# Infrastructure crossing Infrastructure – what are the possible impacts to be mitigated

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# Introduction

Power lines often cross a multitude of other linear infrastructure, especially with an increase in congestion in urban areas, or when passing over farms and industry

*Various risks (Mechanical/Structural, Electrical)*

*Two main classes i.e  SAFETY vs INTEGRITY/AVAILABILITY*

<u>Two types of Mechanical/Structural Risks</u>

- One structure/component fails and fall/affect the other
- Corrosion leading to structural/component failure(s)

<u>Two types of Electrical Shocks</u>

- Long term continuous (50Hz)
- Short term transients (Lightning or Switching)=Step and touch

# SANS10280-1 - 2013

International changes to IEC codes led to changes in SANS10280 in 2013

This standard governs minimum requirements to meet **Safety** standards

Table E.1 — Minimum clearances for power lines

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| | | | Minimum vertical clearances m | | | | Horizontal clearances m |
| Highest system r.m.s. voltage kV | System nominal r.m.s. voltage kV | Minimum safety clearance m | Ground clearance, all areas | Roads in townships and proclaimed roads, railways [d] | To buildings, poles, structures not part of power lines and vegetation | To tele-communication lines and between power lines | To all ground, buildings and structures not part of the power line |
| <1 | – | – | 4,9[a] | 6,1 | 3,0[a] | 0,6[a] | 3 |
| 7,2 | 6,6 | 0,15 | 5,5 | 6,2 | 3,0 | 0,7 | 3 |
| 12 | 11 | 0,20 | 5,5 | 6,3 | 3,0 | 0,8 | 3 |
| 24 | 22 | 0,32 | 5,5 | 6,4 | 3,0 | 0,9 | 3 |
| 36 | 33 | 0,43 | 5,5 | 6,5 | 3,0 | 1,0 | 3 |
| 48 | 44 | 0,54 | 5,5 | 6,6 | 3,0 | 1,1 | 3 |
| 72 | 66 | 0,77 | 5,7 | 6,9 | 3,2 | 1,4 | 3 |
| 100 | 88 | 1,00 | 5,9 | 7,1 | 3,4 | 1,6 | 3 |
| 145 | 132 | 1,45 | 6,3 | 7,5 | 3,8 | 2,0 | 3 |
| 245 | 220 | 2,1 | 7,0 | 8,2 | 4,5 | 2,7 | 3 |
| 300 | 275 | 2,5 | 7,4 | 8,6 | 4,9 | 3,1 | 3 |
| 362 | 330 | 2,9 | 7,8 | 9,0 | 5,3 | 3,5 | 3 |
| 420 | 400 | 3,2 | 8,1 | 9,3 | 5,6 | 3,8 | 3,2 |
| 800[b] | 765 | 5,5 | 10,4 | 11,6 | 8,5 | 6,1 | 5,5 |
| 533d.c.[c] | – | 3,7 | 8,6 | 9,8 | 6,1 | 4,3 | 3,7 |

## Crossing requirements explained – new wind pressures 120Pa and 575Pa

# 10 Crossings

## 10.1 Crossings over roads and railways lines

## 10.2 Crossings between power lines or power lines and telecommunication lines

## 10.3 Crossings over water

**10.3.1** In general, normal ground clearances shall be provided. However, where crossings are made over rivers, dams or lakes, which are, or could be, used as recognized sailing waters, a clearance of 2,5 m plus the relevant minimum urban area ground clearance (in accordance with column 4 in table E.1) shall be provided; this clearance covers a distance over the tallest boat mast likely to be encountered on such water under conditions of a normal high-water level and maximum conductor sag.

