most OHL fitting found on the Dx power network are metallic in nature. They are capable of withstanding loads (mechanical and electrical) and they come with a variety of shapes as indicated in table 1.1 and 1.2. However, for LV lines, there are few items made from a strong

UV resistant thermo plastic material and others consist of a glass fibre reinforced thermo-plastic UV resistant body.

Size

There are various OHL fitting sizes available and the dimensions are material strength dependent. Guidelines are specified in standards and specifications. Sample of average sizes for OHL fitting are shown in the table 2.4.

Table 2.4 Sample sizes for overhead line fittings (approximate values)

Category	Nominal size		Rating
Galvanised pre-fabricated steel (GPS)	Cross arms channel	1300mm long	120kN
	Bonding clip	22mm diameter, 2mm thick plate	N/A
	Sag adjustor	16mm thick plate	120kN
Conductor clamps (CC)	Crosby clamp	13mm and 16mm diameter wire rope	Joint force 34- and 51 kN
	Pistol strain clamp	Conductor range 5mm to 16mm diameter	70kN
	Suspension clamp	Conductor range including armour rods 8mm (3.66 steel wire) to 18mm (Fox)	70kN
Stay steel components (SSC)	Stay rods	1500mm working length and 12mm rod diameter	34kN
	Rock anchor	32mm in diameter and 910mm long	96kN
	Stay plate	M20, 600mmx600mmx6mm, 70mmx22mm slot	96kN
Nuts, bolts and washers (N, B & W)	Galvanised hexagon nut	M6 with clean thread	N/A
	Spring washer	M12 spring steel	N/A
	Galvanised coach screw	6mm diameter thread and 75mm long	N/A
Strain nuts, strain bolts and forgings (SN, SB & F)	Pigtail bolt	M10 with 200mm thread length	4kN
	Eye nut	To be used on M16x2,0-6H bolt	40kN
	Clevis ball	Designation: 16mm 16L 80CL	120kN
Threaded rods (TR)	Galvanised TR	M12 and 350mm long	N/A
	Electro-plated TR	M6 and 500mm log	N/A

Material

OHL fitting is grouped into six categories as shown in section 1.4.3 and each category is made up of the following materials in table 2.5:

Table 2.5 Overhead line fitting materials

Category	Material
Galvanised Pre-fabricated steel	S355JO/350WA
Conductor clamps	Malleable cast iron/Drop forged steel
Stay steel components	Mild steel and S355JR/350WA
Nuts, bolts and washers	Class 6 and Spring steel
Strain nuts, strain bolts and forgings	SAE 1008, S355JO/350WA and Drop forged steel
Threaded rods	070M20 and SAE 1008

3. THE IMPACT OF POOR QUALITY OVERHEAD LINE FITTINGS

In an increasingly competitive arena there is significant pressure on energy producers for greater system reliability and improvement of customer satisfaction. To achieve this, OHL fittings and accessories that make up the electrical infrastructure need to have good quality and reliable. It is impossible to imagine modern society without electricity. The primary sector, secondary sector and the entire cities are primarily dependent on just one interconnected infrastructure: the electricity network. What will happen if one vital fitting in this network fails?

This section of the research report focuses mainly on the impact of poor quality OHL fittings supplied to ESKOM. It aims to identify the different factors contributing to the failures. However it is not intended to apportion blame or liability towards any particular supplier or individual except so far as necessary to achieve the said purpose. Research, Testing and Development division in ESKOM, has during the years conducting investigations on OHL fitting failures and this included amongst identifying accident causing factors and system deficiencies. The following case studies are the actual accidents that occurred in the ESKOM Dx division:

3.1 Case Study 1: Threaded Rod Failure On The 11 kV Overhead Line Feeding The Royal Bafokeng Sports Campus

Royal Bafokeng campus 11 kV line is 10 km in length and was commissioned in May 2010. On 16 June 2010, one of the M20 threaded rods shown in figure 3.1 which supports the Chickadee conductor strain assembly failed. In addition, it was reported that at the time of failure the ambient temperature was approximately negative 3 degrees Celsius. Site investigations were conducted and it revealed several defects and construction error. The technical requirements for the threaded rod as specified by ESKOM Dx are shown in Appendix A.

Figure 3.1 M20 Threaded rod assembly received (Calitz, 2010)

A number of examinations were conducted including visual, corrosion, scanning electron microscope, metallurgical, chemical and mechanical. It was concluded in the investigation report (Calitz, 2010) that the material used to manufacture the threaded rod from, is not SAE 1008 or 070M20 steel as specified by ESKOM Dx specification D-DT-3015 in Appendix A. Furthermore, the rod failure was not the result of one single factor/event, but a combination of different factors such as:

- The use of an incorrect rod material (high phosphorous content) that was less ductile than the recommended steel. Resulting in cracking of the material at the root of the threads when the rod was subjected to a bending load;
- The tendency of the material to behave brittle with reduction in temperature;
- Manufacturing defect were this threaded rod was undersized by about 1mm and;
- Poor installation practice.

3.2 Case Study 2: Investigation Into The Contact Accident (Public Fatality) In Tswelalang Township, The Service Area Of Wolmaranstad

A failure investigation was conducted on the supplied failed full tension automatic mid-span joint, which failed at the Tswelalang township (located within the service area of the Wolmaranstad Technical Service Centre). On 14 July 2010, the failure of the joint resulted in the Aerial Bundled Conductor (ABC) to fall to ground and when a member of the public apparently attempted to re-join the bare neutral conductor of the ABC, he was electrocuted to death. The contact accident was reported to the South African Police Service.

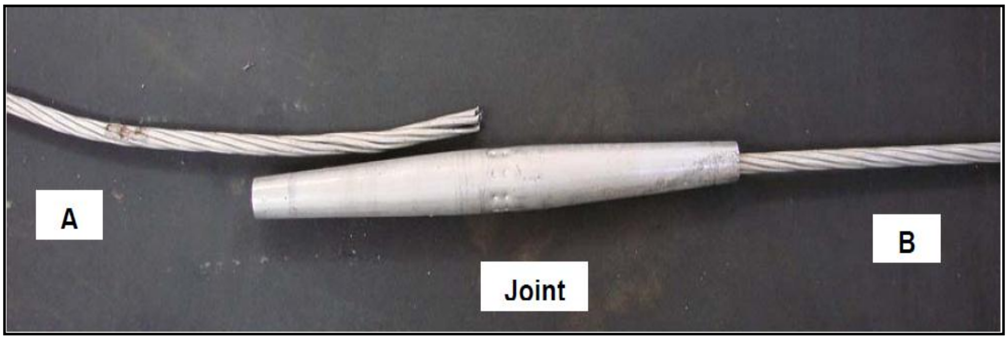


Figure 3.2 Full tension automatic joint received (Calitz, 2010)

The investigation of this incident (Calitz, 2010) consisted of a visual examination of the received full tension automatic joint shown in figure 3.2, evidence obtained during the site visit of the line and the area where the accident occurred. Based on the evidence obtained during the examination, it was perceived that the following contributed to the failure of the joint and electrocution of the child:

- The wear marks found on conductor piece A and within the mouth of the automatic joint indicated that, the jaws did not grip properly onto the neutral conductor hence, movement of the conductor within the joint was allowed. In addition, the formation of aluminium oxide (black deposit) indicated that the movement was allowed or took place for some time;
- Although, the correct range taking full tension automatic joint was used to join the bare neutral conductor, it needs to be taken into consideration for the reason that, the joint does not meet the requirements as specified by the relevant Dx specification. The joint revealed no colour coding, no conductor cup, etc;
- Evidence obtained indicated that the installation of the full tension automatic joint was inadequately done, which resulted in the joint failure.

3.3 Case Study 3: Eberhardt Martin Pistol Grip Failure

A failure investigation was conducted on the supplied Eberhardt Martin (EBM-30) pistol grip, as both the Southern and the Eastern regions experienced the same failure mode on installation of the mentioned fitting. As revealed in figure 3.3, cracking occurs along the flash line of the EBM-30 clamp.

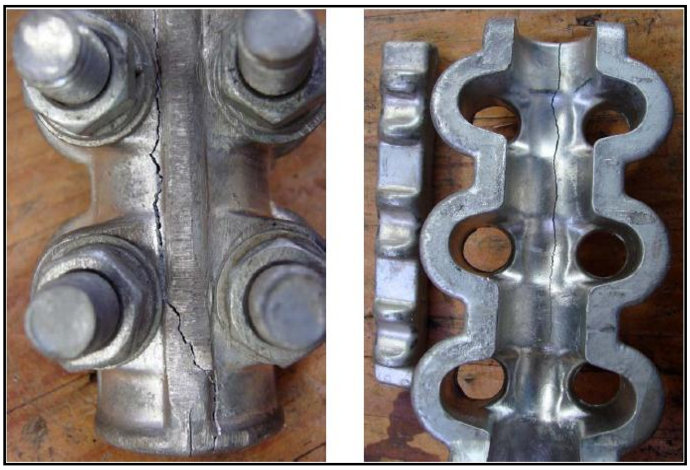


Figure 3.3 Cracking of failed EBM clamp (Calitz, 2013)

Examination of the replacement clamps revealed that a spring washer of one of the clamps was corroded and that not all the clamps had flat washers installed. The failures that corrosion damage caused was as a result of rust, brittleness and deterioration. This is indicated in figure 3.4.

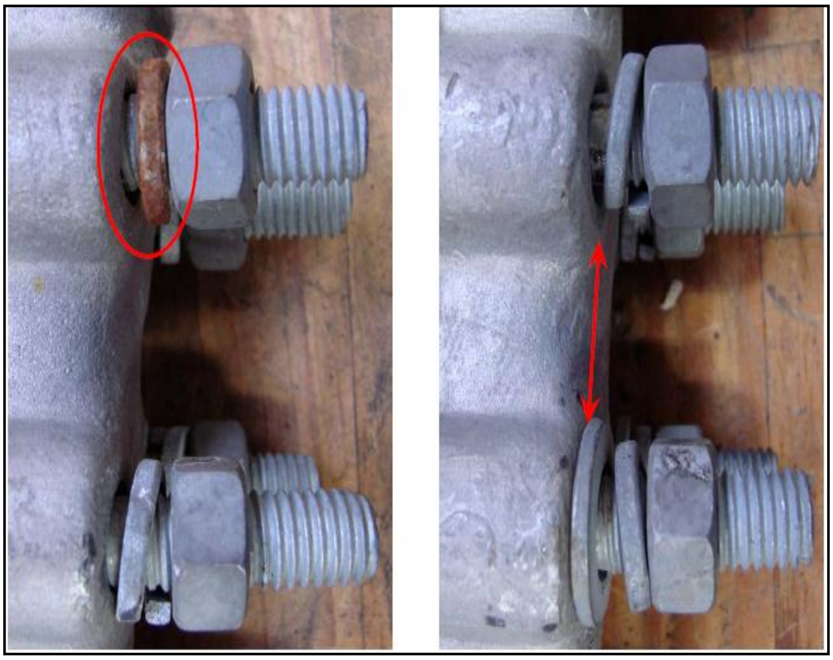


Figure 3.4 Difference in washer arrangement for the replacement clamp (Calitz, 2013)

All the evidence obtained during the investigation indicated that the EBM-30 clamps failed due to casting related problems, which could include the following:

3.3.1 Pouring temperature

An increase in pouring temperature has an effect on the microstructure of a sand cast product as it results in the dendrite arm spacing (DAS) to increase (increase grain size) and in turn reduces the mechanical properties.

3.3.2 Pouring speed

Porosity in aluminium alloy castings generally appears as round or rounded pores associated with gas or as elongated inter-dendritic pores referred to as "shrinkage." This occurs when there is inadequate feeding of the casting during solidification.

3.3.3 Hydrogen porosity

According to Calitz (2013), Hydrogen is the only gas that is appreciably soluble in aluminium and its alloys. Its solubility varies directly with temperature and the square root of pressure. During the cooling and solidification of molten aluminium, dissolved hydrogen in excess of the extremely low solid solubility may precipitate in molecular form, resulting in the formation of primary and/or secondary voids. Two types or forms of hydrogen porosity may occur in cast aluminium. Of greater importance is inter-dendritic porosity, which is encountered when hydrogen contents are sufficiently high that hydrogen rejected at the solidification front results in solution pressures above atmospheric. Secondary (micron size) porosity occurs when dissolved hydrogen contents are low, and void formation is characteristically sub critical.

There are numerous sources of hydrogen in aluminium. Moisture in the atmosphere dissociates at the molten metal surface, offering a concentration of atomic hydrogen capable of diffusing into the melt. The barrier oxide of aluminium resists hydrogen solution by this mechanism, but disturbances of the melt surface that break the oxide barrier result in rapid hydrogen dissolution. Alloying elements, especially magnesium, may also affect hydrogen absorption by forming oxidation reaction products that offer reduced resistance to the diffusion of hydrogen into the melt and by altering liquid solubility.

The introduction of moisture-contaminated tools to the melt dramatically increases dissolved hydrogen levels. Salt fluxes, which may have hydroscopically adsorbed moisture, and unprotected fluxing tubes coated by reaction product salts both increase dissolved hydrogen content. The melt charge may contain both dissolved hydrogen and, when not preheated before charging, moisture-contaminated surfaces. The chemical composition of the EBM-30 clamp revealed no abnormities and conformed to a LM25 material as specified by the ESKOM, confirming that the failure of the clamps is not material related, but manufacturing related as discussed.

3.4 Case Study 4: Ratchet Nut Failure on Vuyani Payne's Farm 132kV

A failure investigation was conducted on a ratchet nut of an adjustable stay rod, which failed at structure 8 of the Vuyani Payne's Farm 132 kV line. It was indicted that while the contractor constructing the Vuyani Payne’s Farm 132 kV was straightening structure 8, the ratchet nut broke while tensioning one of the stays. Figure 3.5 reveals one of the intact ratchet nuts received. In order to explain the terminology used to describe the findings of the examination, figure 3.5 reveals the identification names used to describe the different sections of the ratchet nut.

Figure 3.5 Descriptions used for the different sections of the ratchet nut (Calitz, 2008)

The failed ratchet nut consisted of three pieces is shown in figure 3.6. The failure of the nut occurred at the collar section of the nut. In addition, the 2 pieces received did not represent the complete collar section, assuming that one or more pieces of the failed collar were not collected at site after the failure.

Figure 3.6 Failed ratchet nut (Calitz, 2008)

Examination of the fracture surface in figure 3.7 revealed two areas, which had a darker colour than the rest of the facture surface. In addition, flow lines visible on the fracture surface indicated that the crack growth direction was from the outside toward the inside of the nut.

Figure 3.7 Dark stained areas found on the fracture surface (Calitz, 2008)

Closer examination of the 32 mm threaded section revealed that the thread was not properly cut/machined as only 13 mm of the threaded section had proper threads. The remaining area was smooth with only machine marks visible.

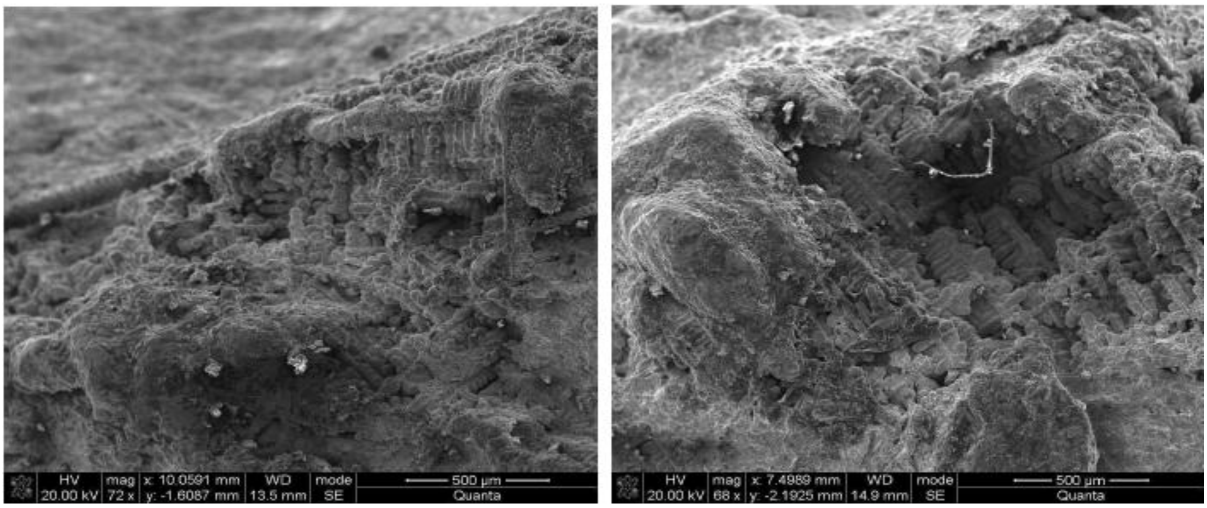


Figure 3.8 Reveals dendrite formation within the shrinkage voids (Calitz, 2008)

Examination of the dark coloured areas visible on the fracture surface as revealed in figure 3.7 revealed that these areas were shrinkage voids. As revealed in figure 3.8, dendrite formation had occurred within these voids.

Further case studies are shown in Appendix B and reports can be obtained from Material, Stress and Vibration Department in ESKOM.

4 RESULTS AND DISCUSSION

This section discuss OHL fitting failure reduction using asset management, life cycle costing, quality management system, value engineering and OHL fitting evaluation. These key elements do not function in isolation but they are interlinked for a successful mitigation of risks and to reduce catastrophic failures. In addition, these elements will be used in deriving quantifiable design specifications and requirements for the OHL fitting evaluation process in section 4.4. The key elements are listed as follows:

4.1 Asset Management

Asset management involves a systematic process of operating, maintaining and upgrading physical assets with a focus on reducing life cycle cost and risks to maximise return on investment. Broadly, assets of a utility consist of a physical infrastructure, information resources, and the people with the knowledge to operate that infrastructure (Pillay, 2010).

This section discusses issues surrounding maintenance of OHL fittings and this includes preventative maintenance (line inspections), predictive maintenance and breakdown maintenance which could be used to improve assets of the utility and consequently reduce catastrophic risks.

4.1.1 Maintenance philosophy and practices for reducing OHL fitting failures

Maintenance is a function of keeping OHL fittings or restoring them to, serviceable condition. It includes line inspection, adjustment/alignment, tests, replacement, reinstallation, condition determination, repair, modification and reclamation. The major types of OHL fitting maintenance are as follows:

Preventative maintenance (line inspections)

The care and repairing by personnel for the purpose of maintaining OHL fittings and the associated infrastructure in satisfactory operating condition by providing systematic inspection, detection and correction of incipient failures either before they occur or before they develop into major defects. It is carried out at predetermined intervals to ensure that

OHL fittings are serviced and have higher potential to work through its life cycle. The single biggest advantage associated with planned preventative maintenance scheme is that it ensures that ESKOM keeps its OHL fittings in good working order. Furthermore, test results over time begin to give an understandable (easy to interpret) indication of the natural ageing of various fitting components. Planned replacement forecasting becomes easier and technical motivation based on reliable long term test results becomes more reasonable.

In ESKOM, preventative maintenance for critical lines is conducted by aerial line inspections. These inspections are carried out by a qualified observer seated on the rear side of a helicopter and equipped with gyroscopically stabilised binoculars for detailed examination of each component. The helicopter follows a regular and well-defined flight path at each tower to facilitate a complete study of the structure from the top to the footing and then proceeds down the span (basically all OHL fitting inspection, corrosion inspection (especially at the coast or in pollution areas), paint work and foundation conditions inspections, a pole numbering inspection and an inspection of all bolts, dampers, connectors, etc. are carried out.) at a speed of less than 5km/hr (Mace, 2010). Further clarity on different types of components inspected is given in Appendix D.

The inspection findings are entered into a custom-designed database on a pen palette type laptop by a computer operator situated in the aircraft, permitting rapid, complete and accurate recording and sorting of the information. Where considered beneficial and to assist the utility in their own assessment of the nature and maintenance priority of the faults detected, photographs are taken for reference. For the infrared inspections, the thermographer is seated on the side of the helicopter and examines all current-carrying components, such as compression dead ends, jumper flag terminals, mid-span splices and conductor repair sleeves (Mace, 2010). Appendix E shows the utilization of infrared imagery on defective components that occurs in many electrical systems.