## 10.4 In the proximity of and in crossings of LV feeders and service connections with telecommunication services

# Crossing Types and Risks . 1

| Crossing type | Risks/Effects |
| --- | --- |
| Power line - Power line | Electrical clearance, Structural failure of 1 line affecting both |
| Power line - Pipeline | Electrical shocks, Corrosion damage |
| Power line - Railway line | Electrical clearance, Structural failure of 1 system affecting the other |
| Power line – Electric Fence | Electrical shocks, False Alarms |
| Power line – Long Game Fence | Electrical shocks |
| Power line - Power Cable | Electrical shocks |
| Power line - Communication cables | Electrical shocks, Interference, Equipment Failure |

# Crossing Types and Risks . 2

| Crossing type | Risks/Effects |
|---|---|
| Power line - Road | Electrical clearance, Conductor or Structural failure of Power line a danger to road users |
| Power line – Farm Fence | Electrical shocks, Corrosion damage |
| Power line and Large Metallic Roof/Building | Electrical shocks |
| Power line – Farm Windmill | Electrical shocks |
| Power Line – Pivot Irrigation | Electrical shocks |
| Power Line – Farm Feed Lot | Electrical shocks |
| Power line – navigable water (inland) | Electrical shocks |

# Power line and Power line

When 1 power line crosses another, the main risk are:

1. electrical flashover due to insufficient clearance

2. Structural failure of 1 line affecting the other

Advanced 3D modelling of conductor behavior in terms of wind and temperature various are used in design phase to limit both these risks

Phase to phase, and phase to ground (SANS10280 required checks)

# Power line and Power line

## OSH ACT Requirements

**10.2.5** Clearances shall be maintained under the conductor conditions given in (a), (b) and (c).

a) Vertical clearance

The minimum clearance between power lines as stated in column 7 of table E.1 shall be determined by considering the templating or design temperature of the top line (minimum 50 °C) with the lower line conductor not exceeding 15 °C.

b) Conductor swing

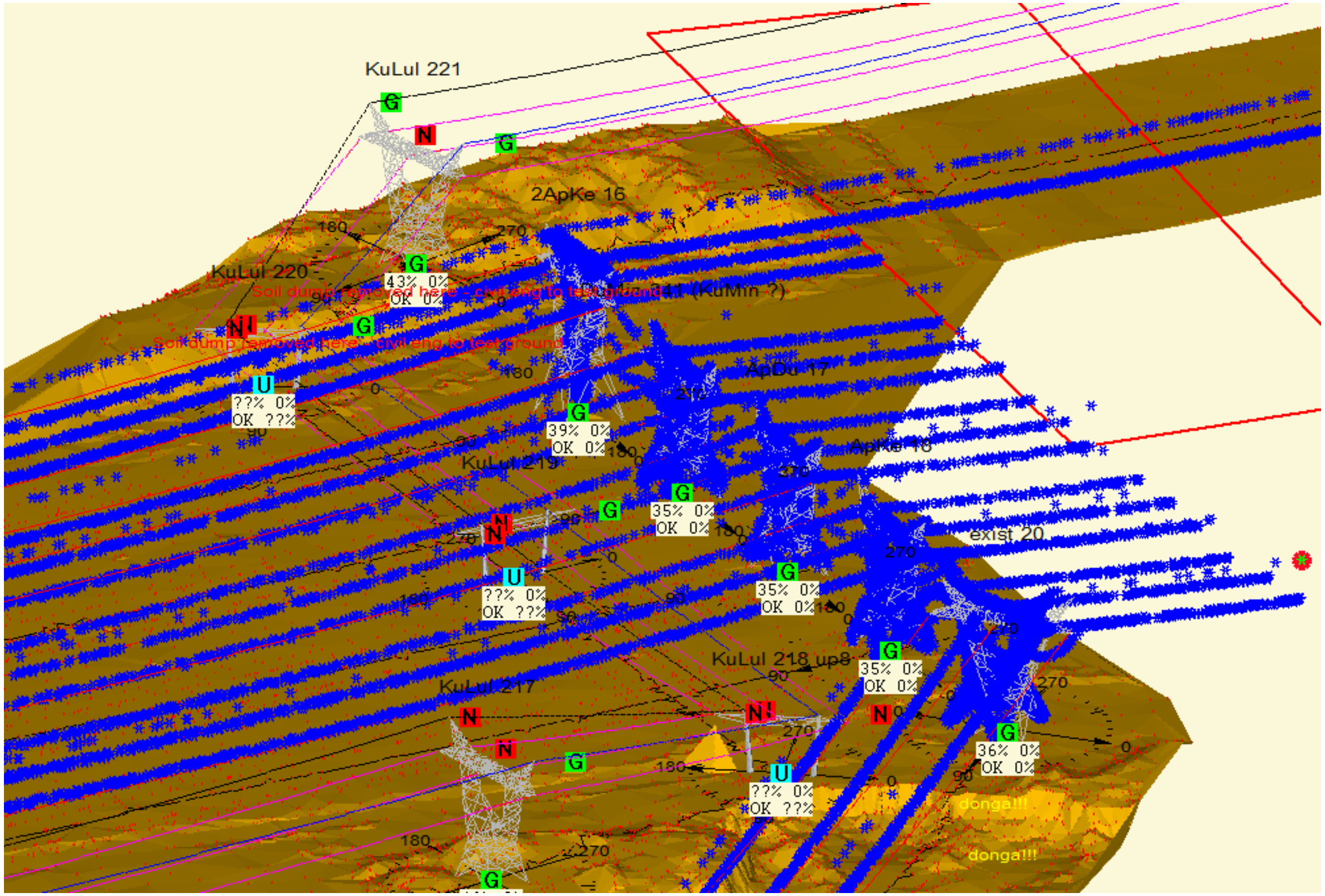
If the orientation of the line crossing is such that blowout of the conductors could cause a reduction in the distance between the conductors of the different lines, the clearances given in column 3 in table E.1 shall be maintained in all positions through to the maximum blowout position of the conductor.

c) Ice loading (where applicable)

Clearances (column 3 in table E.1) shall be maintained under maximum ice loading on the upper conductor at -5 °C with no wind, and on the lower conductor with no ice or wind at -5 °C.

# Power line and Power line

## 1 new 400kV line crossing under 4x400kV lines



# Power line and Pipeline

Metallic pipelines which cross and run in parallel to Power lines can have active cathodic protection (DC Current injected into it), which could enter a power line structure

If the DC current finds a path along the power line (along continuous earth wires that are electrically connected to the power line earth peaks), the current can flow along the earth wires.

Some distance away, where this current flows back into earth (to go back to the DC source at the pipeline). The tower steel will be corroded slowly but significantly over time (10 years plus, sometimes even less).

To prevent this type of destructive current that drives corrosion, the overhead ground wires are insulated from the towers at least 800m from any crossing or parallelism with a metallic pipe which has an active cathodic protection system.

# Power line and Pipeline

| Eskom | Guideline | Technology |
|---|---|---|

Title: **GUIDELINE ON THE ELECTRICAL CO-ORDINATION OF PIPELINES AND POWER LINES**

Unique Identifier: **240-66418968**

Alternative Reference Number: **<n/a>**

### 3.3.4 Limits relating to danger during steady state conditions

During worst case conditions on the power line(s), the touch voltage of the pipeline and its appurtenances shall not exceed:

a) 15 V r.m.s. at pipeline sections exposed only to authorised personnel,

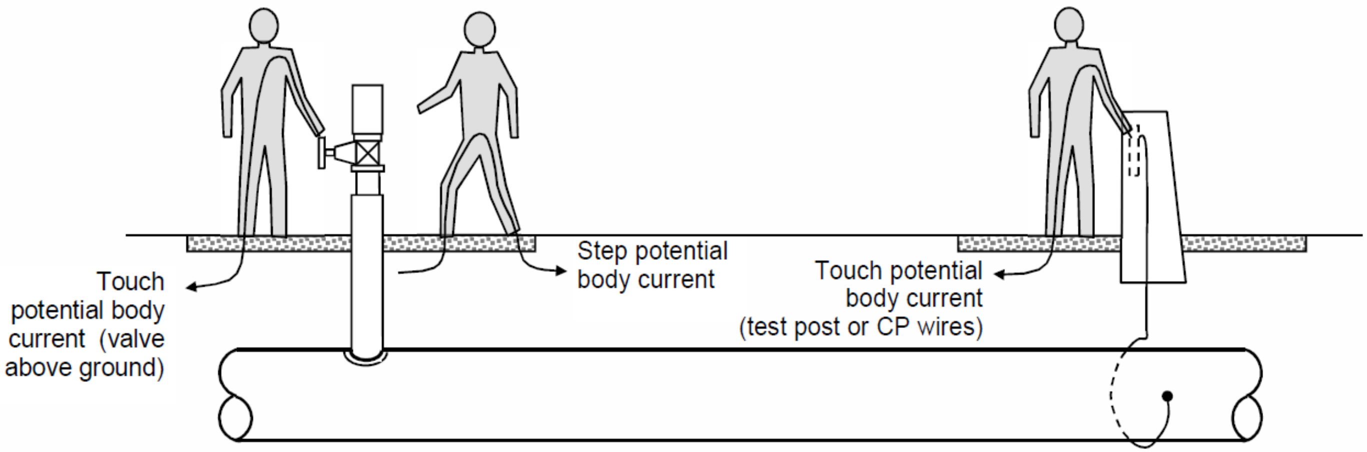
b) 7.5 V r.m.s at pipeline sections exposed to the general public.