However, for typical lines, detailed hands-on inspections are conducted at the frequency specified in table 4.1.

Table 4.1 Inspection frequencies (Ntombela, 2005)

	Inspection frequency (minimum)		
Line type	**Visual**	**Detailed**	**After handover**
1. Distribution (tower, steel pole, wood or concrete)	Annually	10 years	10 months
2. Reticulation (wood or concrete)	Annually	10 years	10 months
3. Low voltage (380V/230V)	Annually	10 years	10 months

Predictive maintenance

Predictive maintenance techniques assist in determining the condition of in-service OHL fittings in order to predict when maintenance should be performed. This approach offers cost savings over routine or time-based preventive maintenance, because tasks are performed only when warranted. The condition of the fittings with measurable characteristics will be conducted and corrective actions will be implemented as applicable.

Breakdown maintenance

This is the type of maintenance used during OHL fitting failure. Because it is catastrophic in nature, the Dx network will be out of service and immediate repair of the network needs to be effected. The most important aspect relating to breakdown maintenance is having the necessary spare parts in order to perform the repair. OHL fittings are made locally while some are imported and lead times can be within or less than a week. At time of order placement, the supplier is furnished with the latest buyers' guide of the exact item that failed. The consequence here is that OHL fittings spares are sometimes not easily interchangeable and thus many different fitting spares need to be catered for, due to the variety of line constructions and types that exist in the ESKOM Dx network.

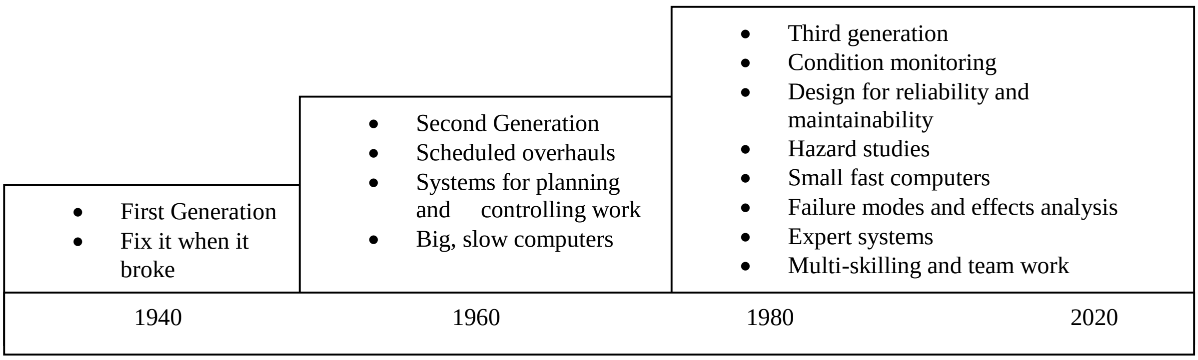


Figure 4.1 Changing maintenance techniques (Gosling, 2010)

In ESKOM, the above discussed maintenance techniques are in the third generation as depicted in figure 4.1. These techniques are very important in reducing failures, improving safety and the reliability of OHL fittings.

4.2 Life Cycle Costing

A realistic economic evaluation of the costs to build and upgrade a line to an acceptable level of reliability and then to maintain it, must include long-term costs of management and maintenance of the line. The use of Net Present Value allows the life cycle costs of the management options to be compared over a predetermined time period. The economic evaluation provides ESKOM with an effective tool to compare the management options available. The option chosen for any OHL fittings will be dependent on a number of factors including age of the fitting, line condition (reliability, servitude and the environment), history of fitting failures, line criticality (importance of the line in the system) and the utility's internal maintenance strategy.

OHL fitting life cycle costing is described in a flow diagram in figure 4.2. Quality is of highest importance throughout the product life cycle so as to achieve the optimum return on investment.

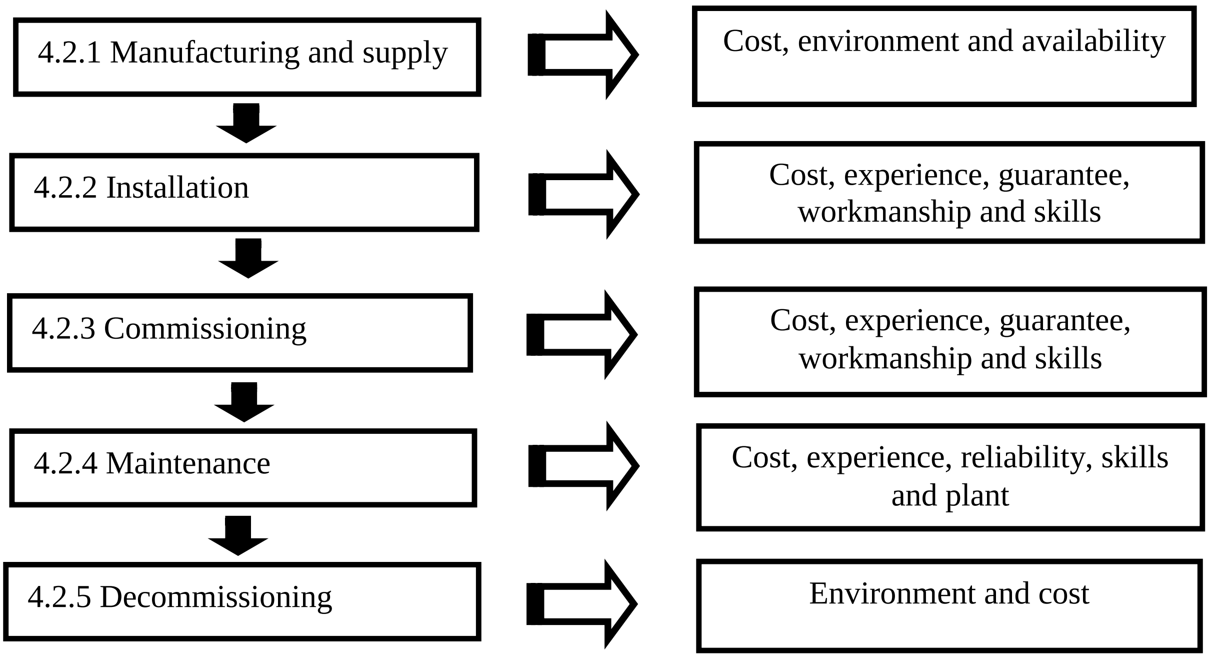


Figure 4.2 Overhead line fitting life cycle cost

4.2.1 Manufacture and supply

OHL fittings have been in use for many decades and since their inception many technological advances have taken place. This rate of advance has continued unabated as manufacturers strive to improve the reliability, performance and operating life expectancy of these fittings.

In ESKOM, the process of OHL fitting evaluation that verifies quality and technical requirements to obtain an acceptable quality approved product is not yet 100 % established. By implementing this process once it is established, the company is able to identify and buy technical and quality acceptable products which are envisaged to last longer than 30 years and perform according to the requirements.

The cost of acquiring OHL fittings varies from manufacturer to manufacturer. The availability of manufacturers for OHL fittings is not limited. There are many local manufacturers in South Africa and importers that represent overseas companies that are part of ESKOM’s supply chain.

4.2.2 Installation

The installation of OHL fittings demands experienced manpower. The labour for capital installations is currently being outsourced and there are many contractors who are competent to carryout/supervise installations for ESKOM Dx networks. On all installation sites there is always an ESKOM employee who checks whether the installation is done according to ESKOM standards and specification. OHL fitting installation checklist is developed, available and makes installation more dependable as it is checked at every stage by an in house employee, although the work is carried out by contractors. OHL fitting which were installed over a period of thirty years are still operating which clearly indicates that the installation of these components has been managed well.

4.2.3 Commissioning

Commissioning of a system is carried out in a standardised manner which is procedurally documented. Over and above, routine line inspections which are carried out by a designated person during network construction are conducted in accordance to the requirements for a line inspection in a works order attached in Appendix C.

4.2.4 Maintenance

There is a task manual which was developed to facilitate the implementation of maintenance tasks on OHL fittings on the Dx network. DST 0030: *"Routine inspection and maintenance of sub-transmission and reticulation lines"*, together with other task manuals for live-work, have been prepared to establish and promote uniform maintenance procedures for OHL Dx systems.

All the regions are required to schedule maintenance for the OHL fittings based on the requirements of the maintenance standard. The national job plans are in place and checklists were made to make the maintenance work to be easily implemented. With the implementation of the published task manual, there is a greater potential for improvement on OHL fitting reliability and quality of supply. The task manuals are all inclusive and cover all or most of the aspects required on maintaining OHL fittings.

4.2.5 Decommissioning

Many redundant OHL fittings remain hanging on pylons. Depending on the severity of deterioration of the fittings, they can be used as spares for repairs to existing networks. Another aspect of decommissioning is that it acts as a cost recovery mechanism whereby, due to many OHL fittings being metallic, they can be treated as "scrap metal" where they can be sorted into different types of metals and sold to metal recycling industries to recover costs.

4.2.6 Financial implications

Asset management and LCC for OHL fittings when applied to the network should make sure that the return on investment is a positive one. The point about OHL fittings is that the measures of performance are sometimes difficult to put economic figures to. They encompass things such as cost of a failure saved, improvement in customer satisfaction, or simply the economic cost of delaying a failure. Listing the areas where savings can be made is relatively easy. Putting costs to these will depend on the type of network in which the fitting is used. The major costs saving categories are:

- Saving the cost of failures;
- Saving the cost of multiple repairs;
- Saving customer outages;
- Savings in a capital replacement scheme by delaying replacement;
- Savings on improving asset quality during commissioning;
- Safety considerations due to failures on OHL fittings.

4.3 Quality Management System

ESKOM in its policies have stated that they only conduct business with ISO (International Organization for Standardization) 9001 certified manufacturers of OHL fittings. Certification to ISO 9001 is objective evidence that the manufacturers have a Quality Management System (QMS) compliant to the standard. The importance of certification, lies not in the physical certificate, but in the fact that the manufacturers of OHL fittings have a working QMS that is compliant to ISO 9001. The following are the advantages for using the ISO approach in reducing risk and ensuring correct process are documented and followed in manufacturing good quality OHL fittings intended for ESKOM usage:

4.3.1 Competitiveness

Possibly the most well-known of the benefits associated with QMS is that certification allows the manufacturer to compete worldwide. OHL fitting manufacturers need standards to do business and this include small businesses can use certification to prove that they are in control of their own manufacturing processes. They are considered as serious competitors.

4.3.2 Productivity and performance

Certification also guarantees that procedures are consistent and that there is a mindset of control and command present in the business. A further benefit for certified manufacturers is better financial performance. The authors add that certification allows for better-defined internal processes, improved profitability and ultimately leads to increased competitiveness.

4.3.3 Controlled processes

Although certification does not guarantee that the OHL products are of high quality, it at least indicates that they have documented their system and is operating it. Points to the importance of a strong quality inspection programme.

4.3.4 People involvement

Small manufacturing companies introducing low-cost elements of QMS such as rearranging processes, developing quality programs and getting employees involved, can culminate in many benefits. These benefits are getting top management involved, changing their thinking and attitude, educating employees and winning support.

From the above, the obvious analogy can be drawn that there are benefits to be gained by developing and implementing a QMS that complies with ISO 9001. It is also evident that should a manufacturer not have a QMS, there is no mechanism for the customer to be certain that good management is being practised. The lack of a QMS may indicate potential risks in the very areas the benefits are realised, and include the following:

- Diminished capability to do business internationally;
- Productivity and financial performance could be substandard, procedures and processes poorly described, and control impaired;
- Any procedures there that may be, may not be operated within;
- Quality inspection may be weak, non-existent;
- There could well be no employee support, or management involvement;

4.4 Value Engineering

Value Engineering (VE) is a collection of techniques designed to examine all the cost components of a product or systems in order to determine whether any cost items can be reduced or eliminated without detracting from its functional and quality elements. This technique was also used to identify, analyse and mitigate risks associated with OHL fitting failure. It encompasses elements from asset management, life cycle costing, QMS and technical requirements. VE Excel spread-sheets were completed and are shown as follows in Appendix:

Appendix G.1: Value engineering cover Page
Appendix G.2: Value engineering issues and concerns
Appendix G.3: Value engineering objective matrix
Appendix G.4: Value engineering results to achieve
Appendix G.5: Value engineering numerical evaluation and cause and effect graph
Appendix G.6: Value engineering recommendations and action plans
Appendix G.7: Perspective modelling matrix

Based on the cause and effect graph the following functions were considered critical:

- Improve manufacturing quality
- Create jobs
- Monitor local manufacturers and importers
- Optimise reliability
- Rationalize items
- Reduce/mitigate risks
- Reduce costs
- Sustain local skills and expertise

The function with the highest score, which is also regarded as the basic function is “optimise reliability”. It can also be deduced from the analysis that rationalize items, reduce/mitigate risks, improve manufacturing quality and sustain local skills and expertise is the secondary functions of this evaluation. These functions are adequately addressed in Value Engineering recommendations and action plan sheet shown in Appendix G.6 and perspective modelling matrix sheet in Appendix G.7. These were generated to ensure that an effective risk mitigation strategy is included in the evaluation process and it is chosen and implemented successfully. In Appendix G.7, the most effective risk assessment methodology in meeting and addressing the abovementioned functions is the OHL fitting evaluation with a score of 219, followed by QMS with 211 points, asset management with 176 points, life cycle costing with 162 points and VE with 137 points.

4.5 Overhead Line Fitting Evaluation Process

To ensure that ESKOM obtains satisfactory and high quality products, there should be a process of evaluation. This process verifies both the quality and technical requirements, which efforts are led by at least a quality and technical specialist. By implementing this process the ESKOM is able to identify and buy acceptable products which are envisaged to last longer and perform according to requirements. In section 5, asset management, life cycle costing, QMS and VE were discussed in depth and this led to the development of the evaluation methodology.

The evaluation is conducted in a two stage approach. The initial evaluation is conducted on submitted documentation (technical A & B schedules, drawings and type test reports). Once this part of the evaluation is passed, samples will be inspected at the manufacturing premises. The manufacturer will be given sufficient notification for them to prepare their samples for inspection. The final result of the evaluation is determined by calculating a weighted score for each item. The score is based on the completeness of submitted schedules, quality of product drawings, level of acceptance of testing and inspection of samples.

A Microsoft Excel spreadsheet (available only in electronic format) was developed to evaluate OHL fittings. This requires input from users to accurately compute required results. The functionality of the spreadsheet is such that, it captures information submitted by manufacturers with regards to a particular fitting, computes and automatically gives results. This process avoids errors and onerous exercise of typing numbers manually. The capturing process not only stores information for future use, it also assists in benchmarking and improving many of ESKOM local and overseas manufacturers.

For ease of reference, a compact disk (accessible through the library) is attached in Appendix H with an example of how the spreadsheet works. Due to computational complexity, it is advisable to use Microsoft Office 2010 and above, as it is faster and allows more characters to be typed when naming folders. Figure 4.3 is the overall OHL fitting evaluation process:

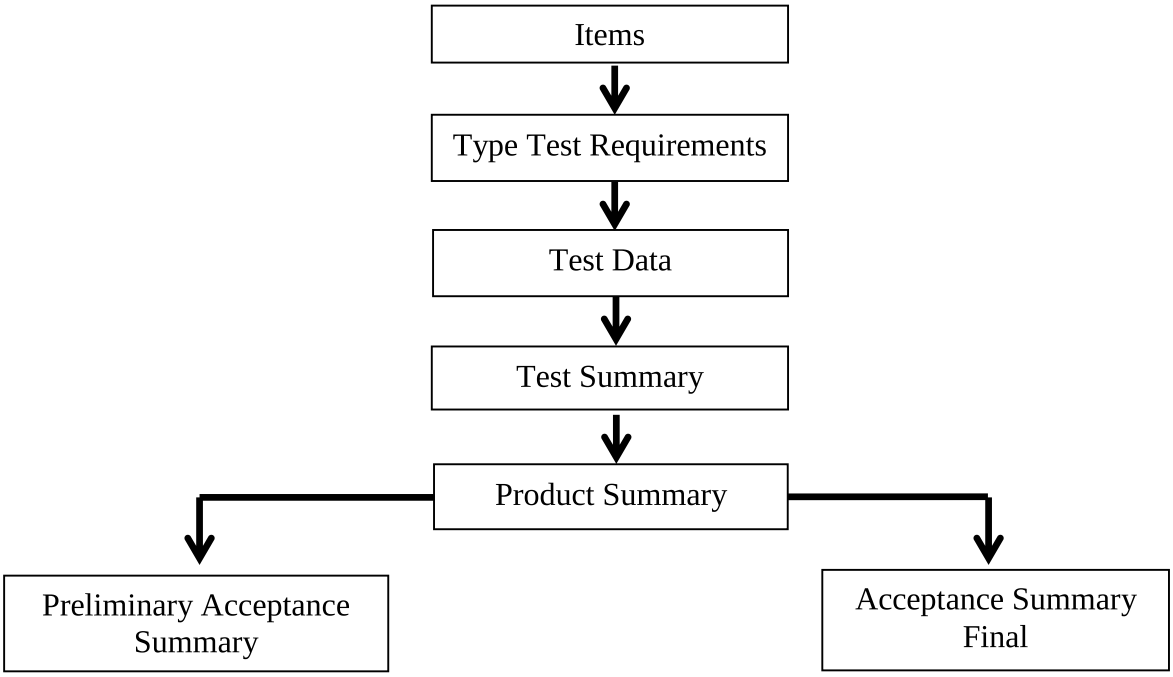


Figure 4.3 OHL fitting evaluation process

4.5.1 Items

This part of the spreadsheet captures number of OHL fitting items submitted by the manufacturer for evaluations. Table 4.2 below indicates that if an item is submitted, "Y" is entered in the cell while "N/A" is entered if there was no submission.

Table 4.2 Example on the input spreadsheet

	Manufacturer A	Manufacturer B	Manufacturer C	Manufacturer D	Manufacturer E	Manufacturer F	Manufacturer G	Manufacturer H
Description	**Item Coverage Before Evaluation**							
XARM,ST CHANNEL 2400 LG.	Y	N/A	N/A	Y	N/A	Y	Y	Y
CLAMP,SUSP CRADLE CON 15.0-24.4	Y	N/A	Y	N/A	N/A	Y	N/A	N/A
WASHER,CURVED M16 65SQX6T 18D HOLE	Y	N/A	Y	Y	N/A	Y	Y	Y
ROD,THREADED GALV M16x250 WASH+NUTS	Y	N/A	N/A	Y	N/A	Y	Y	Y
SET SCREW,HX GALV M16x40 NUT+WASH	Y	N/A	N/A	N/A	N/A	Y	N/A	Y
PLATE,STAY M12 300x300x6 55x14	Y	N/A	N/A	Y	N/A	N/A	Y	Y
NUT,HX GALV M20	Y	N/A	Y	N/A	N/A	Y	N/A	Y
CROSBY CLAMP 16 WIRE ROPE	Y	N/A	Y	N/A	Y	Y	N/A	N/A
BRACKET,STRAIN OP.1 ST UTS 120kN GALV.	Y	N/A	Y	N/A	Y	Y	N/A	N/A
SAG ADJUSTOR 120kN	Y	N/A	Y	N/A	Y	Y	N/A	N/A
BALL-CLEVIS,V BOLT TYPE 120kN	Y	N/A	Y	N/A	Y	Y	N/A	N/A

4.5.2 Type test requirements

The test requirements associated with each category that is, threaded rods (TR), stay steel components (SSC), conductor clamps (CC), nuts, bolts and washers (NBW), strain nuts (SN), strain bolts (SB) and forgings (F) and galvanized pre-fabricated steel (GPS) are entered in each cell on the spreadsheet as shown in table 4.3. This information will be used in the "Test Data" sheet.