### 3.3.3 Limits relating to danger during fault conditions

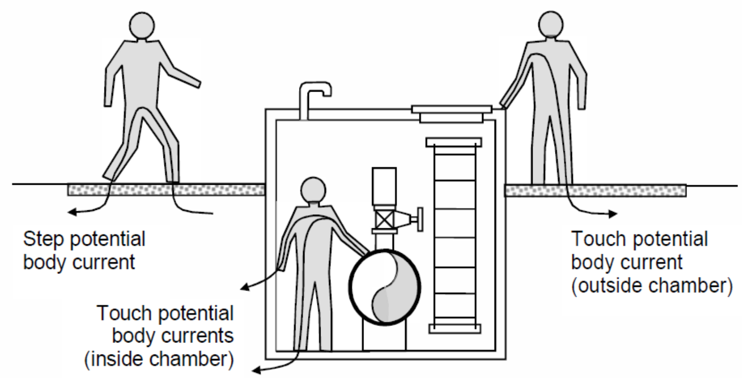
In the event of an earth fault on the power line(s), the touch and step voltages with respect to local earth at any accessible section of the pipeline shall not exceed the values given in Table 1, for public and occupational exposure respectively.

For most pipelines the occupational exposure limits will be applicable. The public exposure limits are only applicable for above - ground pipelines or appurtenances that are not protected from public access.

# Power line and Pipeline

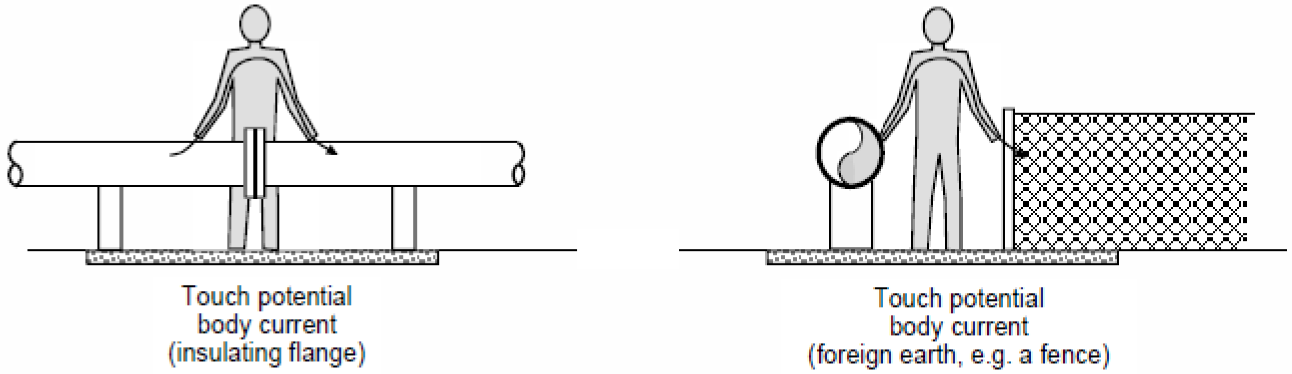



**(b) at above-ground appurtenances**




**(a) at partially buried valve chambers**

# Power line and Pipeline




**(c) across insulating flanges and to separate earths**

# Power line and Railway line

Railway lines, especially those with overhead electrification, needs sufficient clearance between their circuits and the power line conductors and structures for safe co-existence

DC return currents from Railway traction systems can cause corrosion and dangerous voltage and currents or arching over rail sections if not coordinated properly

Infrastructure that can collapse and damage each other is a risk to be catered for.

# Power line and Electric Fence

Power lines running across or along large electric fence installations pose a few problems and risks to the fence owner:

1. Danger during stringing (installation) of the fence wires
2. High AC voltages (50Hz) constantly induced on the fence which pose a maintenance risk, as well as leading to false alarms on the fence
3. Unless special fence energizers are installed, the reliability/longevity of the fence energizers will be adversely affected
4. Lightning strikes or electrical faults on the power line may induce high electrical voltage and current on the electric fence and lead to failures.

# Power line and Electric Fence

Mitigation of the effects of the power line on the electric fence can be complex and costly:

1. Special equipment (isolating transformers or narrow band filters) may have to be designed and specified to overcome the problem of false alarms on the energizers

2. The earthing scheme of the electric fence must be specially designed and installed to limit the problem (possibly including surge arrestors)

3. During installation and maintenance of the fence wires near the energized power line(s), special earthing techniques and/or the use of electrical gloves and shoes to protect workers must be specified and enforced to avoid electrical shock of workers

# Power line and Long Game Fence

## Powerlines

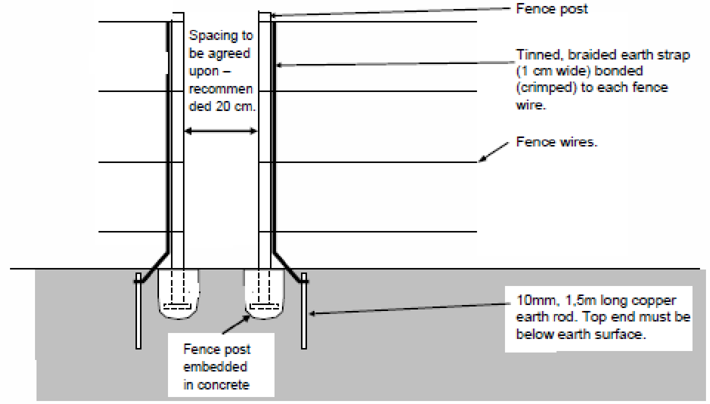



**Figure H-14:** Required installation at each of the main fence posts (poles) – fence wire supporting droppers excluded (Not to scale).

(a) (b)

**Figure H-4:** (a) Earthing of the fence wires and fence anchor posts and (b) warning signs fitted to the fence following the required safety installation

# Power line and Long Game Fence

## Alternative non-metallic fencing

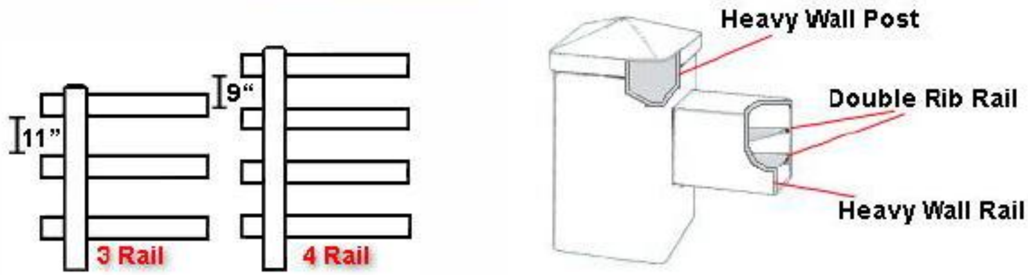



**Figure J-2:** Extruded Rigid Polyvinyl Chloride (PVC) Fence.

# Power line and Power Cable

The electrical earthing of the power cable, in relation to the power line tower earthing systems must be coordinated in such a way that workers or members of the public will not be in danger during maintenance or operation of both systems

Any metallic components that are connected to the cable earth or armour, which can be touched by a member of the public, needs to be earthed properly to avoid electric shock during a fault on the cable or the power line

Small power cables can be put inside a concrete pipe or duct to make it safer.