Table 4.3 Example on type test requirements

INX	Test Description	CC	B, N & W	SN, SB & F	TR	GPS	SSC
1	Verification of general dimensions:	Drawings	Drawings	Drawings	Drawings	Drawings	Drawings
2	Verification of Ball / Socket couplings:	N/A	N/A	SANS 60120	N/A	N/A	N/A
3	Verification of Clevis / Tongue:	SANS 60471	N/A	SANS 60471	N/A	N/A	N/A
4	Verification of material type & hardness:	SANS 1431	SANS1431/ EN 10025-2	SANS 1431	BSEN 970	SANS1431 or EN 10025	SANS1431
5	Galvanising of product body	SANS 121	SANS 121	SANS 121	SANS 121	SANS 121	SANS 121
8	Damage and failure load test	SANS 61284	N/A	SANS 61284	N/A	N/A	N/A
9	Slip test (e.g. Suspension clamps, e.t.c.)	SANS 61284	N/A	N/A	N/A	N/A	N/A
10	Clamp bolt tightening test	SANS 61284	N/A	N/A	N/A	N/A	N/A
11	Tensile test	SANS 61284	N/A	SANS 61284	N/A	SANS 61284	N/A
13	Thread pull test (Threaded rods, bolts)	N/A	SANS1700	N/A	SANS 1700	N/A	N/A
14	Visual inspection of welds (Structures)	N/A	N/A	N/A	N/A	DSP 34-2051	DSP34-2051

4.5.3 Test data

All tests requirements for a particular item are specified in this section. Specification requirements are used to highlight information about a particular test. In addition, information such as test report number, testing facility and report dates are also captured. The "Accept" column gives scores as indicated in table 4.4.

Table 4.4 Overhead line fitting test criteria

Symbol	Criteria	Result
Y	Complies satisfactory with ESKOM specification (≥70%)	Passed
P	Further clarification is required before tests can be accepted (≤40%<70%)	Provisional
N	Does not comply with ESKOM specification (<40%)	Failed
N/A	No offer from manufacturer received or test are not applicable	N/A

4.5.4 Test summary

This part summarizes and consolidates all test information and computes the compliance level of all the tests for each fitting.

4.5.5 Product summary

As mentioned previously, the evaluation is conducted in a two stage approach. This section captures the overall evaluation results. The preliminary results are based on initial evaluation without factory visit. Once this part is completed, sample inspection at the manufacturer's premise including factory assessments follows, thereafter a final score is calculated for each item. Table 4.5 gives the scoring, both preliminary and final:

Table 4.5 Overhead line fitting acceptance criteria

Symbol	Criteria	Preliminary	Final
Y	Complies satisfactory with ESKOM specification (≥70%)	Visit	Passed
P	Further clarification is required before the products can be accepted (≤40%<70%)	Provisional	Provisional
N	Does not comply with ESKOM specification (<40%)	No visit	Failed
N/A	No offer from manufacturer received	N/A	N/A

4.5.6 Preliminary acceptance summary

Acceptance summary report when evaluating technical A & B schedules, drawings and tests.

4.5.7 Acceptance summary final

Final acceptance summary report when evaluating technical A & B schedules, drawings, tests, samples and factory assessments.

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5. CONCLUSION

Literature review was conducted to understand the ESKOM's existing Dx networks together with their associated OHL fittings. Failures of OHL fittings experienced by the utility, demonstrate that there are serious challenges. The impact of poor quality fittings manufactured locally and abroad causes power supply interruptions and greatly impacts installations and cause personal injuries including fatalities.

It was discovered that most poor quality fittings that failed results from manufacturing defects ranging from using incorrect source material, flawed manufacturing process and inadequate inspection and testing by manufacturers. This also revealed an inconsistent QMS employed by manufacturers whereby, they are unable to trace OHL fitting defects and take corrective action to prevent future failures. Design-related failures were not encountered during these investigations, and this clearly indicates the importance of always adhering and meeting ESKOM's requirements.

A systematic process of utilising asset management principles, life cycle costing analysis, quality management system and value engineering principles have returned that risks generally associated with manufacturing defects can be effectively mitigated and this will eventually be eradicated from the system and that the impact and benefits achieved by each aspect, will improve the quality of OHL fittings.

The Microsoft Excel spreadsheet used to conduct OHL fitting evaluations is a great way to identify and buy acceptable products which are envisaged to last longer and perform according to ESKOM's requirements.

6. RECOMMENDATIONS FOR FUTURE WORK

For ESKOM Dx to align itself with the intention to mitigate OHL fitting failures, the following recommendations are suggested:

- Due to time constraints, continue to analyse failures to determine the root causes and to act accordingly. Identify where the most common defects occur to enable process change that will reduce and eliminate defects.
- Life cycle costing analysis is required to determine failure costs incurred during the life of all OHL fittings. It will be of great benefit to line designers to obtain real figures to enable them to make the most informed decision about future investments in infrastructure.
- Verify that ESKOM networks are within operating limits and that OHL fittings are not stressed beyond design life. This verification should include, but not limited to:
  - Improved electrical protection system (e.g. to deliver a more rapid response);
  - Improved support for the contact wire;
  - Enhanced resilience of the contact wire.
- Use new technologies/designs (see Appendix F) to manage failure risks and to be able to identify any trends (same manufacturer, supplier of raw material, distribution region and operating conditions).
- Manufacturer's QMS should be rigorous. Non-conformance reports should be investigated by the manufacturer as a matter of urgency in order to determine the root cause and take corrective actions.
- Encourage small manufacturers to seek ISO 9001 certification. This should be executed where practical. If appropriate, the manufacturer should be subsidised if the technology is a critical asset and the requirement for certification is required.
- Support local manufacturing of world class products and all recommendations on strategic sourcing in Appendix I.
- Continue to improve the evaluation methodology of OHL fittings

REFERENCES

ABB, http://www.abb.co.za/product/, 29 February 2013

Commission of the European Communities, (2003). *Undergrounding of electricity lines in Europe*

Calitz, J., (2008). CSD/MAT/12/DRAFT *" Vuyani Payne's Farm 132 KV – Adjustable stay rod ratchet nut failure",* January 2008

Calitz, J., (2010). CSD/MAT/10/100 *"Threaded rod failure on the 11 kV overhead line feeding the Royal Bafokeng sports campus",* September

Calitz, J., (2010). CSD/MAT/10/122 *"Investigation into the contact accident (public fatality)",* September 2010

Calitz, J. (2013). CSD/MAT/11/0 60 *"EBM pistol grip failure",* January 2013

Department of Trade and Industry, http://www.dti.gov.za, 27 August 2013

ESKOM, http://www.ESKOM.co.za, 29 February 2013

ESKOM, Power Series: *"The planning, design & construction of Overhead Power Lines"*, vol. 1, pp. 442-443, 2005

Gosling J., (2010). ESKOM TLP handouts, *Assignment 3*, May 2010

Mace, R.E., (2010). LIM 1002/4 *Mace Electrical Technologies, Case study 1,* September 2010

Maudu, A.J., (2006). DISASAAM2, *"Low voltage reticulation section 1: Low voltage overhead reticulation"*, rev.2, pp103-108.

Ntombela, N.D., (2005). DST 0030, *"Routine Inspection and Maintenance of Sub-Transmission and Reticulation Lines"*, 2005

Pillay, L., (2010). ESKOM TLP handouts, *Assignment 4*, 17-23 October 2010.

Research, Consulting and Publication, http://www.neurametrics.com/images/Supply_Risk_Assessment.pdf, 23 July 2013

Van Wyk, R.J., (1999). *"Technology and the corporate board",*

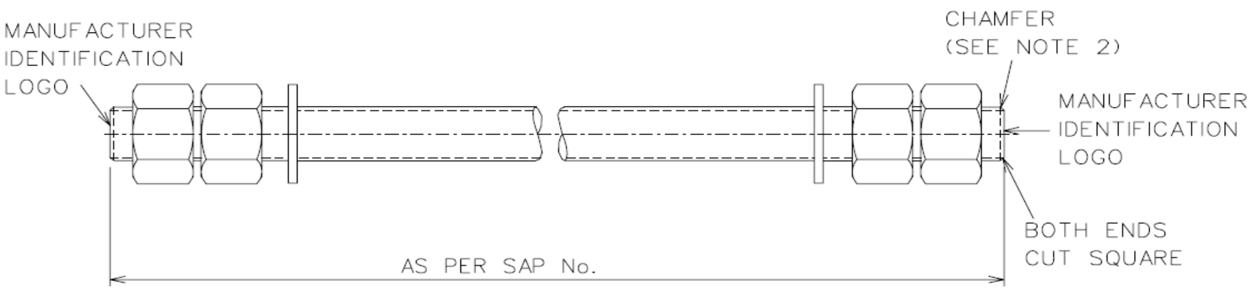
Vrey, D.J., du Preez M.E.N. and van der Merwe H.H., (n.d.). *Network asset condition assessment and refurbishment planning*

Wyman O, http://www.oliverwyman.com, 23 February 2013

Wikipedia, http://en.wikipedia.org/wiki/undergrounding, 08 March 2013

APPENDIX A

TECHNICAL REQUIREMENTS FOR THREADED ROD AS SPECIFIED BY ESKOM DISTRIBUTION



NOTE :
1. SKETCH NOT FOR MANUFACTURING PURPOSES.
2. THREAD TO BE CHAMFERED BOTH ENDS SEE SAP TECHNICAL DESCRIPTION FOR CHAMFER AMOUNT AND TO BE CUT AT RIGHT ANGLES.

SAP MATERIAL No.:	0163868
SHORT DESCRIPTION:	ROD,THREADED E/PL. M6x500 WASH+NUTS D3015

TECH. DESCRIPTION:

FULL THREADED ROD M6x1.0-6g BEFORE ELECTRO PLATING x 500mm LG.*
NO CHAMFER REQUIRED IF <6mm *
GRADE SAE 1008 STEEL * ELECTRO PLATED ACCORDING TO SANS 1700-5-11 *
COMPLETE WITH TWO M6 FLAT SQUARE WASHERS(D-DT-3014),
AND M6 FOUR HEXAGON NUTS (D-DT-3173) *
PACKAGING : SHRINK WRAPPED 10 PER PACK COMPLETE WITH *
NUTS AND WASHERS ETC. TO BE RUN ONTO THREAD 25% EACH END *
ESKOM DRAWING No. D-DT-3015 *

ITEM	:-	ROD THREADED
MATERIAL SPECIFICATION	:-	GRADE SAE 1008 STEEL, GRADE 070M20 STEEL
CORROSION SPECIFICATION	:-	SANS 121
STANDARD SPECIFICATION	:-	SANS 1700
ESKOM SPECIFICATION	:-	
TEST & CERTIFICATION REQUIREMENTS	:-	TYPE TEST ACCORDING TO SANS 1700 (THREAD PULL TEST ONLY)

INSPECTION	Yes	No	ESKOM RELEASE NOTE	Yes	No

IDENTIFICATION:- INDELIBLE MANUFACTURES TRADEMARK & PART No. ON ALL ITEMS

REV	REVISION DESCRIPTION	BY	CHKD	AUTH	DATE	REF. DWGS
23	TYPE TEST AND NUTS AND WASHER RUN ON THREAD CHANGED	P.A.T.	S. MASHABA	B. HILL	07.09.2010	
22	TEST & CERTIFICATION SANS SPEC AND HEX NUT DRG NO. ADDED	P.A.T.	S. MASHABA	B. HILL	06.08.2009	
21	MANUFACTURING ID, BOLT CHAMFER & NUTS ETC. RUN ONTO THREAD AND SPRING WASHER DRG.NO. SHOWN	N.M. P.A.T.	B. HILL	B. HILL	19.05.2009	
20	MATERIAL CHANGED AND THREAD ON M6 + M12 CORRECTED	P.A.V.	B. HILL	B. HILL	22.06.2007	

AUTH:	S.A.CILLIERS	DATE:	MARCH 93	SCALE NTS	Eskom Distribution
CHKD:		DATE:		CAD REF: SERIES 3000	SAP No: 0163868
DRAWN:	R.V.R.	DATE:	14-09-92	FILE No: 3015	D-DT-3015

SET	SHEET	REV
5	1	23

OVERHEAD LINE FITTING FAILURES EXPERIENCED ON THE ESKOM DISTRIBUTION NETWORK (cont...)

DATE	REGION	LINE NAME	FITTING TYPE	REASON FOR FAILURE	RECOMMENDATIONS
1996	No information	Albany - Pembroke 132 kV line	Insulator discs	Degradation of the pins - Corrosion	Audit in 7 years
1996	No information	Albany - Pembroke 132 kV line	Metal hook	Wear damage - Softer as reset of fitting	No information
1998	All regions	No information	Fibreglass ladders	Crack propagation, resulting in a fatigue failure and manufacturing defect.	• Prevent over crimping at the bottom of the swage joints and sharp edges (stress concentration points) at the rung-swage joint interface. • A different heat treatment process could be used for the extruded aluminium alloy rungs before forming of the swage joints take place. • If the change in the heat treatment process results in the rungs not attaining the specified requirements, then for the specific heat treatment used an increase in the thickness of the aluminium alloy material used for the rungs should be considered. • The different methods used for transporting ladders are evaluated in order to determine which methods could cause damage to the ladder and which methods would prevent damage to the ladder.
1999	Rigi Technical Services	Coalbrook-Traction / SAR Ywer 88 kV feeder	Suspension U-bolt	Overload as a result of the external loading.	U-bolts should be inspected for defects and need to be replaced.
2001	Dunnottar Technical Service Centre	No information	Crew cabin	Welded areas that had penetrated the chassis, gusset plates and cabin floor are not sufficient to carry the loads the crew cabin was design for. Resulting in the welded sections where contacts between the welded parts failed, due to overloading of these welded sections.	• It is recommended that it be communicated to all ESKOM depots using trucks with crew cabins fitted to it, that these cabins be inspected and tested for possible cracking and soundness of the welds. • Non-destructive testing methods such as magnetic particle inspection (MPI) and dye penetrate can be used or a combination of the two methods, depending on the accessibility of the welds. • Furthermore, it is recommended that the crew cabins be bolted to the chassis of the trucks and not welded. As the cracking of the gusset plates indicated that fatigue damaged do occur, due to the movement experienced by the cabin. • The thickness of the attachment plates between the crew cabin and chassis need to be increased to a minimum of 10 mm and not the 5 mm that was used.
2002	ESKOM Southern Region	Chaba-Aloe Glen 22 kV line	Wire type dead-end fittings	This fitting failed due to fatigue damage to the individual wires of the fittings. The over tension of both conductors, as reported by Mr. Blaauw, could have resulted in an increase in vibration levels on the lines and promoted fatigue damage to both line fitting and conductor.	It is recommended that the Butterworth-Tsomo and Chaba-Aloe Glen 22 kV lines be measured in order to determine if these lines are over tensioned

APPENDIX B

OVERHEAD LINE FITTING FAILURES EXPERIENCED ON THE ESKOM DISTRIBUTION NETWORK (cont...)

DATE	REGION	LINE NAME	FITTING TYPE	REASON FOR FAILURE	RECOMMENDATIONS
2002	ESKOM Southern Region	Zimbane-Kokstad line	Compression dead end joints	The joint failed as a result of overloading introduced on the jumper flag, combined with insufficient and very poor welding.	Replace immediately in order to prevent loss of supply to customers and a possible fatal accident.
2003	ESKOM Southern Region	No information	Line splice	Poor electrical jointing preparation.	It is recommended that staff conducting installations be trained in the correct procedure / practice to install electrical fittings.
2003	ESKOM Southern Region	Mafini - Zithulele. MNI 64 spur	PLP dead end fitting	Fatigue damage caused by aeolian vibration of the phase conductor.	No information.
2004	No information	Vrede-Memel 22 kV line	Wire type dead end fitting	Failed due to fatigue damage to the individual wires.	No information.
2004	No information		Wire type dead end fittings	Failed due to fatigue damage to the individual wires.	No information.
2005	ESKOM Southern Region	Zimbane-Mafini 66 kV	4-point indentation compression joint	Bird caging of the conductor at the mouth of the joint could have contributed to the fatigue failure of the two aluminium strands.	All crimping tools used should conform to the Distribution technical instruction 01 TI-015.
2005	ESKOM Southern Region	Dumasi-Kohlo 66 kV line	Full tension helical splice	Improper electrical jointing preparation	Staff conducting installations should be trained in the correct procedure / practice to install electrical fittings.
2006	ESKOM Southern Region	Fort Beaufort-Glendenee 66 kV line	Threaded rod	• Material used not 300W steel as specified by ESKOM distribution specification D-DT-3015. • The rod failure was not the result of one single factor/event, but a combination of different factors such as: a) The use of the incorrect rod material that was less ductile than the recommended 300W steel. Resulting in cracking of the material at the root of the threads (act as a stress raiser) when the rod was subjected to a bending load. b) Possibility that the moisture content of the poles differed from the environment it was exposed to, resulting in twisting of the wooden poles. The degree of twisting will determine the bending load introduced to the rod.	Rods of all structures revealing severe twisting should be replaced with 300W steel rods.
2006	ESKOM Southern Region	Chaba Aloe Glen 22 kV	Full tension automatic fitting	Incorrectly install	No information
2007	ESKOM Southern Region	Dumasi-Flagstaff 22 kV line	4-point indentation compression joint	Incorrect crimping practice	Manufacturer/supplier of fittings/joints be approached to provide training to contractors and staff conducting line construction and maintenance regarding the identification of the different type of fittings/joints and the proper installation thereof

APPENDIX B

OVERHEAD LINE FITTING FAILURES EXPERIENCED ON THE ESKOM DISTRIBUTION NETWORK

DATE	REGION	LINE NAME	FITTING TYPE	REASON FOR FAILURE	RECOMMENDATIONS
2007	ESKOM Southern Region	Qumbu-Libode 22 kV line	Full tension automatic fitting	The fitting did not adhere to the requirements of the Distribution specification DSP0034 - Grease	Personnel conducting line maintenance and/or repair work be trained/informed to verify that both the conductor and fitting/joint are properly prepared prior to joining a conductor.
2007	ESKOM Southern Region	Melkhout – St Francis 22 kV line	Line splice	The line splice failed due to a tensile overload, as a result of arcing between the conductor and the splice rods, causing localised annealing of the splice rods, resulting in a reduction of the mechanical properties of the line splice	Use correct installation practise
2008	ESKOM Southern Region	Kareedouw - Tsitsikamma 66 kV line	4-point indentation compression joint	The wrong crimping method (hexagon compression) was used for crimping the joint onto the conductor	The mid-span joints on the line be inspected and those found to be incorrectly crimped must be replaced
2008	ESKOM Southern Region	Qumbu-Sappie 22kV line	Full tension line splice	Splice was correctly installed, the conductor was not properly prepared prior to installation	Adhering to the standard installation practice for electrical joints and the low conductivity of the splice grit.
2009	ESKOM Southern Region	Cintsa Aleo Glen 22 kV line	T-crimp joint (tap connector)	Amount of greased applied during installation was insufficient to prevent moisture from penetrate the enclosed area, causing a severe built-up of a corrosion deposit on the inside of the main slide tube, due to both crevice and bi-metallic corrosion that occurred within the joint.	No information
2010	Northern Region	Mandla – Moutse feede	Dead end	Failure is electrical related (arc damage)	No information
2010	No information	Dundee	Spindle	Failure mechanism of the received spindle was fatigue related. The installation practise used contributed to the failure by increasing the bending force at the collar of the spindle during cycle loading caused by wind induced conductor movement.	Conductor attachment height and conductor incline angle at the pole where the failure occurred be corrected in order to meet the line design criteria, hence minimising and/or prevent a similar failure from happing in the future

APPENDIX C

MINIMUM REQUIREMENTS FOR LINE INSPECTION IN WORKS ORDER (cont...)

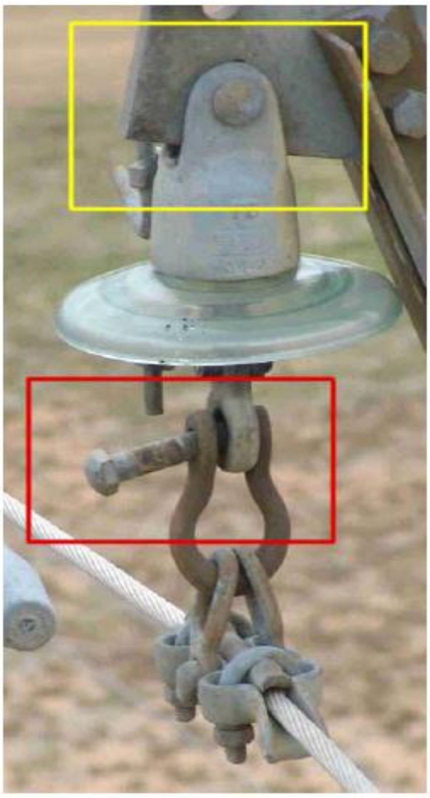
Lattice Tower			TOWER NUMBER / Column	
			SELF SUPPORTING	
	INSPECTED BY	DATE:	GUYED TOWER	
A: Tower/Mast Structural Steel Corrosion: Tower/Masts Beams Cross arms Footings Plates/Bolts Loose/Damaged members	GALVANISING: Is there reddish/whitish discoloration?: 1 Are the whole members or only a portion showing rust?: 2. Does the metal appear to be corroded away?: 3. Is there rust streaking off the bolts? 4. Does the galvanizing appear to be sandblasted? 5. FOUNDATIONS: Is there any subsiding at the foundation? 7. Is there any erosion at the footing? 8. Is any erosion getting close to the tower? 9. Is the concrete 150mm above ground level? 10. Is there sand/soil over the concrete foundation? 11. Is there any hairline cracks on the footing/benching? 12.	MEMBERS: Look for loose members, if you see none - hit the structure with a rubber mallet or similar and listen for bolt ringing. 13. Are there missing members? 14. Is there any loose step bolts? 16. Are the bottom members bent or damaged? 15. PAINT: Is the paint blistering? 17. Is the paint peeling? 18.	REMARKS:	1. 2. 3. 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
B. Earthing : Adequate Test results	Is it bolted tightly? 1. Is the bolt rusting? 2.	Remove some soil where the earth strap enters The ground - is the metal corroding? 3.		1 2 3
C Stays/ Guys Corrosion: Tension Grip : Strand	Is the guy/cross head housing, or U-bolt rusting? 1. Is there visible slip between guy wire and performed rods? 2 Are the tamper guards in place? 3. Examine cut guy end - are strands all the same lengths? 4. Remove some soil around anchor link.	Is bitumen still present - is there rust? 5. Does the guy wire appear to be slack? 6. (note if wind is blowing as leeward slack) Tension on a wire dynamometer: 22dia>3,5 ton, 24dia>4,3 ton, 28dia>6 ton, 32dia>7,5 ton		1 2 3 4 5 6
D. Insulators: Clean Damaged Clips Missing	Are the insulators dirty? 1. Is it bird dirt? 2. . Is it pollution? 3. Are insulators broken? 4. Insert number of broken per string & position. 5. Is there faulting on insulators? 6. Is there any security clips missing? 7	Is there wasting at pins/stems? 8 Is there a discoloration of hardware? 9. Insulator Type: 10 (Insert letter in block 10) Porcelain (A) Glass (B Cycloaliphatic (C) Composites (D)	Indicate Strain Towers to Self Supporting above.	1 2 3 4 5 6 7 8 9 10

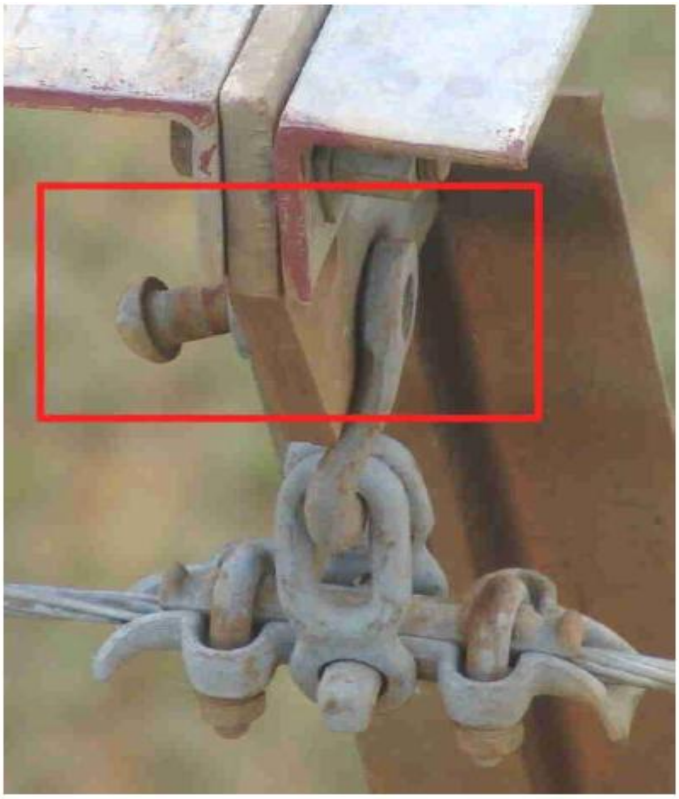
APPENDIX C

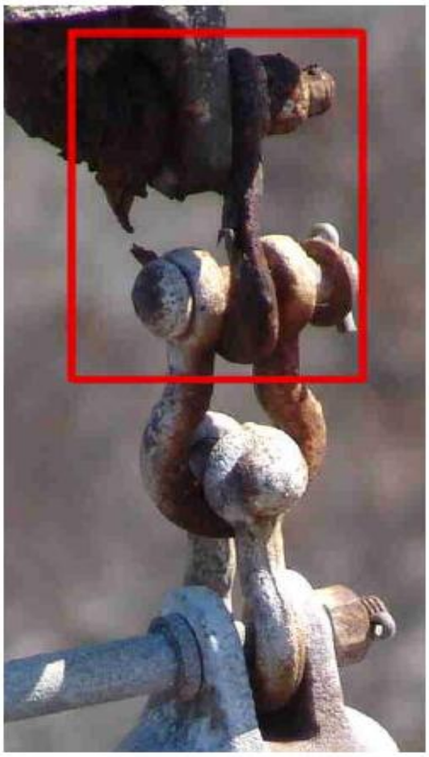
MINIMUM REQUIREMENTS FOR LINE INSPECTION IN WORKS ORDER

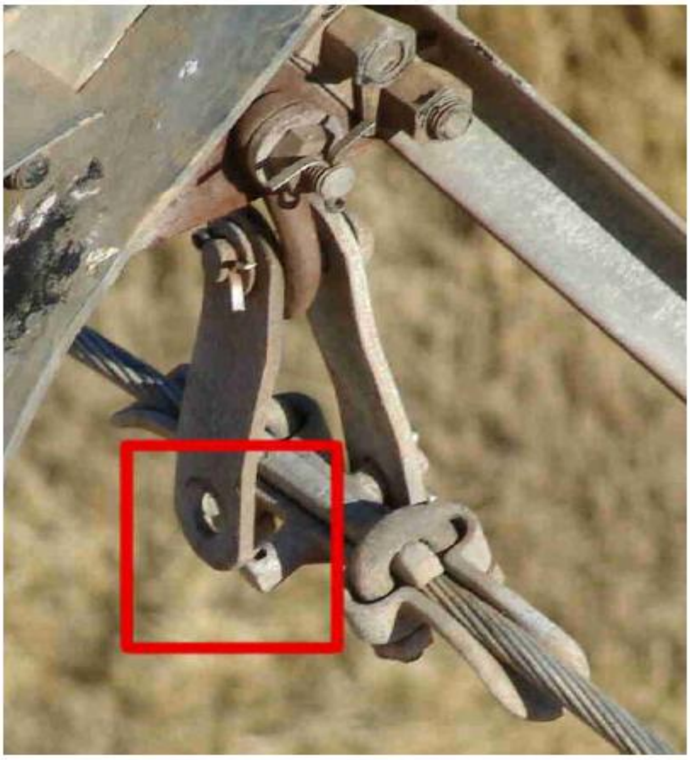
Lattice Tower			TOWER NUMBER / Column	
			SELF SUPPORTING	
	INSPECTED BY	DATE:	INSPECTED BY DATE: GUYED	
E. Conductors & Earth Wire Condition Spacers Dampers Jumpers Joints	Check suspension clamp for wear. 1 Is the damper / spacer distorted? 2 Is there any loose wire or bird-caging? 3 Is there any bulging of the wire? 4 Is there a white powder on the conductor? 5 Does the conductor appear to be wearing? 6 Are there burn marks on the conductor? 7 Is the bundle twisted? 8 Is the hardware wearing? 9 (use binoculars)	Is conductor pulling through the two halves of the AGS clamps? 10 Look for heat discolouration on the ends of the mid-span joints and strain clamps dampers, etc. 11 Is the a railway line within +- 800m? 12 Is there insulation on the earth wires? 13 Are there loose bolts on the clamps? 14 Is the Crosby clamp in place on the jumper? 15 Have the dampers moved along the span? 16 Is there damage due to armour rods? 17		1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
General : Identification.. : Anti-climbing.. : Servitude.. : Tree clearance :. Gate locks : Access	Is the tower numbered? 1 Is the number peeling? 2 Is the number clear? 3 Is anti-climbing device damaged? 4. Is anti-climbing device obstruction free? 5. Is the service road obstruction free? 6.	Are there access road wash-a-ways? 7. Is the retaining wall damaged? 8 Are any trees growing towards the phases, could the get too close to the line? 9 Are all locks in place? 10 Is there any damage to the gates? 11 Is access difficult, is helicopter required? - or new roads or quarries appearing? 12(Use remarks column)		1 2 3 4 5 6 7 8 9 10 11 12

AERIAL LINE INSPECTIONS FOR OHL FITTINGS (cont...)



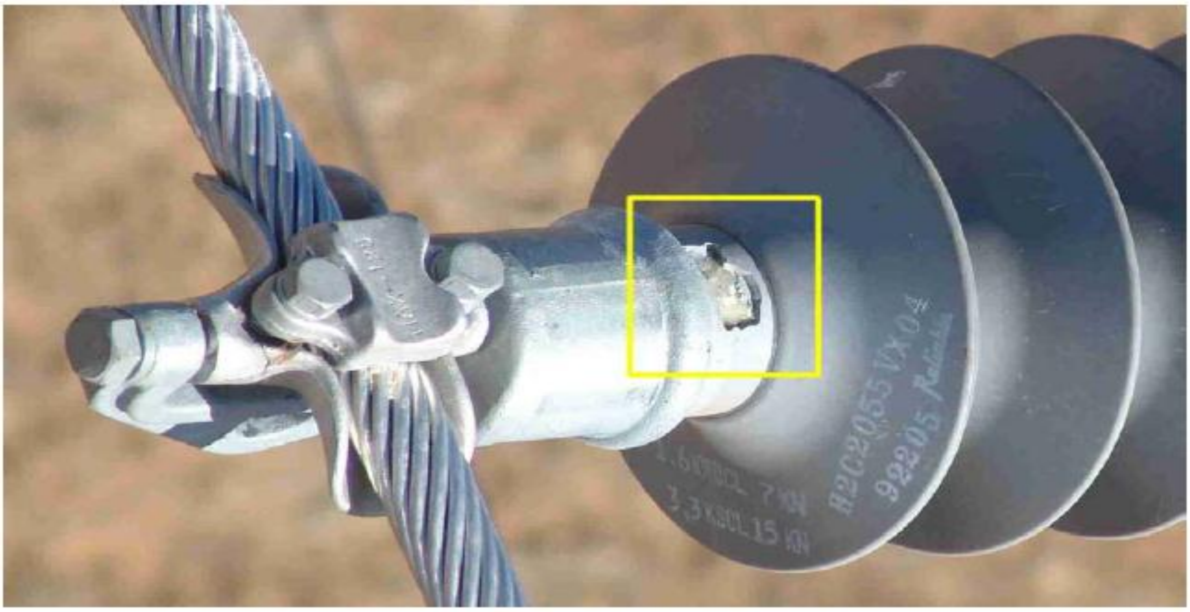


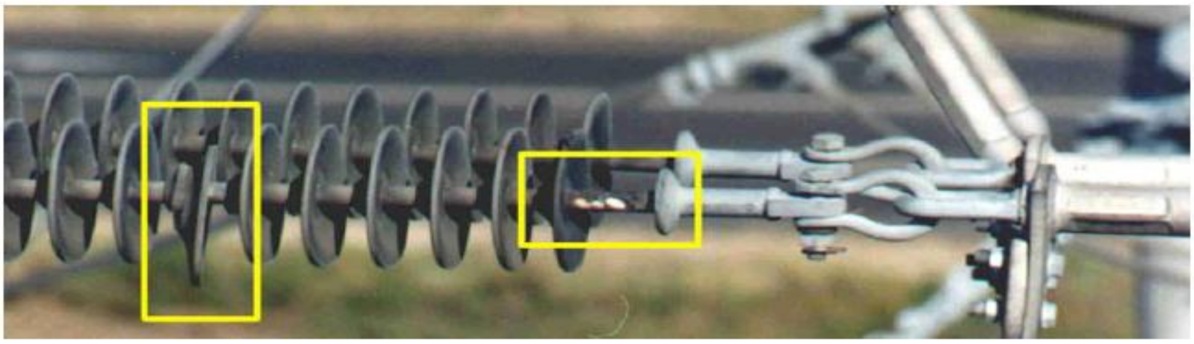


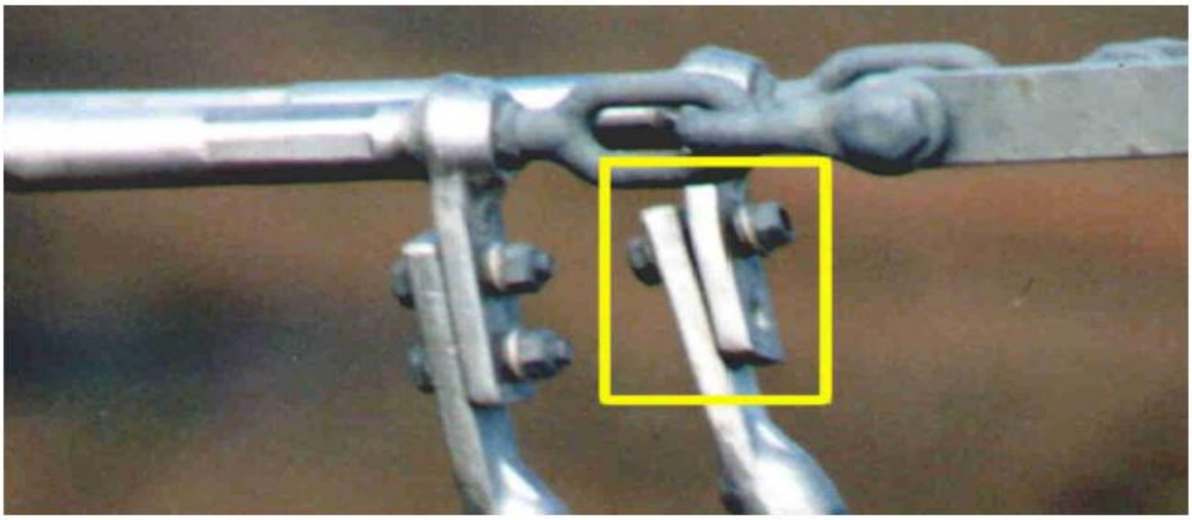


AERIAL LINE INSPECTIONS FOR OHL FITTINGS (cont...)

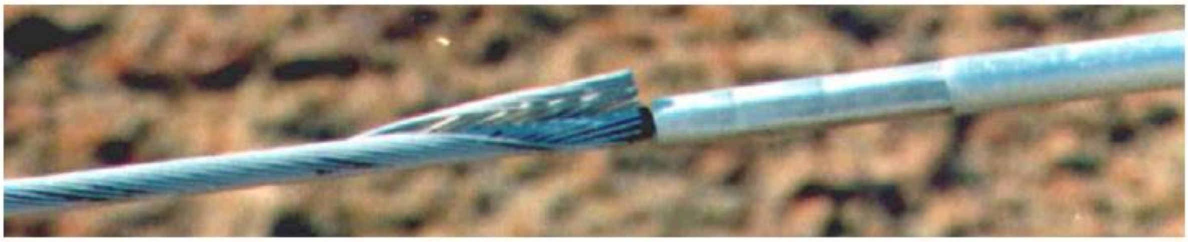
AERIAL LINE INSPECTIONS FOR OHL FITTINGS (cont...)

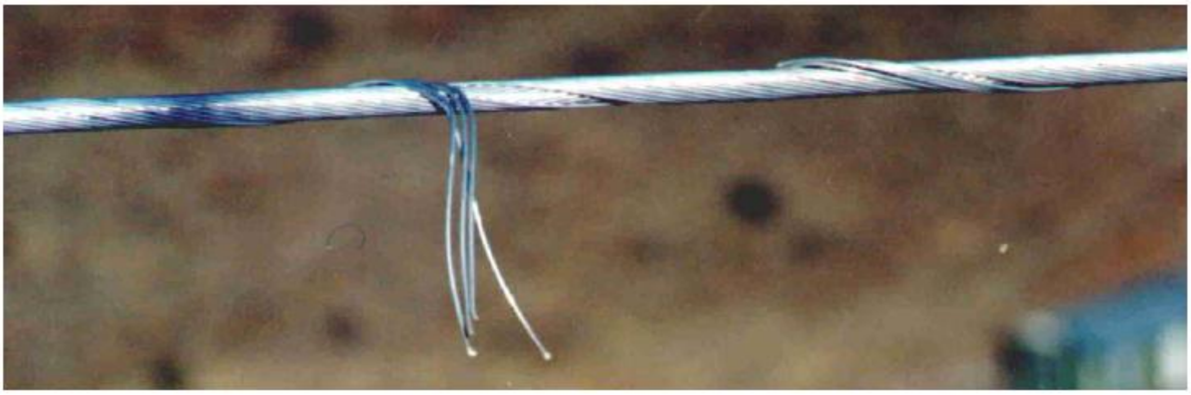




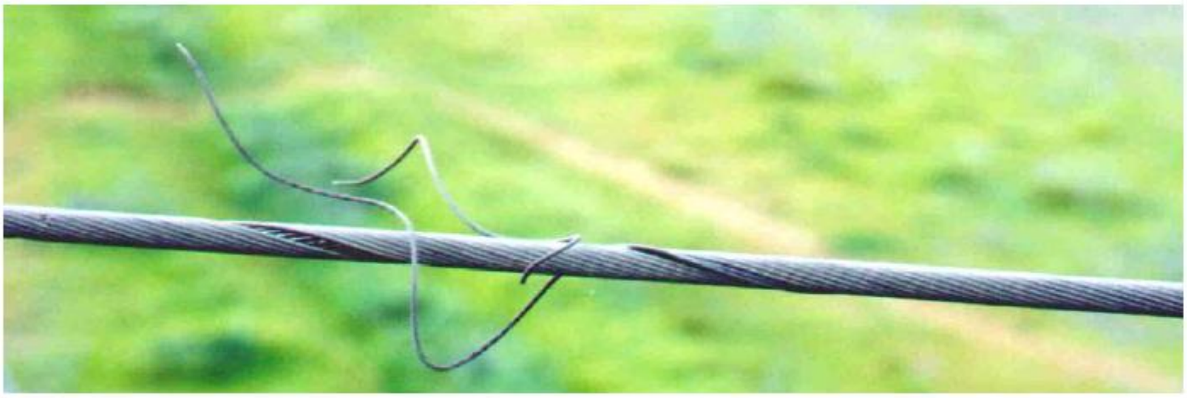


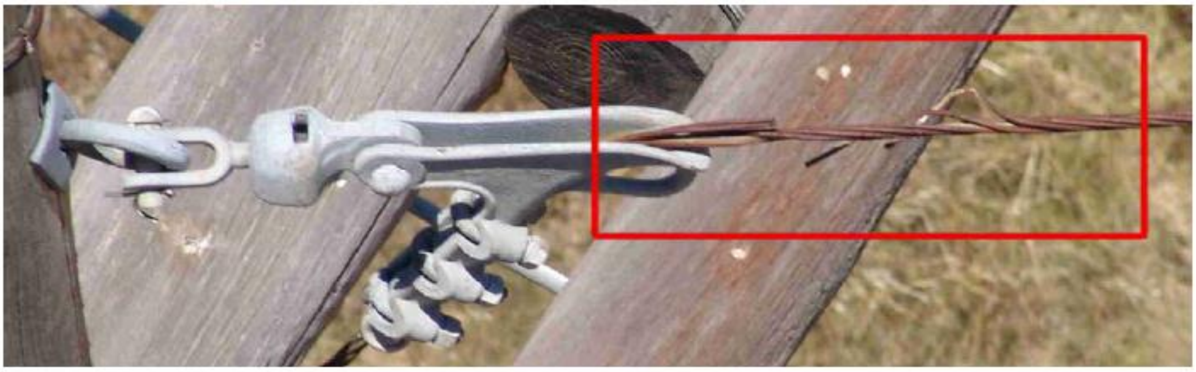
AERIAL LINE INSPECTIONS FOR OHL FITTINGS (cont...)