# Power line and Communication cable

Metallic communication cables, such as those used by railway operators, needs to be shielded electrically to prevent communication signal interference from the power line.

Any metallic parts of the cable, especially those that can be touched by workers or members of the public, must be earthed in such a way that they will not be dangerous to touch, or to step near them.

(similar to pipeline components that are located above ground but interconnected to metallic screens of cable below the ground)

# Power line and Road

Power lines crossing over roads should have extra mechanical integrity as per SANS10280 (strain towers at least on one side of the road) and the towers should not be too close to the road to allow for road expansion.

A conductor failure can cause serious accidents, and abnormal routes need extra clearance

Emergency Helicopters flying along major road routes can collide with power lines unless the conductors are clearly marked with aerial warning spheres

# Power line and Farm Fence

Power lines running in parallel and crossing long lengths of fences can induce dangerous shocks if a gate is inserted in the fence

There must always be a direct electrical connection between the gate posts which should be metallic (Eskom servitude gate standard)

Fences close to a power line can conduct a high voltage and cause dangerous electrical shocks to people touching the fence up to 100's of metres (especially on fences running away from the power line where nobody expects a risk)

Special modifications to fences can mitigate this risk (but in general, this risk is remote)

(potentially more dangerous when having similar length and exposure to long parallel game fences)

# Power line and Farm Fence


# Power line and Large Metallic Roof/Building

Power lines crossing over large metallic roofs, such as car ports, can expose members of the public to 2 types of electrical risks:

1. Electrostatic charge collecting on the metallic roof can discharge through a person who makes contact with it

2. If a fault/flash-over occurs on a nearby tower, and a person touches the structure at the same time (very low probability of coincidence), a dangerous touch voltage can develop

# Power line and Large Metallic Roof/Building

# Power line and Farm Windmill

# Power line and Farm Windmill

Power lines sometimes pass over wind mills, and if the risk is considered low, can be left to co-exist.

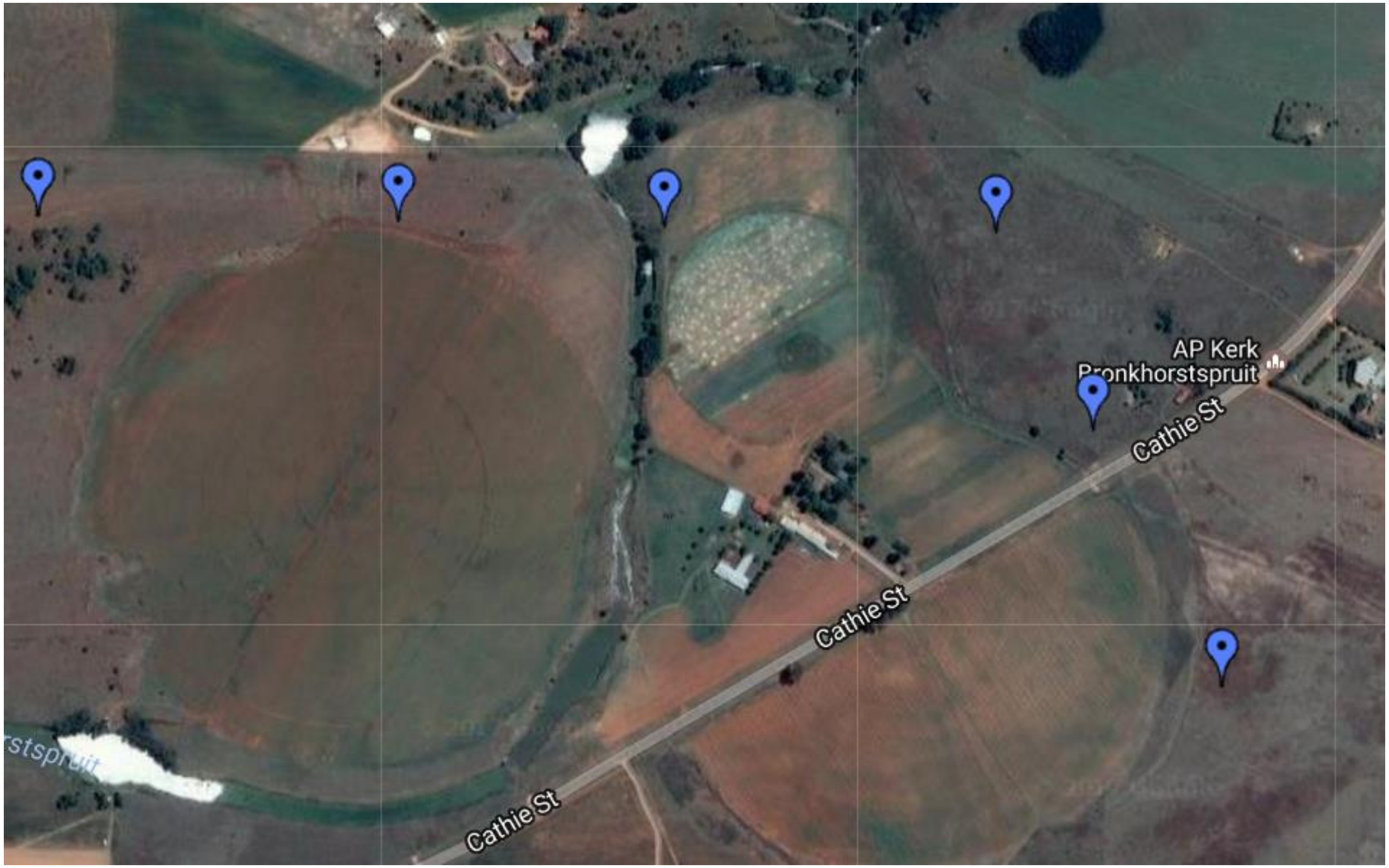
The biggest risk is a possible contact incident while pulling pipes from a borehole for maintenance or replacement, but in most cases, farmers don’t use large cranes to work on wind mills. A method statement or safe work procedure should be drafted and maintained to ensure safe practice is implemented.