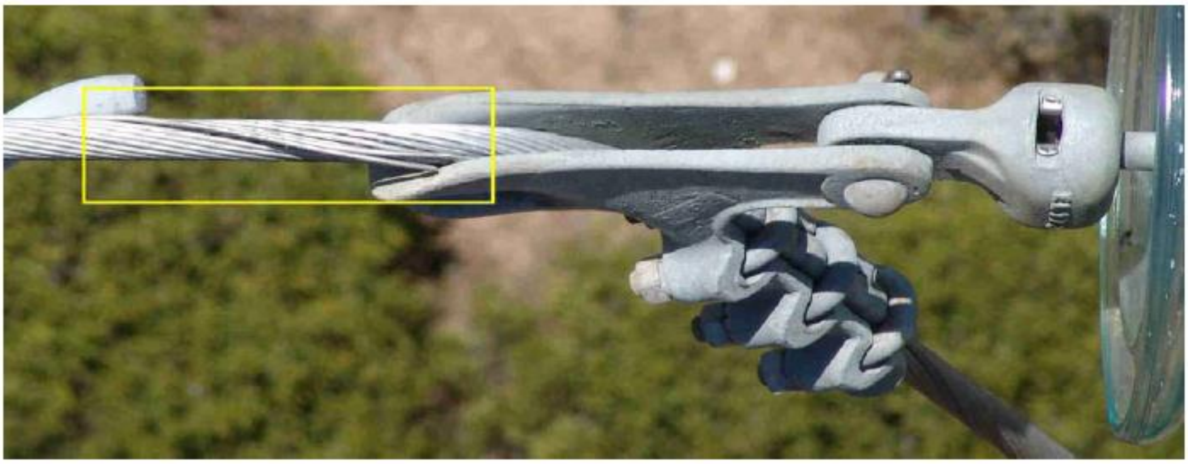




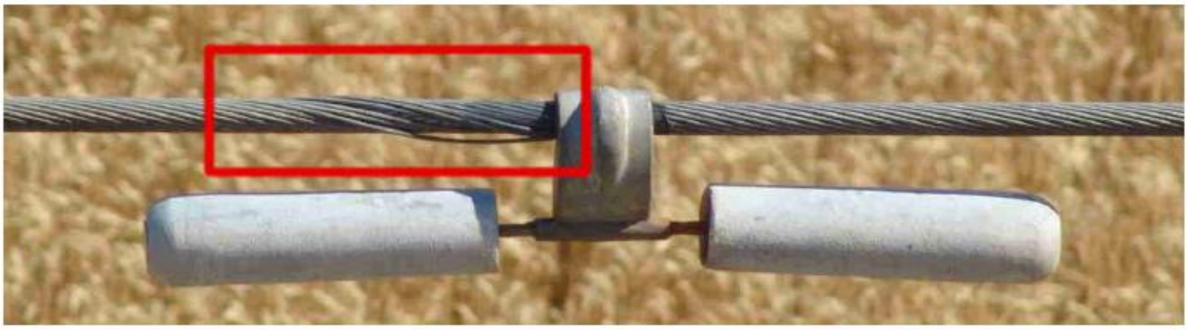
AERIAL LINE INSPECTIONS FOR OHL FITTINGS (cont...)

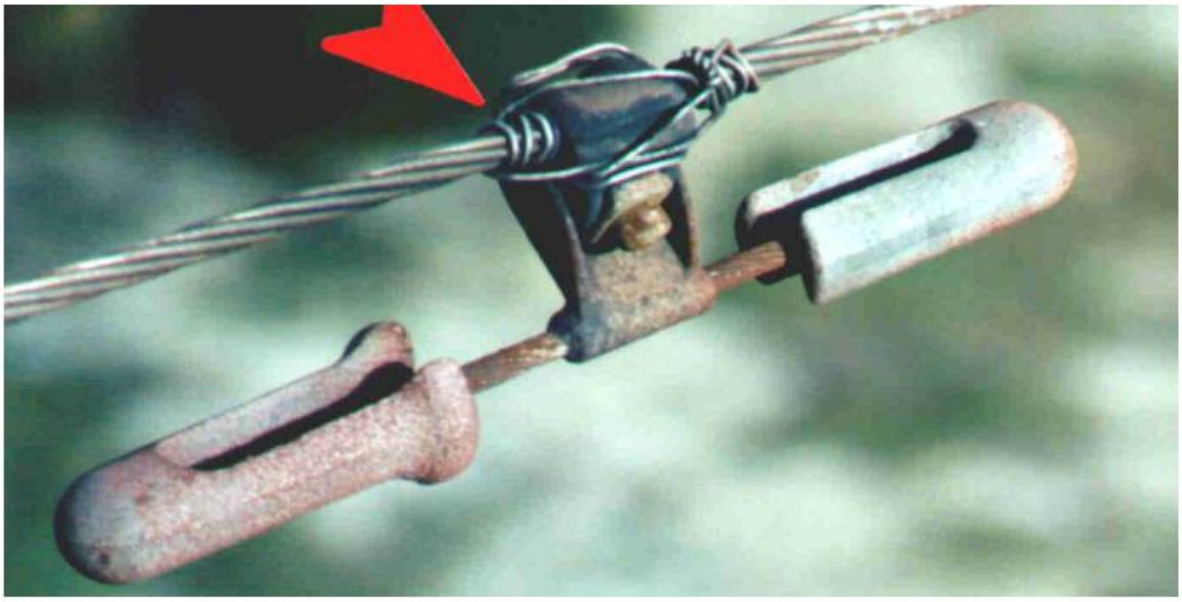




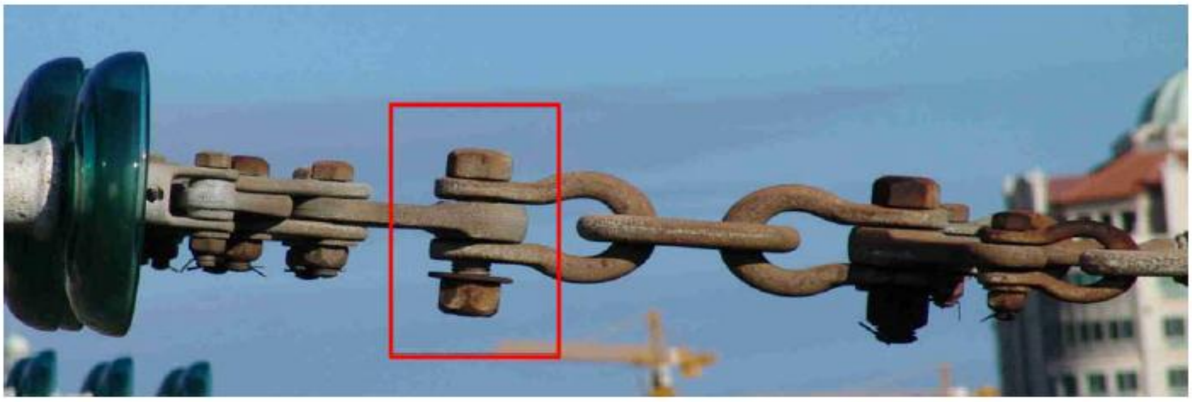


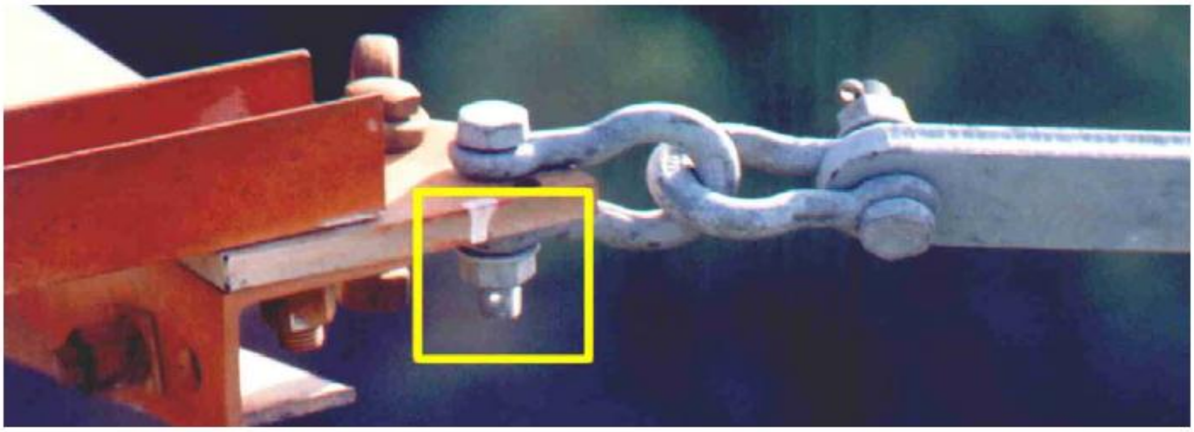
AERIAL LINE INSPECTIONS FOR OHL FITTINGS (cont...)

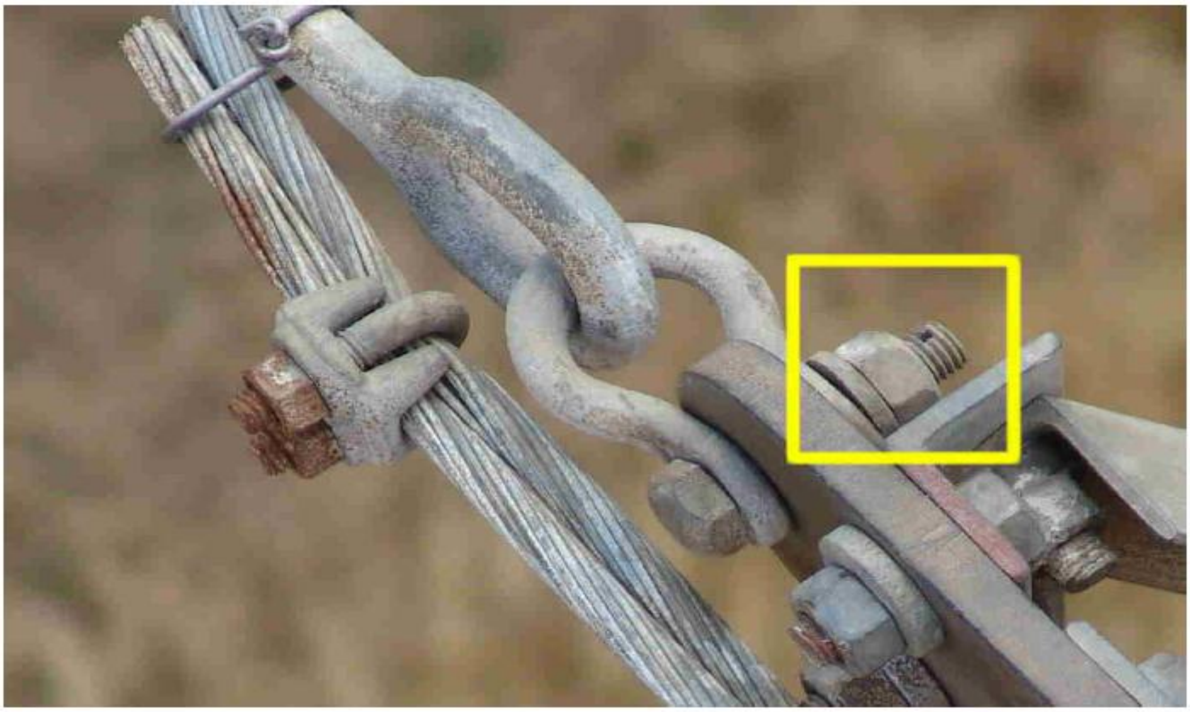




AERIAL LINE INSPECTIONS FOR OHL FITTINGS (cont...)

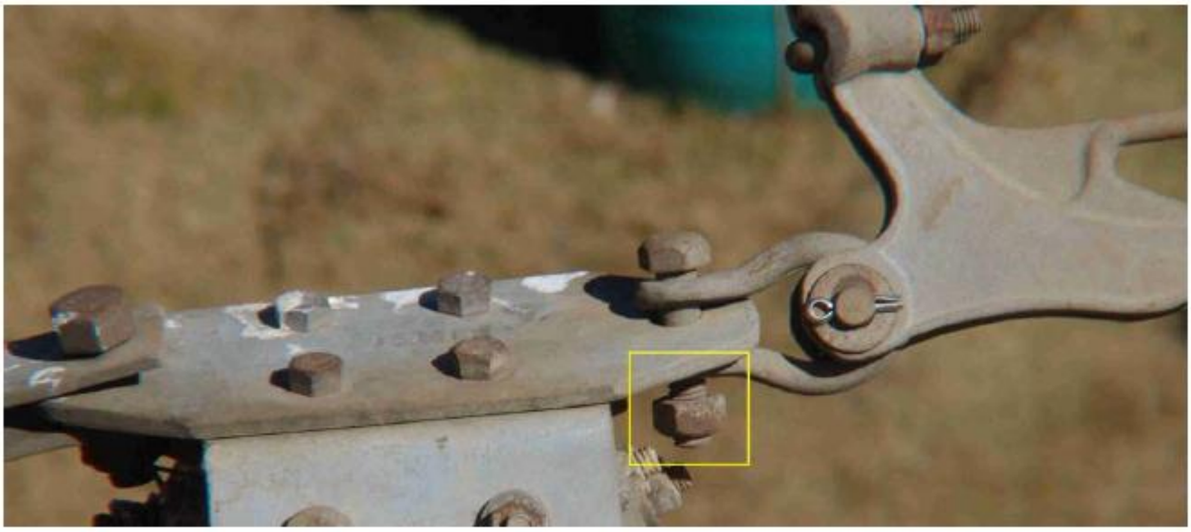


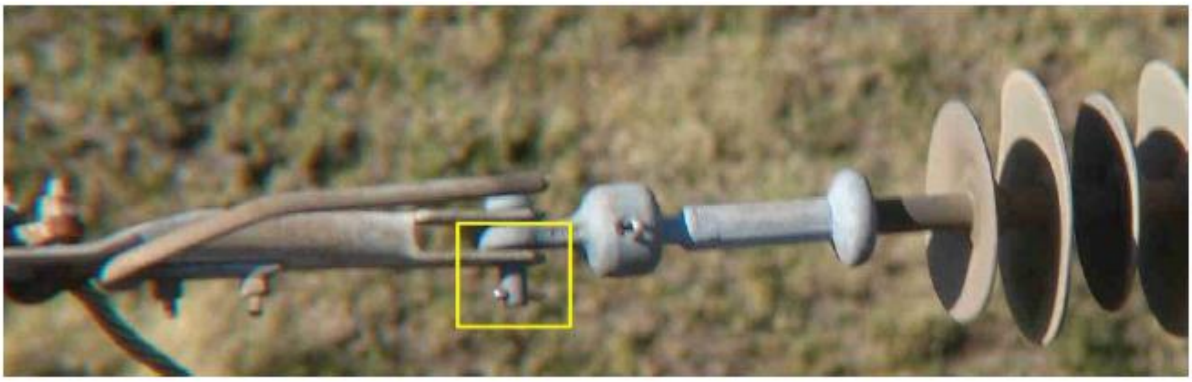




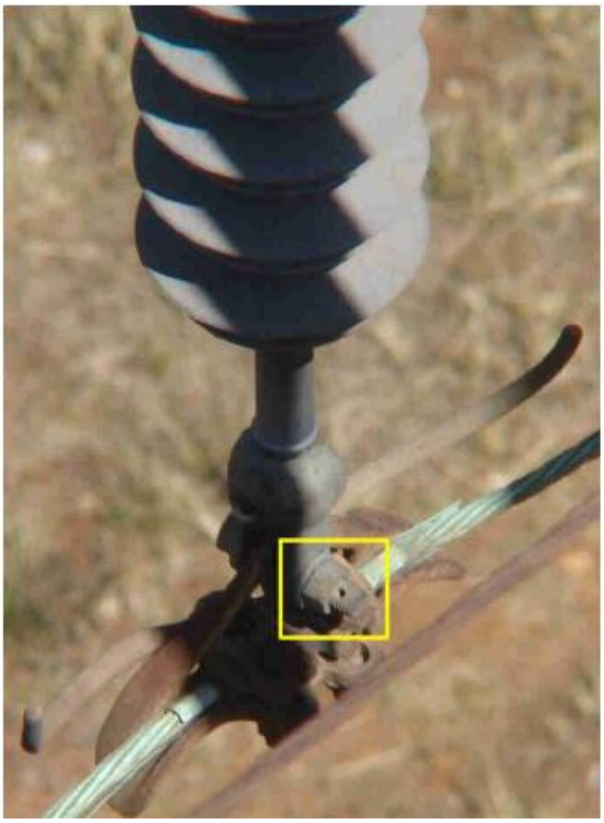
APPENDIX D

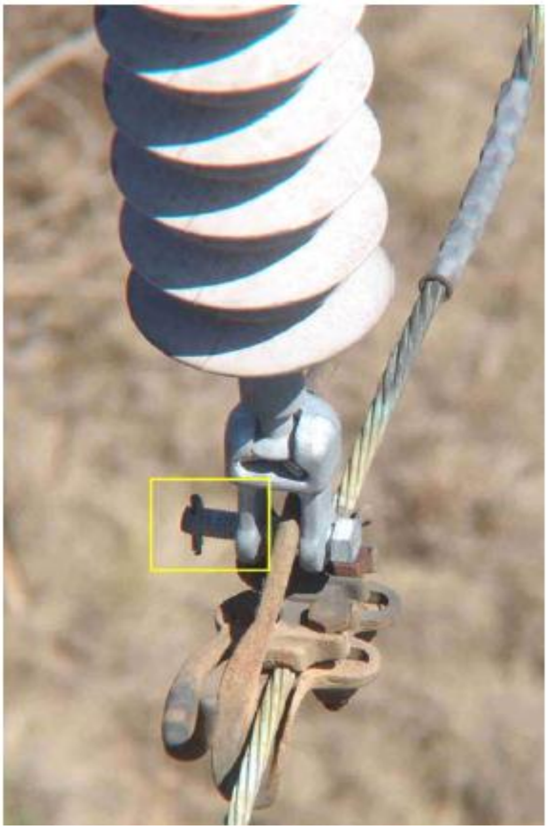
AERIAL LINE INSPECTIONS FOR OHL FITTINGS (cont...)





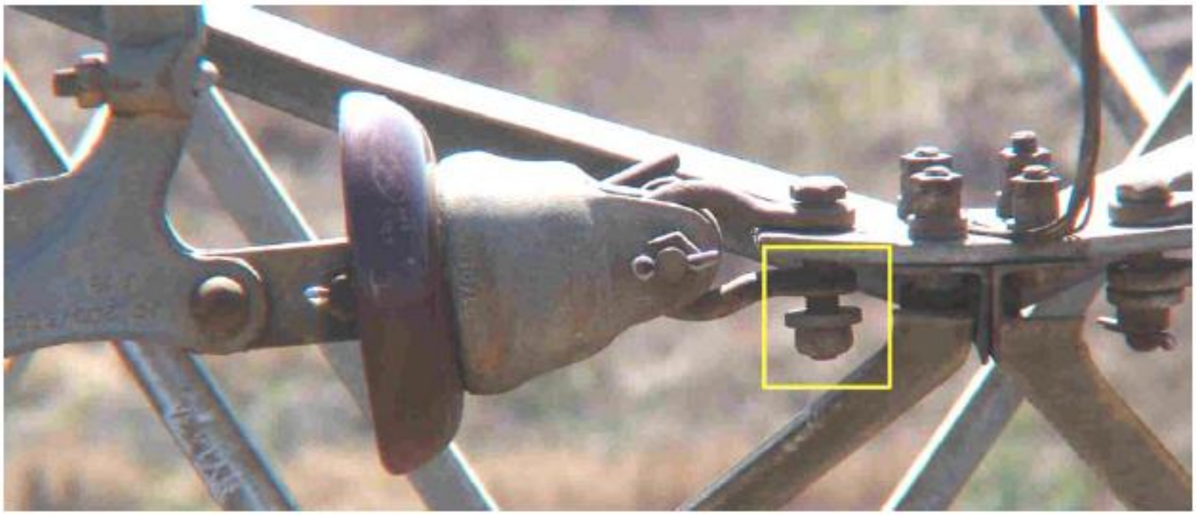
AERIAL LINE INSPECTIONS FOR OHL FITTINGS (cont...)

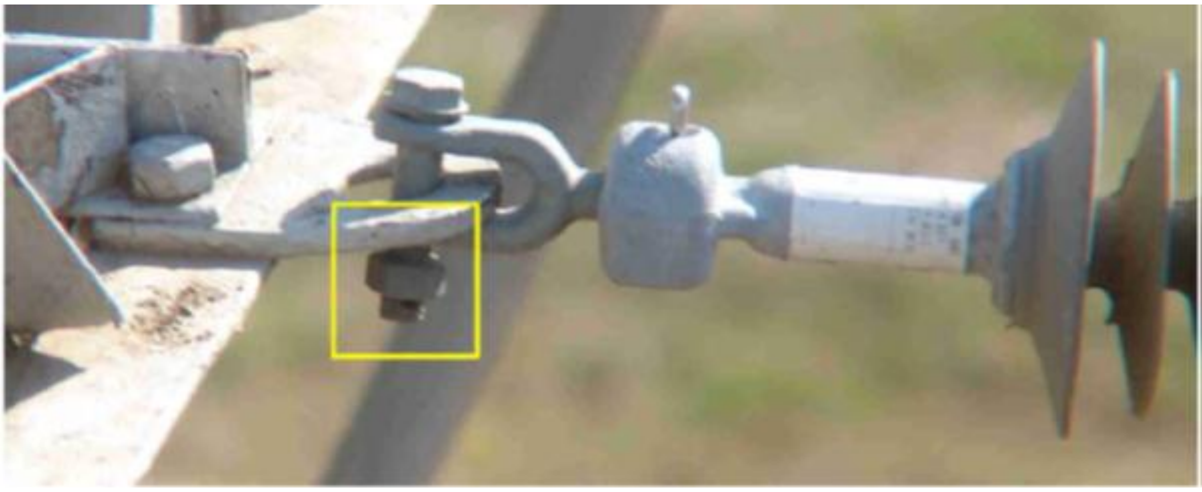




APPENDIX D

AERIAL LINE INSPECTIONS FOR OHL FITTINGS





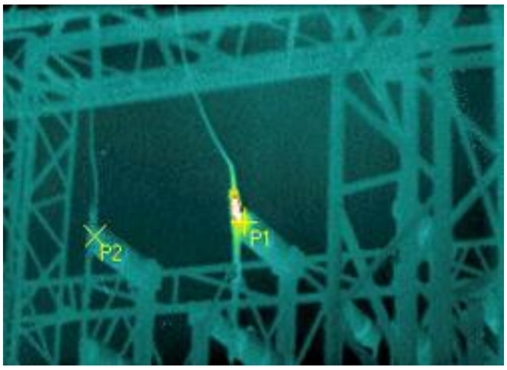
APPENDIX E

INFRARED INSPECTIONS

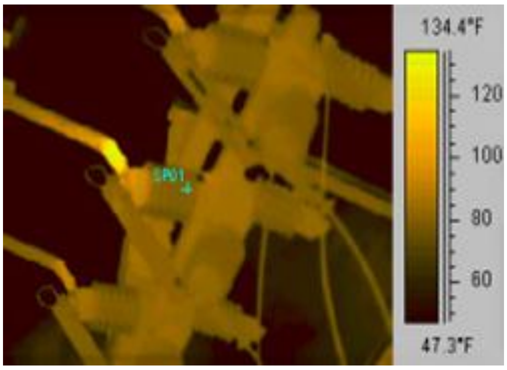
Infrared has proven to be an ideal inspection method for all types of preventative maintenance. Infrared technology gives thermographers the ability to “see”, measure, and record temperatures on defective components and the normal wear, chemical contamination, corrosion, fatigue and faulty assembly that occurs in many electrical systems. The molecular friction produced by problem electrical components is visible within the infrared spectrum and recordable by infrared cameras. Overheating can occur in any electrical component including generators, transformers, pole top connections, insulators, disconnects, jumpers, shoe connections, fuse connections, switchgear, starters, contactors.

E.1 How Electrical Inspectors Use Infrared Imaging Technology

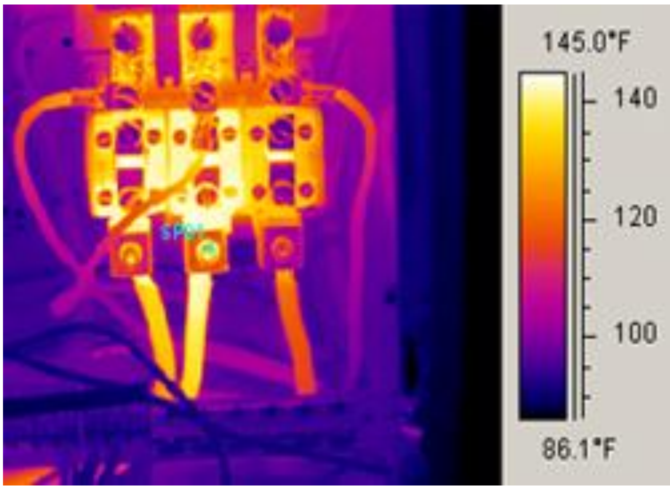
E.1.1 Connectors, Relays, and Switches: Find poorly secured, corroded, or current overloaded hardware



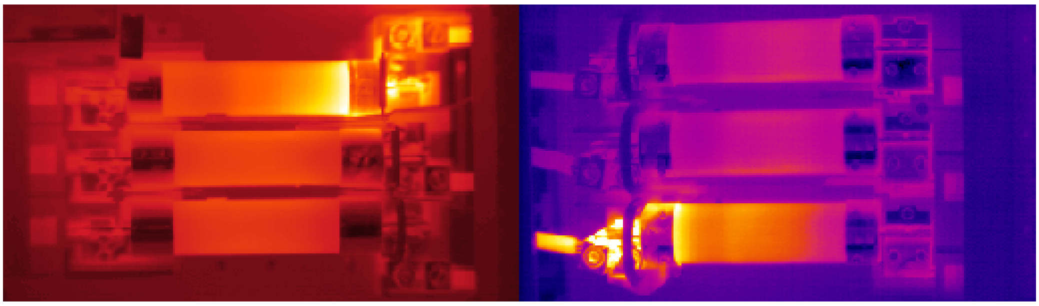
E.1.2 Semiconductors: Find poorly bonded, die attached, open, shorted, or leaky active devices



E.1.3 Circuit Boards: Find overstressed components, plated through holes, poor heat sinks, and bad solder joints



E.1.4 Discrete Components: Find overstressed transformers, capacitors, and resistors



APPENDIX F

NEW TECHNOLOGIES/DESIGNS TO MANAGE FAILURE RISKS

F.1 Change from pin type to bolt type shackle

Replace the clevis pin type connection shown in figure F.1 with a bolt type connection in figure F.2, consisting of high tensile bolt (Grade 8.8), nut, washer and clevis pin. The bolt type connection will prevent the nut from becoming loose due to vibration. The hump back split pin if securely placed will also play a role in preventing the nut from becoming loose subsequently falling on the ground. In a highly corrosive environment, a stainless steel high tensile bolt may be used to limit the effects of corrosion. The solution is simple and very inexpensive. The bolt will integrate easily with the existing shackle without any re-designing of the shackle.

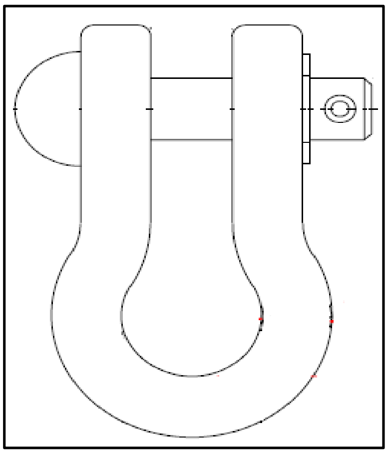


Figure F.1 Pin type shackle

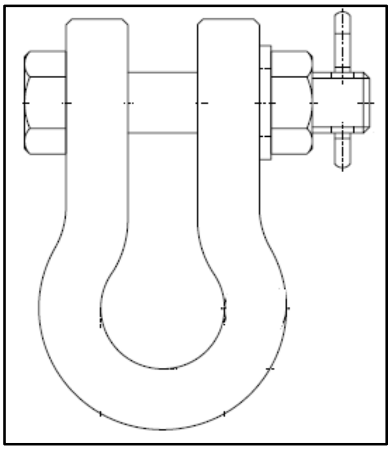


Figure F.2 Bolt type shackle

F.2 The body of the shackle

The body of the shackle must be manufactured by a forging process rather than casting. Forging process improves the characteristics of steel by making it stronger and more reliable. Defects are refined during the pre-heating process. Casting related problems are due to the following:

Pouring temperature - Reduces mechanical properties of steel

Pouring speed - Gas or pores may form due to inadequate feeding of the casting during solidification

If any of these elements are not controlled during manufacturing, the shackle body could be rendered unsafe. It could fail without warning since the plastic deformation region of that steel simply does not exist.

F.3 Corrosion

Coatings applied by hot dip galvanizing are designed to protect steel against corrosion. All galvanising procedures on the shackle body and tests must be conducted by a SANAS accredited facility in accordance to SANS 121: Hot dip galvanized coatings on fabricated iron and steel articles. Certificates must indicate at least five coating thickness measurements and the average value.

F.4 Tests

F.4.1 Mechanical tests

To verify the integrity and robustness of the shackle, it must be tested. The shackle must be tested by a SANAS accredited facility in accordance to SANS 61284: Overhead lines - Requirements and tests for fittings. The following mechanical tests must be conducted before the shackle can be used in Eskom:

- Damage and failure load test
- Tensile test

F.4.2 Hump back split pin tests

The Eskom specification DSP 34-1667: Distribution specification: Hump back split pins for new and refurbished power lines up to 132kV states precisely the technical requirements for hump back split pins. To improve the reliability of these pins, the hole size which the hump back split pin must be matched to must be 6mm ± 0,2 mm. The mechanical tests must be completed on both the minimum hole size of 5,8 mm and the maximum hole size of 6,2 mm. The mechanical tests consist of the pull-out and push-in tests with the following criteria:

- all pull-out values shall be greater than 15 N and less than 60 N.
- all push-in values shall be less than 60 N.

F.4.3 Verification of material grades

The material grade for the shackle body can be verified before it can be used in Eskom by a SANAS accredited facility. The certificate provided to Eskom must include chemical analysis, mechanical properties and impact energy tests of the grade of steel used.

F.4.4 Verification of shackle dimensions

Shackle dimensions are critical and they have to be verified. If they do not comply with SANS 60471: Dimensions of clevis and tongue couplings of string insulator units, they can interfere with other existing components during installation thus increasing maintenance hours.

Please note that all OHL hardware wear out failures do not necessary correspond to the colloquial use of the hardware. Some wear out failures may result due to:

- Wearout that commence immediately when OHL hardware is put into service.
- Wearout that commence sometime after OHL hardware is first used.
- Wearout that may start before OHL hardware is put into service, that is, OHL hardware that deteriorate in storage facilities especially those facilities that exposes them to the sun, rain etc.

F.5 Adding redundancy on the system

A redundant system can also be a solution to prevent catastrophic failures. Not only that it provides safety, but benefits such as delaying power failure, maintenance and line refurbishments can be achieved.

Figure F.3 Installed OHL fitting

Figure F.4 Redundant assembly

The only critical component and the only attachment between the insulator and tower landing plate is made possible by the OHL fitting indicated in figure F.3. It can be noticed that there are two unused holes on the tower landing plate (were the shackle is attached). These holes are called service holes and they are normally used during maintenance or during emergency situations. Figure F.4 show a simple and inexpensive redundant assembly which uses one of the service holes for backup during failure of the main shackle. Such a backup system will definitely improve the reliability of the entire network.

APPENDIX G.1

VALUE ENGINEERING COVER PAGE

Value Management Workshop/Studies Application

Web site: www.vmservices.co.za

We acknowledge the design input from Mr Edgar Mhindurwa

Project Title:

Overhead Line Fitting Evaluation For ESKOM Distribution Business

Project Leader:	Sylvester Mashaba

-

Purpose:

To establish the impact of OHL fitting failures on the ESKOM Distribution business and develop a methodology for effective OHL fitting evaluation which will encompass technical requirements

Date/s:	14-05-2013

Venue:	ESKOM - Rosherville

Participants:

	Name	Designation	Company/Dept
1	Sylvester Mashaba	Engineer	Lines Engineering Services (LES)
2			
3			
4			
5			

APPENDIX G.2

VALUE ENGINEERING ISSUES AND CONCERNS

Value Management &
Value Engineering
Workshop/Studies

	Issues & Concerns
1	Life cycle costing
2	GDP
3	Cost
4	Politics
5	Theft and vandalism
6	Strategic sourcing
7	BEE criteria
8	Jobs
9	Pricing (local vs. imports)
10	Supplier performance
11	Tender process
12	Logistics
13	Industrialization
14	Local manufacturers
15	Imports
16	Bulk purchasing
17	Security of supply
18	Integrity (Network and OHL fitting)
19	Failure (OHL fitting)
20	Safety
21	Fatalities
22	Reliability (OHL fitting)
23	Tests (Sample, type and routine)
24	Technical expertise
25	Landing tests
26	Human resource
27	Skills
28	Loss of expertise
29	Customer's expectation
30	Quality specialists
31	Quality assurance
32	Manufacturing quality
33	ISO 9001
34	Maintenance plan
35	Policy and regulation
36	ESKOM buyer's guide
37	Existing standards and specification
38	Evaluations (OHL fitting)
39	Risk assessments
40	Rationalization (OHL fitting)
41	Innovation

VALUE ENGINEERING OBJECTIVE MATRIX

Value Management & Value Engineering Workshop/Studies - Objective Matrix

Objective

To develop a methodology for effective OHL fitting evaluation which will encompass technical requirements by the end of June 2014

	Results to Achieve		Results to Prevent
1	Reduce OHL fitting risks	1	Poor quality control
2	Adhere to latest standards and specification	2	Unemployment
3	Optimise reliability	3	Loss of skills and expertise
4	Improve manufacturing quality	4	Negative impact to the economy
5	Optimise life cycle cost	5	Unhappy customers
6	Reduce replacement/repair costs	6	Fatalities
7	Promote bulk purchasing		
8	Promote rationalization of OHL fitting		
9	Increase capacity for local manufacturers		
10	Reduce running costs		
11	Moderate/control imports		
12	Create jobs		
13	Improve quality of supply		
14	Secure skills and expertise		
15	Improve forecast accuracy		

	Available Resources		Constraints
1	Private Sector	1	Lack of industry knowledge
2	Government	2	Lack of policies and regulatory systems
3	Suppliers/Manufacturers	3	Lack of capacity by local manufacturers
4	Current ESKOM employees (technical, quality & procurement specialists)	4	Unavailability of resources e.g. quality and technical specialists
5	Customers/communities	5	Non-conformance to requirements
		6	Accuracy of OHL fitting forecast
		7	Tendering and approval processes

	Functions	Functions continued
A	Improve manufacturing quality	
B	Create jobs	
C	Monitor local manufacturers and imports	
D	Optimise reliability	
E	Rationalize items	
F	Reduce/mitigate risks	
G	Reduce costs	
H	Sustain local skills and expertise	

APPENDIX G.4

VALUE ENGINEERING RESULTS TO ACHIEVE

Results to Achieve → ↓ Issues & Concerns Matrix

		Results to Achieve														
		Reduce OHL fitting risks	Adhere to latest standards and specification	Optimise reliability	Improve manufacturing quality	Optimise life cycle cost	Reduce replacement/repair costs	Promote bulk purchasing	Promote rationalization of OHL fitting	Increase capacity for local manufacturers	Reduce running costs	Moderate/control imports	Create jobs	Improve quality of supply	Secure skills and expertise	Improve forecast accuracy
#	Issues & Concerns	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Life cycle costing				■	■										
2	GDP									■		■	■			
3	Costs					■	■	■			■					
4	Politics											■				
5	Theft and vandalism												■	■	■	
6	Strategic sourcing							■	■	■		■				
7	BEE criteria									■			■			
8	Jobs									■			■		■	
9	Pricing (local vs. imports)							■		■		■				
10	Supplier performance	■												■		
11	Tender process							■					■		■	
12	Logistics							■	■	■						
13	Industrialization									■			■		■	
14	Local manufacturers									■		■	■		■	
15	Imports		■		■							■				
16	Bulk purchasing							■	■							■
17	Security of supply						■							■		■
18	Integrity (Network and OHL fitting)			■			■									
19	Failure (OHL fitting)	■	■		■		■									
20	Safety	■	■													
21	Fatalities	■												■		
22	Reliability (OHL fitting)			■			■							■		
23	Tests (Sample, type and routine)	■	■				■							■		
24	Technical expertise														■	
25	Landing tests	■					■							■		
26	Human resource												■		■	
27	Skills												■		■	
28	Loss of expertise												■		■	
29	Customer's expectation						■							■		
30	Quality specialists				■										■	
31	Quality assurance	■	■		■									■		
32	Manufacturing quality		■		■									■		
33	ISO 9001				■							■		■		
34	Maintenance plan	■					■							■		
35	Policy and regulation							■				■	■			
36	ESKOM buyer's guide	■	■	■												
37	Existing standards and specification	■	■	■												
38	Evaluations (OHL fitting)		■	■	■							■				
39	Risk assessments	■										■		■		■
40	Rationalization (OHL fitting)								■							■
41	Innovation			■		■								■		

VALUE ENGINEERING NUMERICAL EVALUATION AND CAUSE AND EFFECT GRAPH

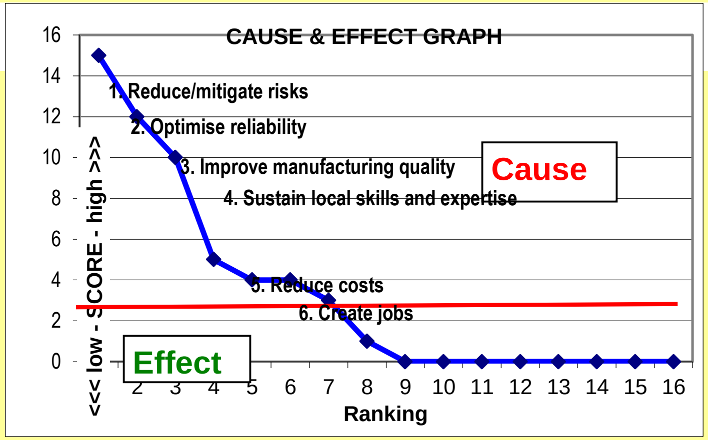
Numerical Evaluation

Objective:

To establish the impact of OHL fitting failures on the ESKOM Distribution business and develop a methodology for effective OHL fitting evaluation which will encompass technical requirements by the end of June 2014.