Windmills are usually well earthed with metallic frames and pipes touching the water in the borehole.

# Power line and Pivot Irrigation

Power lines usually goes around center pivots, but in some cases may pass over the side of a land.

As long as sufficient electrical clearance is maintained, the risk is relatively low.



# Power line and Farm Feed Lot

Power lines cross over farm feedlots on occasion.

Wordlwide, research conducted into this topic did not reach conclusive arguments point at power lines as an adverse affect on live stock (e.g. Manitoba Hydro)

Livestock, most systematically cattle, were the focus of both observational and experimental EMF research. Farm surveys and observational studies of grazing cattle conducted near 765-kV and 400-kV transmission lines reported no consistent differences in behavior, fertility, or productivity between animals near or farther away from the lines (Busby et al., 1974; Ware, 1974; Amstutz and Miller, 1980; Algers et al., 1982; Hennichs, 1982; Algers and Hennichs, 1985; Algers and Hultgren, 1986, 1987). A series of controlled experiments to evaluate potential effects of EMF exposure on various physiological parameters of dairy cattle were conducted by Canadian researchers (e.g., Rodriguez et al., 2002, 2003, 2004; Burchard et al., 2003, 2004, 2007). Electric-field exposures up to 10 kV/m and magnetic-field exposures up to 300 mG were used in the experiments that evaluated measures of reproductive function (e.g., estrus cycle and gestational hormone levels), quality and quantity of milk production, feed intake, and various hormone levels. While some variability between exposed and control cows was observed in some of the examined parameters, these differences were typically within a few percent and were within physiological ranges. Overall, no consistent differences between exposed and unexposed animals were observed in various measures of milk yield, hormone concentrations, and other parameters. As the authors concluded in one of their papers, "[t]he absence of abnormal clinical signs and the absolute magnitude of the significant changes detected during MF [magnetic field] exposure, make it plausible to preclude any major animal health hazard" (Burchard et al., 2007, p. 471).

# Industry Perspective / Interaction

OHS Act

SANS10280

Eskom Fault Duration Study (S Ramadhin 2016)

Corrosion Institute – Guideline for Powerlines and Pipelines (Sasol, Rand Water, DWS, Joburg Water)

Transnet, Metropolitan Utilities etc

# Thank you