Scoring Rules:	1	Minor
Minor/Medium/Major Difference	2	Med
	3	Major

Numerical Evaluation												Function	Score	Rank
A	A3	A3	D3	A2	F2	A2	H2				A	**Improve manufacturing quality**	10	3
	B	B2	D2	B2	F2	G1	H1				B	**Create jobs**	4	6
		C	D2	C1	F2	C2	H1				C	**Monitor local manufacturers and imports**	3	7
			D	D2	F3	D2	D1				D	**Optimise reliability**	12	2
				E	F2	E1	H1				E	**Rationalize items**	1	8
					F	F2	F2				F	**Reduce/mitigate risks**	15	1
						G	G3				G	**Reduce costs**	4	5
							H				H	**Sustain local skills and expertise**	5	4
								I					0	0
									J				0	0
										K			0	0
													0	0



APPENDIX G.6

VALUE ENGINEERING RECOMMENDATIONS AND ACTION PLANS

Recommendations, Evaluation & Action Plan

				Rating scale 1-3	
			1	Slightly important	
			2	Moderate	
			3	Very important	
Functional Requirement	**Code**	**Recommendations**	**Rating**	**When**	**Who**
1. Optimise reliability	1.01	Introduce clear maintenance plan	4	On going	Engineering
	1.02	Conduct OHL inspections	3	As per specification	Engineering
	1.03	Conduct and economic analysis for all fitting	3	On going	Engineering
2. Rationalize items	2.01	Conduct OHL fitting evaluation	3	30-June-11	Engineering
	2.02	Standardise all OHL fitting	4	On going	Engineering
	2.03	Conduct OHL fitting evaluation	3	On going	Engineering
3. Reduce/mitigate risks	3.01	Conduct risk assessment	2	On going	Engineering / Procurement
	3.02	Improve internal demand planning and forecasting		On going	Procurement
	3.03	Clearly define contract conditions and enforce them	3	On going	Procurement
4. Improve manufacturing quality	4.01	Improve quality assurance policy	4	On going	Engineering
	4.02	Identify and qualify reputable manufacturers	2	On going	Engineering/ Procurement
	4.03	Conduct OHL fitting tests		On going per phase	Manufacturers
5. Sustain local skills and expertise	5.01	Hire more quality and technical specialists	4	31 August 2014	Engineering
	5.02	Introduce a system to capture knowledge	4	Currently being used	ESKOM
6. Monitor local manufacturers and imports	6.01	Monitor, control and conduct landing test for imports	4	On going per order	Procurement/ Manufacturers
	6.02	Introduce strategic sourcing for distribution OHL fittings		On going	Procurement
	6.03	On-going manufacturer delivery performance monitoring	3	On going	Procurement
	6.04	Create transparent and open relationship with manufacturers	3	On going	Engineering/ Procurement
7. Create jobs	7.01	Develop and support local manufacturers	5	On going	SD & L
	7.02	Provide seminars and training		On going	SD & L
	7.03	Assist emerging manufacturers with funding		On going	SD & L
8. Reduce costs	8.01	Introduce bulk purchasing of OHL fitting	3	On going per order	Procurement
	8.02	Benchmark prices	3	On going per phase	Procurement

APPENDIX G.7

PERSPECTIVE MODELLING MATRIX

Perspective Modelling Matrix

a	**Functions □**	Optimise reliability		Rationalize items		Reduce/mitigate risks		Improve manufacturing quality		Sustain local skills and expertise		Monitor local manufacturers and imports		Create jobs		Reduce costs		
b	Evaluation score >	13		12		11		8		6		4		2		1		
	Alternatives □																	**Total**
1	Asset Management	5	65	2	24	5	55	2	16	1	6	1	4	1	2	4	4	**176**
2	Life Cycle Costing	1	13	5	60	4	44	3	24	1	6	2	8	1	2	5	5	**162**
3	Quality Management System	2	26	5	60	4	44	5	40	2	12	4	16	4	8	5	5	**211**
4	Value Engineering/Management	3	39	4	48	4	44	1	8	1	12	2	8	2	4	4	4	**137**
5	Overhead Line Fitting Evaluation Process	5	65	4	48	5	55	4	32	1	6	2	8	2	4	1	1	**219**

Consider the Impact of each Alternative on each Function

5. Excellently
4. Very Good
3. Good
2. Fairly
1. Poorly

Instructions:
1. Insert Functions in "row a" - from the Numerical Evaluation, from the left highest scoring to lowest.
2. Insert respective scores from Numerical Evaluation into "row b".
3. Award a score 1 to 5 and place in the shaded column, evaluating the impact of each Alternative against each Function.
4. Multiply the above score by the Evaluation Score, insert the result to the right of the above score.
5. Add the Result Scores in the far right column.

APPENDIX H

OHL FITTING EVALUATION EXCEL SPREADSHEET (AVAILABLE ONLY IN ELECTRONIC FORMAT)

H.1 Items

						Original Equipment Manufacturer	Manuafcturer A	Manuafcturer B	Manuafcturer C	Manuafcturer D	Manuafcturer E	Manuafcturer F	Manuafcturer G	Manuafcturer H		
Item	SAP No	Description	Drawing	DNP Iter	Material Group	Test CAT	Item Coverage Before Evaluation								No.	Item Coverage Before Evaluatio
001	0189877	XARM,ST CHANNEL 2400 LG.	3000	1	Line Hardware - Galvanised Prefabricated Steel	GPS	N/A	Y	N/A	N/A	N/A	Y	N/A	Y	3	37.50%
002	0168689	XARM, ST INTERM T 90x65x8x2000LG L	3001	2	Line Hardware - Galvanised Prefabricated Steel	GPS	N/A	Y	N/A	N/A	N/A	Y	N/A	Y	3	37.50%
003	0206691	XARM, ST INTERM T 50x50x6x600LG L	3001	3	Line Hardware - Galvanised Prefabricated Steel	GPS	N/A	Y	N/A	N/A	N/A	Y	N/A	Y	3	37.50%
004	0163767	BOLT,PIGTAIL ASSY M16x380	3003	4	Line Hardware - Fasteners - Strain Nuts, Strain Bolts & Forgings	SN,SB&F	Y	Y	N/A	Y	Y	Y	Y	Y	7	87.50%
005	0163791	BOLT,PIGTAIL ASSY M10x280	3003	5	Line Hardware - Fasteners - Strain Nuts, Strain Bolts & Forgings	SN,SB&F	Y	Y	N/A	Y	Y	Y	Y	Y	7	87.50%
006	0163908	NUT,EYE 40kN FOR M16x2,0-6H BOLT	3004	6	Line Hardware - Fasteners - Strain Nuts, Strain Bolts & Forgings	SN,SB&F	Y	Y	Y	Y	Y	Y	Y	Y	8	100.00%
007	0163909	NUT,EYE 70kN FOR M20x2,5-6H BOLT	3004	7	Line Hardware - Fasteners - Strain Nuts, Strain Bolts & Forgings	SN,SB&F	Y	Y	Y	Y	Y	Y	Y	Y	8	100.00%
008	0163768	BOLT, EYE GALV M20x250	3005	8	Line Hardware - Fasteners - Strain Nuts, Strain Bolts & Forgings	SN,SB&F	Y	Y	Y	Y	Y	Y	Y	Y	8	100.00%
009	0010896	CLAMP,THIMBLE CLEV A-ALLOY 40kN	3007	9	Line Hardware - Conductor Clamps	CC	Y	Y	N/A	N/A	Y	N/A	Y	Y	5	62.50%
010	0168534	CLAMP,SUSP CRADLE CON 8,0-18,0	3008	10	Line Hardware - Conductor Clamps	CC	Y	Y	N/A	Y	Y	N/A	N/A	Y	5	62.50%
011	0010840	CLAMP,SUSP CRADLE CON 15.0-24.4	3008	11	Line Hardware - Conductor Clamps	CC	Y	Y	N/A	Y	Y	N/A	N/A	Y	5	62.50%
012	0163400	SHACKLE,STRAIGHT PIN TYPE 70KN	3010	12	Line Hardware - Fasteners - Strain Nuts, Strain Bolts & Forgings	SN,SB&F	Y	Y	Y	Y	Y	N/A	Y	Y	7	87.50%
013	0163396	STAYROD 1500xM12 NON-ADJUST	3011	13	Line Hardware - Stays Steel Components	SSC	Y	Y	N/A	N/A	N/A	Y	Y	Y	5	62.50%
014	0163402	STAYROD 2000xM20 96kN NON-ADJUST	3012	14	Line Hardware - Stays Steel Components	SSC	Y	Y	N/A	N/A	N/A	Y	Y	Y	5	62.50%
015	0087472	WASHER,RD FLAT M10 20.6D 11.25D HL	3014	15	Line Hardware - Fasteners - Bolt, Nuts & Washers	B,N&W	Y	N/A	N/A	Y	Y	Y	N/A	Y	5	62.50%
						Items tendered/submitted	12	14	4	9	10	11	9	15		
						Manufacturer Coverage	80%	93%	27%	60%	67%	73%	60%	100%		

APPENDIX H

H.2 Type Test Requirements

INX	Test Description	Test CAT	CC	B,N&W	SN,SB&F	TR	GPS	SSC
			3	**4**	**5**	**6**	**7**	**8**
1	Verification of general dimensions: **Eskom Drawings**	1	Drawings	Drawings	Drawings	Drawings	Drawings	Drawings
2	Verification of Ball / Socket couplings: **SANS 60120**	2	N/A	N/A	SANS 60120	N/A	N/A	N/A
3	Verification of Clevis / Tongue: **SANS 60471**	3	SANS 60471	N/A	SANS 60471	N/A	N/A	N/A
4	Verification of material type & hardness: **Test reports vs SANS 1431 or EN 10025-2, e.t.c.**	4	SANS 1431	SANS1431/ EN 10025-2	SANS 1431	BS EN 970	SANS1431/ EN 10025-2	SANS 1431
5	Galvanising of product body: **SANS 121**	5	SANS 121	SANS 121	SANS 121	SANS 121	SANS 121	SANS 121
6	Galvanising of coupling pins: **SANS 121**	6	SANS 121	N/A	SANS 121	N/A	N/A	N/A
7	Damage and failure load test procedure (Stays): **10TB-034**	7	N/A	N/A	N/A	N/A	N/A	10TB-034
8	Damage and failure load test: **SANS 61284**	8	SANS 61284	N/A	SANS 61284	N/A	N/A	N/A
9	Slip test (e.g. Suspension clamps, e.t.c.): **SANS 61284**	9	SANS 61284	N/A	N/A	N/A	N/A	N/A
10	Clamp bolt tightening test: **SANS 61284**	10	SANS 61284	N/A	N/A	N/A	N/A	N/A
11	Tensile test: **SANS 61284**	11	SANS 61284	N/A	SANS 61284	N/A	SANS 61284	N/A
12	Hump back split pin pull test: **DSP 34-1667**	12	DSP 34 1667	N/A	DSP 34-1667	N/A	N/A	N/A
13	Thread pull test (Threaded rods, bolts,nuts, e.t.c.): **SANS 1700**	13	N/A	SANS 1700	N/A	SANS 1700-5-1	N/A	N/A
14	Visual inspection of welds (Structures): **DSP 34-2051**	14	N/A	N/A	N/A	N/A	DSP 34-2051	DSP 34-2051
15	Slip test (Crosby clamps): **SANS 813**	15	SANS 813	N/A	N/A	N/A	N/A	N/A

APPENDIX H

H.3 Test Data

Supplier	SAP No	Test CAT	Inx	DNP No	Iter	Description	Type Test	Test Repo No	Testing Facility	Repor Date	Comments	Accep
Manuafcturer A	0163767	SN,SB&F	5	4	004	BOLT,PIGTAIL ASSY	Verification of general dimensions: Eskom Drawings	419 A & 10-539	Metlab	2012		Y
Manuafcturer A	0163767	SN,SB&F	5	4			Verification of Ball / Socket couplings: SANS 60120				N/A	N/A
Manuafcturer A	0163767	SN,SB&F	5	4			Verification of Clevis / Tongue: SANS 60471				N/A	N/A
Manuafcturer A	0163767	SN,SB&F	5	4			Verification of material type & hardness: Test reports vs SAN	12-1419 A, 12-	Metlab	2012	NO MECHANICAL PROPERTIES OF THE	P
Manuafcturer A	0163767	SN,SB&F	5	4			Galvanising of product body: SANS 121	12-1419 A &	Metlab	2012	NOT A SANAS ACCREDITED ACTIVITY	N
Manuafcturer A	0163767	SN,SB&F	5	4			Galvanising of coupling pins: SANS 121				N/A	N/A
Manuafcturer A	0163767	SN,SB&F	5	4			Damage and failure load test procedure (Stays): 10TB-034				N/A	N/A
Manuafcturer A	0163767	SN,SB&F	5	4			Damage and failure load test: SANS 61284				N/A	N/A
Manuafcturer A	0163767	SN,SB&F	5	4			Slip test (e.g. Suspension clamps, e.t.c.): SANS 61284				N/A	N/A
Manuafcturer A	0163767	SN,SB&F	5	4			Clamp bolt tightening test: SANS 61284				N/A	N/A
Manuafcturer A	0163767	SN,SB&F	5	4			Tensile test: SANS 61284	396 B, 12-1419	Metlab	2012		Y
Manuafcturer A	0163767	SN,SB&F	5	4			Hump back split pin pull test: DSP 34-1667				N/A	N/A
Manuafcturer A	0163767	SN,SB&F	5	4			Thread pull test (Threaded rods, bolts,nuts, e.t.c.): SANS 17				N/A	N/A
Manuafcturer A	0163767	SN,SB&F	5	4			Visual inspection of welds (Structures): DSP 34-2051				N/A	N/A
Manuafcturer A	0163767	SN,SB&F	5	4	004	BOLT,PIGTAIL ASSY	Slip test (Crosby clamps): SANS 813				N/A	N/A
Manuafcturer A	0163791	SN,SB&F	5	5	005	BOLT,PIGTAIL ASSY	Verification of general dimensions: Eskom Drawings	419 B & 10-539	Metlab	2012		Y
Manuafcturer A	0163791	SN,SB&F	5	5			Verification of Ball / Socket couplings: SANS 60120				N/A	N/A
Manuafcturer A	0163791	SN,SB&F	5	5			Verification of Clevis / Tongue: SANS 60471				N/A	N/A
Manuafcturer A	0163791	SN,SB&F	5	5			Verification of material type & hardness: Test reports vs SAN	12-1419 B, 12-	Metlab	2012	NO MECHANICAL PROPERTIES OF THE	P
Manuafcturer A	0163791	SN,SB&F	5	5			Galvanising of product body: SANS 121	419 B & 10-539	Metlab	2012	NOT A SANAS ACCREDITED ACTIVITY	N
Manuafcturer A	0163791	SN,SB&F	5	5			Galvanising of coupling pins: SANS 121				N/A	N/A
Manuafcturer A	0163791	SN,SB&F	5	5			Damage and failure load test procedure (Stays): 10TB-034				N/A	N/A
Manuafcturer A	0163791	SN,SB&F	5	5			Damage and failure load test: SANS 61284				N/A	N/A
Manuafcturer A	0163791	SN,SB&F	5	5			Slip test (e.g. Suspension clamps, e.t.c.): SANS 61284				N/A	N/A
Manuafcturer A	0163791	SN,SB&F	5	5			Clamp bolt tightening test: SANS 61284				N/A	N/A
Manuafcturer A	0163791	SN,SB&F	5	5			Tensile test: SANS 61284	10-5396 A	Metlab	2012		Y
Manuafcturer A	0163791	SN,SB&F	5	5			Hump back split pin pull test: DSP 34-1667				N/A	N/A
Manuafcturer A	0163791	SN,SB&F	5	5			Thread pull test (Threaded rods, bolts,nuts, e.t.c.): SANS 17				N/A	N/A
Manuafcturer A	0163791	SN,SB&F	5	5			Visual inspection of welds (Structures): DSP 34-2051				N/A	N/A
Manuafcturer A	0163791	SN,SB&F	5	5	005	BOLT,PIGTAIL ASSY	Slip test (Crosby clamps): SANS 813				N/A	N/A

H.3 Test Summary

Manufacturer	Item	SAP No	Description	1 Verification of general dimensions: Eskom Drawings	2 Verification of Ball / Socket couplings: SANS 60120	3 Verification of Clevis / Tongue: SANS 60471	4 Verification of material type & hardness: Test reports vs SANS 1431 or EN 10025-2, e.t.c.	5 Galvanising of product body: SANS 121	6 Galvanising of coupling pins: SANS 121	7 Damage and failure load test procedure (Stays): 10TB-034	8 Damage and failure load test: SANS 61284	9 Slip test (e.g. Suspension clamps, e.t.c.): SANS 61284	10 Clamp bolt tightening test: SANS 61284	11 Tensile test: SANS 61284	12 Hump back split pin pull test: DSP 34-1667	13 Thread pull test (Threaded rods, bolts,nuts, e.t.c.): SANS 1700	14 Visual inspection of welds (Structures): DSP34-2051	15 Slip test (Crosby clamps): SANS 813	Y (1)	P (0.5)	N (0)	N/	Compliance Level
Manuafcturer A	1	0189877	XARM,ST CHANNEL 2400 LG.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	15	N/A
Manuafcturer A	2	0168689	XARM, ST INTERM T 90x65x8x2000LG L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	15	N/A
Manuafcturer A	3	0206691	XARM, ST INTERM T 50x50x6x600LG L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	15	N/A
Manuafcturer A	4	0163767	BOLT,PIGTAIL ASSY M16x380	Y	N/A	N/A	P	N	N/A	N/A	N/A	N/A	N/A	Y	N/A	N/A	N/A	N/A	2	1	1	11	63%
Manuafcturer A	5	0163791	BOLT,PIGTAIL ASSY M10x280	Y	N/A	N/A	P	N	N/A	N/A	N/A	N/A	N/A	Y	N/A	N/A	N/A	N/A	2	1	1	11	63%
Manuafcturer A	6	0163908	NUT,EYE 40kN FOR M16x2,0-6H BOLT	Y	N/A	N/A	P	N	N/A	N/A	N/A	N/A	N/A	Y	N/A	N/A	N/A	N/A	2	1	1	11	63%
Manuafcturer A	7	0163909	NUT,EYE 70kN FOR M20x2,5-6H BOLT	Y	N/A	N/A	P	N	N/A	N/A	N/A	N/A	N/A	Y	N/A	N/A	N/A	N/A	2	1	1	11	63%
Manuafcturer A	8	0163768	BOLT, EYE GALV M20x250	Y	N/A	N/A	P	N	N/A	N/A	N/A	N/A	N/A	Y	N/A	N/A	N/A	N/A	2	1	1	11	63%
Manuafcturer A	9	0010896	CLAMP,THIMBLE CLEV A-ALLOY 40kN	N	N/A	N	N	N/A	N/A	N/A	N	N/A	N/A	N	N	N/A	N/A	N/A	0	0	6	9	0
Manuafcturer A	10	0168534	CLAMP,SUSP CRADLE CON 8,0-18,0	N	N/A	N	N	N/A	N/A	N/A	N	N	N	N	N	N/A	N/A	N/A	0	0	8	7	0
Manuafcturer A	11	0010840	CLAMP,SUSP CRADLE CON 15.0-24.4	N	N/A	N	N	N/A	N/A	N/A	N	N	N	N	N	N/A	N/A	N/A	0	0	8	7	0
Manuafcturer A	12	0163400	SHACKLE,STRAIGHT PIN TYPE 70KN	Y	N/A	N	P	N/A	N	N/A	N	N/A	N/A	N/A	N	N/A	N/A	N/A	1	1	4	9	25%
Manuafcturer A	13	0163396	STAYROD 1500xM12 NON-ADJUST	Y	N/A	N/A	N	N	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	Y	N/A	2	0	3	10	40%
Manuafcturer A	14	0163402	STAYROD 2000xM20 96kN NON-ADJUST	Y	N/A	N/A	P	N	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	Y	N/A	2	1	2	10	50%
Manuafcturer A	15	0087472	WASHER,RD FLAT M10 20.6D 11.25D HL	Y	N/A	N/A	P	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	1	12	50%
Manuafcturer B	1	0189877	XARM,ST CHANNEL 2400 LG.	P	N/A	N/A	Y	Y	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	1	0	12	83%
Manuafcturer B	2	0168689	XARM, ST INTERM T 90x65x8x2000LG L	Y	N/A	N/A	P	Y	N/A	N/A	N/A	N/A	N/A	Y	N/A	N/A	Y	N/A	4	1	0	10	90%
Manuafcturer B	3	0206691	XARM, ST INTERM T 50x50x6x600LG L	Y	N/A	N/A	Y	Y	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A	3	0	1	11	75%
Manuafcturer B	4	0163767	BOLT,PIGTAIL ASSY M16x380	P	N/A	N/A	N	Y	N/A	N/A	N/A	N/A	N/A	Y	N/A	N/A	N/A	N/A	2	1	1	11	63%
Manuafcturer B	5	0163791	BOLT,PIGTAIL ASSY M10x280	N	N/A	N/A	N	Y	N/A	N/A	N/A	N/A	N/A	Y	N/A	N/A	N/A	N/A	2	0	2	11	50%
Manuafcturer B	6	0163908	NUT,EYE 40kN FOR M16x2,0-6H BOLT	Y	N/A	N/A	Y	Y	N/A	N/A	N/A	N/A	N/A	Y	N/A	N/A	N/A	N/A	4	0	0	11	100%
Manuafcturer B	7	0163909	NUT,EYE 70kN FOR M20x2,5-6H BOLT	Y	N/A	N/A	Y	Y	N/A	N/A	N/A	N/A	N/A	Y	N/A	N/A	N/A	N/A	4	0	0	11	100%
Manuafcturer B	8	0163768	BOLT, EYE GALV M20x250	Y	N/A	N/A	Y	Y	N/A	N/A	N/A	N/A	N/A	Y	N/A	N/A	N/A	N/A	4	0	0	11	100%
Manuafcturer B	9	0010896	CLAMP,THIMBLE CLEV A-ALLOY 40kN	Y	N/A	Y	Y	Y	Y	N/A	Y	N/A	N/A	Y	Y	N/A	N/A	N/A	8	0	0	7	100%
Manuafcturer B	10	0168534	CLAMP,SUSP CRADLE CON 8,0-18,0	Y	N/A	Y	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N/A	N/A	N/A	10	0	0	5	100%
Manuafcturer B	11	0010840	CLAMP,SUSP CRADLE CON 15.0-24.4	Y	N/A	Y	Y	Y	Y	N/A	Y	Y	Y	Y	Y	N/A	N/A	N/A	10	0	0	5	100%
Manuafcturer B	12	0163400	SHACKLE,STRAIGHT PIN TYPE 70KN	Y	Y	Y	Y	Y	N/A	N/A	N/A	N/A	N/A	Y	N/A	N/A	N/A	N/A	6	0	0	9	100%
Manuafcturer B	13	0163396	STAYROD 1500xM12 NON-ADJUST	Y	N/A	N/A	P	Y	N/A	Y	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	1	0	11	88%
Manuafcturer B	14	0163402	STAYROD 2000xM20 96kN NON-ADJUST	Y	N/A	N/A	P	Y	N/A	Y	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	1	0	11	88%
Manuafcturer B	15	0087472	WASHER,RD FLAT M10 20.6D 11.25D HL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	15	N/A

H.4 Product Summary

							127.66%		Schedules					
	2277						Description					100%	100%	
Manufacturer	SAP No	DNP No	Material group	Test CAT	Info OK?	Item	Description	Submitted?	Country	Manufacturer	Product Code	Compliance	Total	Results
Manuafcturer A	0189877	1	Line Hardware - Galvanised Prefabric	GPS	TRUE	001	XARM,ST CHANNEL 2400 LG.	N/A	-	-	-	-	N/A	N/A
Manuafcturer A	0168689	2	Line Hardware - Galvanised Prefabric	GPS	TRUE	002	XARM, ST INTERM T 90x65x8x2000LG	N/A	-	-	-	-	N/A	N/A
Manuafcturer A	0206691	3	Line Hardware - Galvanised Prefabric	GPS	TRUE	003	XARM, ST INTERM T 50x50x6x600LG L	N/A	-	-	-	-	N/A	N/A
Manuafcturer A	0163767	4	Line Hardware - Fasteners - Strain Nu	SN,SB&F	FALSE	004	BOLT,PIGTAIL ASSY M16x380	Y	India	A.Damiano & Co	Pt16/380	70%	70%	Y
Manuafcturer A	0163791	5	Line Hardware - Fasteners - Strain Nu	SN,SB&F	FALSE	005	BOLT,PIGTAIL ASSY M10x280	Y	India	A.Damiano & Co	Pt16/381	70%	70%	Y
Manuafcturer A	0163908	6	Line Hardware - Fasteners - Strain Nu	SN,SB&F	FALSE	006	NUT,EYE 40kN FOR M16x2,0-6H BOLT	Y	India	A.Damiano & Co	Pt16/382	70%	70%	Y
Manuafcturer A	0163909	7	Line Hardware - Fasteners - Strain Nu	SN,SB&F	FALSE	007	NUT,EYE 70kN FOR M20x2,5-6H BOLT	Y	India	A.Damiano & Co	Pt16/383	70%	70%	Y
Manuafcturer A	0163768	8	Line Hardware - Fasteners - Strain Nu	SN,SB&F	FALSE	008	BOLT, EYE GALV M20x250	Y	India	A.Damiano & Co	Pt16/384	70%	70%	Y
Manuafcturer A	0010896	9	Line Hardware - Conductor Clamps	CC	FALSE	009	CLAMP,THIMBLE CLEV A-ALLOY 40kN	Y	India	A.Damiano & Co	Pt16/385	50%	50%	P
Manuafcturer A	0168534	10	Line Hardware - Conductor Clamps	CC	FALSE	010	CLAMP,SUSP CRADLE CON 8,0-18,0	Y	India	A.Damiano & Co	Pt16/386	50%	50%	P
Manuafcturer A	0010840	11	Line Hardware - Conductor Clamps	CC	FALSE	011	CLAMP,SUSP CRADLE CON 15.0-24.4	Y	India	A.Damiano & Co	Pt16/387	50%	50%	P
Manuafcturer A	0163400	12	Line Hardware - Fasteners - Strain Nu	SN,SB&F	FALSE	012	SHACKLE,STRAIGHT PIN TYPE 70KN	Y	India	A.Damiano & Co	Pt16/388	70%	70%	Y
Manuafcturer A	0163396	13	Line Hardware - Stays Steel Compone	SSC	FALSE	013	STAYROD 1500xM12 NON-ADJUST	Y	India	A.Damiano & Co	Pt16/389	70%	70%	Y
Manuafcturer A	0163402	14	Line Hardware - Stays Steel Compone	SSC	FALSE	014	STAYROD 2000xM20 96kN NON-	Y	India	A.Damiano & Co	Pt16/390	70%	70%	Y
Manuafcturer A	0087472	15	Line Hardware - Fasteners - Bolt, Nuts	B,N&W	FALSE	015	WASHER,RD FLAT M10 20.6D 11.25D	Y	India	A.Damiano & Co	Pt16/391	70%	70%	Y
Manuafcturer B	0189877	1	Line Hardware - Galvanised Prefabric	GPS	TRUE	001	XARM,ST CHANNEL 2400 LG.	N/A	-	-	-	-	N/A	N/A
Manuafcturer B	0168689	2	Line Hardware - Galvanised Prefabric	GPS	TRUE	002	XARM, ST INTERM T 90x65x8x2000LG	N/A	-	-	-	-	N/A	N/A
Manuafcturer B	0206691	3	Line Hardware - Galvanised Prefabric	GPS	TRUE	003	XARM, ST INTERM T 50x50x6x600LG L	N/A	-	-	-	-	N/A	N/A
Manuafcturer B	0163767	4	Line Hardware - Fasteners - Strain Nu	SN,SB&F	FALSE	004	BOLT,PIGTAIL ASSY M16x380	Y	China	Hutang	D166	80%	80%	Y
Manuafcturer B	0163791	5	Line Hardware - Fasteners - Strain Nu	SN,SB&F	FALSE	005	BOLT,PIGTAIL ASSY M10x280	Y	China	Hutang	D167	80%	80%	Y
Manuafcturer B	0163908	6	Line Hardware - Fasteners - Strain Nu	SN,SB&F	FALSE	006	NUT,EYE 40kN FOR M16x2,0-6H BOLT	Y	China	Hutang	D168	80%	80%	Y
Manuafcturer B	0163909	7	Line Hardware - Fasteners - Strain Nu	SN,SB&F	FALSE	007	NUT,EYE 70kN FOR M20x2,5-6H BOLT	Y	China	Hutang	D169	80%	80%	Y
Manuafcturer B	0163768	8	Line Hardware - Fasteners - Strain Nu	SN,SB&F	FALSE	008	BOLT, EYE GALV M20x250	Y	China	Hutang	D170	80%	80%	Y
Manuafcturer B	0010896	9	Line Hardware - Conductor Clamps	CC	TRUE	009	CLAMP,THIMBLE CLEV A-ALLOY 40kN	Y	China	Hutang	D171	80%	80%	Y
Manuafcturer B	0168534	10	Line Hardware - Conductor Clamps	CC	TRUE	010	CLAMP,SUSP CRADLE CON 8,0-18,0	Y	China	Hutang	D172	80%	80%	Y
Manuafcturer B	0010840	11	Line Hardware - Conductor Clamps	CC	TRUE	011	CLAMP,SUSP CRADLE CON 15.0-24.4	Y	China	Hutang	D173	80%	80%	Y
Manuafcturer B	0163400	12	Line Hardware - Fasteners - Strain Nu	SN,SB&F	FALSE	012	SHACKLE,STRAIGHT PIN TYPE 70KN	Y	China	Hutang	D174	80%	80%	Y
Manuafcturer B	0163396	13	Line Hardware - Stays Steel Compone	SSC	TRUE	013	STAYROD 1500xM12 NON-ADJUST	Y	China	Hutang	D175	80%	80%	Y
Manuafcturer B	0163402	14	Line Hardware - Stays Steel Compone	SSC	FALSE	014	STAYROD 2000xM20 96kN NON-	Y	China	Hutang	D176	80%	80%	Y
Manuafcturer B	0087472	15	Line Hardware - Fasteners - Bolt, Nuts	B,N&W	FALSE	015	WASHER,RD FLAT M10 20.6D 11.25D	Y	China	Hutang	D177	80%	80%	Y

APPENDIX I

INTORDUCTION TO STRATEGIC SOURCING TO REDUCE RISKS

I.1 Strategic Sourcing

Strategic sourcing is a critical aspect of risk assessment for OHL fittings since it identifies, prioritize, manage and mitigate supplier risks such that those risks do not cascade with detrimental effects to the intended purchaser, in this case, ESKOM Dx. It specifically deals with managing the supply base in an effective manner by identifying and selecting manufacturers for strategic long-term partnerships, and manufacturer development initiatives.

I.1.1 Introduction to strategic sourcing in ESKOM

In ESKOM, strategic sourcing was launched in 2005 to target significant spend areas in ESKOM for value extraction. It also has the objective of making an impact on ESKOM's journey to improve its supply chain capability to ensure sustainability of savings. This initiative supports ESKOM's vision and the requirement to meet growing future energy demands in Southern Africa. Currently, ESKOM is embarking on a period of major capital expenditure to support demand. It is envisaged that a significant portion of the investment can be funded from operational and capital expenditure savings.

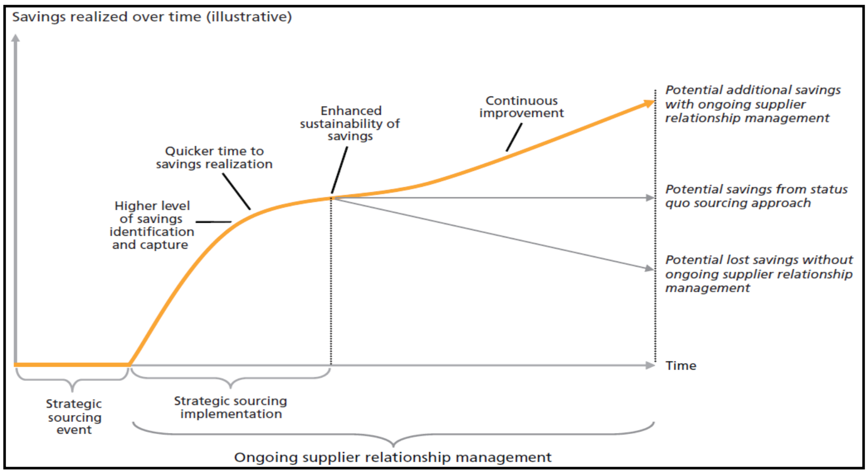


Figure I.1 Strategic sourcing as a function of savings over time (Wyman, 2013)

Strategic thinking pays close attention to future positioning and needs of the company. Forward looking manufacturer partnerships become a key lever for sustainable value creation in ESKOM as shown in figure I.1 Products evolve over time thus, it is critical to form relationships with manufacturers that can effectively meet the changing requirements from the perspective of new product development, design, manufacturing processes and manufacturing capability at lower costs. Currently, distribution OHL fitting work stream charter is being developed to address these issues. The key focus areas to be included in the charter are to identify and pursue value opportunities such as:

- Value bundling of requirements within distribution in order to gain the best negotiated price benefit (leverage);
- Standardisation - rationalisation of OHL fitting ranges in collaboration with the ESKOM pricing policy;
- The selection of a local manufacturing market to create opportunities to optimize on ASGISA and stimulating the South African economy;
- Improve internal demand planning and forecasting in order to secure best possible bulk ordering leverage;
- Reviewing of contract terms and duration, warranties and penalty clauses. Enhancing ESKOM's ability to manage these contracts more efficiently;
- There will be more financial benefit through the streamlining of production lines;
- An analysis of the breakdown of manufacturer's cost components will be performed in order to determine the true costing and margins tendered to ESKOM consequently opening the door to more effective negotiations.

H.1.2 Strategic sourcing as a risk assessment tool

Organizations quantify and manage risks effectively in order to be successful over time. When dealing with manufacturers, there are substantial risks and potential for disaster in the form of bankruptcy, environmental problems, and supply interruptions, lack of materials, poor performance or product defects. One important and a cost effective step is to monitor and manage the performance of manufacturers periodically (audits). Although, some risks can be addressed purely by the manufacturer's QMS, it is very crucial that manufacturers are making significant investments in systems and processes to improve quality.

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Procurement and Supply Chain Management (P & SCM) together with Supplier Development and Localisation (SD & L) in ESKOM can better understand the drivers that create supply disruptions and mitigate the risk more proactively and this is indicated in figure I.2

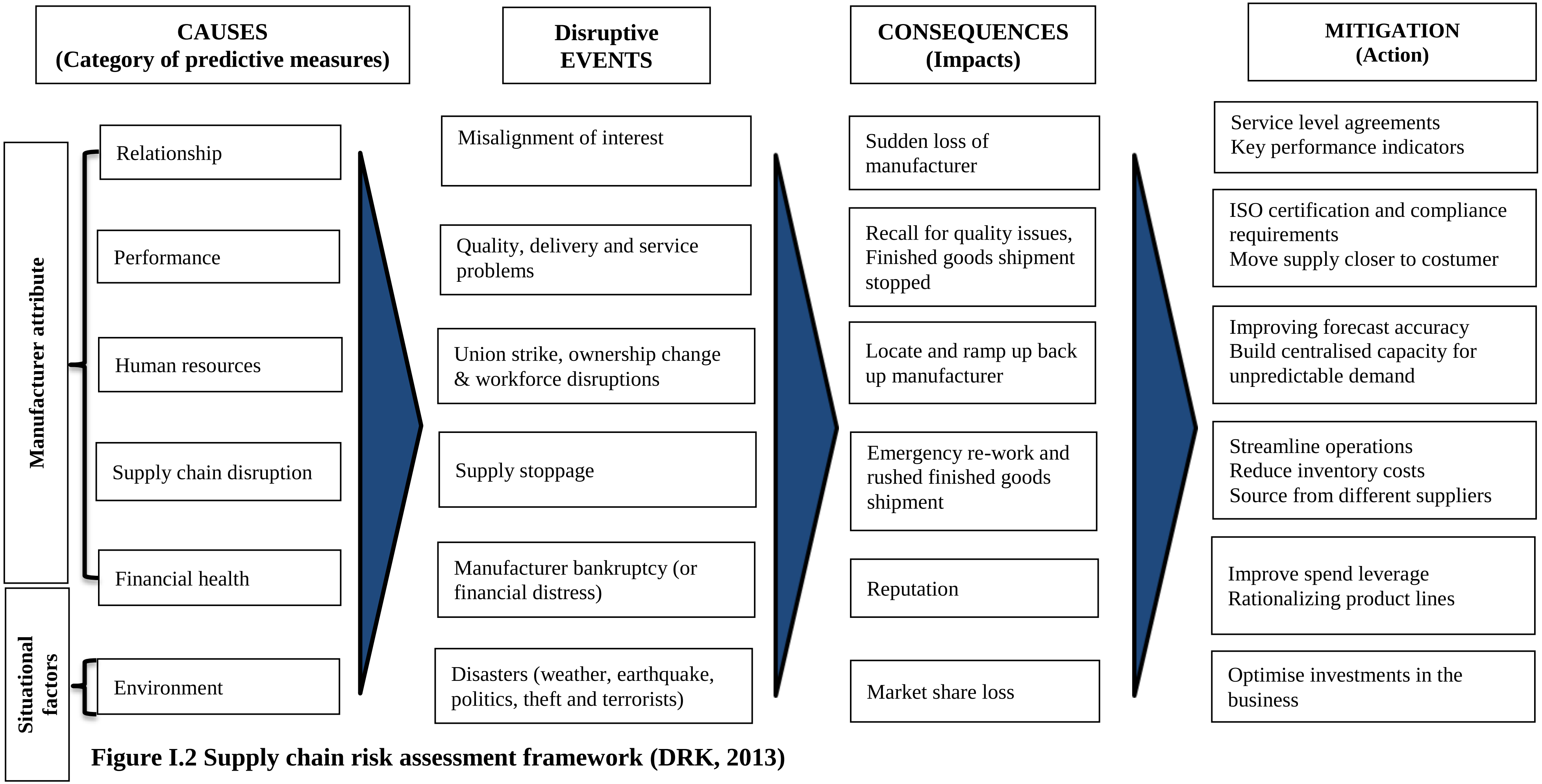

Figure I.2 Supply chain risk assessment framework (DRK, 2013)

I.1.3 Other risks affecting the country's Gross Domestic Products

Strategic efforts, by design, need to consider a broad landscape in order to put OHL fitting sourcing initiatives in the context of value creation which will perpetually create jobs. The following section is critical in the sense that it directly highlights the impact of risks associated with strategic sourcing as far as the South African GDP is concerned.

I.1.3.1 The loss of jobs and expertise created by exports and imports imbalance

The international trade based on comparative advantage highlights that the people of a country will be poorer if low-cost goods are imported from other countries, because of this, people will not be able to get jobs. This is true from the South African context were by, most of the OHL fitting manufacturers who are still emerging and trying to make it in the markets find it difficult to compete with foreign manufacturers like China and India. There is also a concern from local manufacturers that importing OHL fittings from other countries, jobs might be lost due to unfair advantage. Funds that could have been used to develop the ailing South African economy especially in the manufacturing sector are being transferred to other countries. While such action is creating unemployment and closure of many OHL manufacturing firms in South Africa, there will be creation of jobs and OHL fitting industry boom in those countries from where the OHL fittings are imported.

Figure I.3 Countries exports, imports & trade balance (DTI, 2013)

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Since 2002, imports increased more than exports, and the trade deficit increased as depicted in figure I.3. Exports growth is a good thing and generally creates jobs at home while imports create jobs abroad. Increased foreign trade it is not a very good mechanism. It does not increase the countries standard of living. Imports are treated as a minus in GDP calculations to correct for the over counting caused by the import content of other spending categories (such as, consumption, investment and government spending)