NS214
Guide to Live Line Design Principles

November 2008

Amendments: NSA1638 Apr 2012

SUMMARY

Network Standard NS214 applies to the design of overhead mains to facilitate the use of HV Live Line techniques.

ISSUE

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1 Scope

This guideline applies to the design of overhead mains to facilitate the use of HV Live Line techniques.

2 Definitions

ABC	Aerial Bundled Conductor
CCT	Covered Conductor Thick
EWP	Elevating Work Platform
EHV	Extra High Voltage
HAZOP	Hazard and Operability study - a technique to identify potential hazards and operating issues with the design and construction of equipment and plant.
HV	High Voltage
LV	Low Voltage
HV Live Line work	Work performed on on overhead HV mains and apparatus, whilst they are alive, utilising either hot stick method which uses insulating sticks, insulating barriers and tools or the glove and barrier method. All HV live line work must be carried out by certified persons who hold a current Live Line Authorisation.

3 References

- NS125 – Specification for LV Overhead Conductors
- NS126 – Specification for Design and Construction of High Voltage Overhead Mains
- NS135 – Specification for the Design and Construction of Overhead Sub-Transmission Lines
- Ausgrid's Electrical Safety Rules
- Draft AS 1418.10-2008 Cranes Hoists and Winches – Elevating Work Platforms
- ENA C(b)1 Guidelines for Design and Maintenance of Overhead Distribution and Transmission Lines

4 Live Line Design Principles

4.1 General

The following factors should be taken into account by designers of overhead mains. The designer must balance these issues with construction costs, Ausgrid Network Standards (NS125, NS126, NS135, etc) and the job specific Design Information as issued by the local Ausgrid office.

4.2 Ferro Resonance, Ferranti Effect and Induction Hazards

Ferro Resonance is a phenomenon that occurs typically when single phase switching is carried out on a transformer that is supplied by a long length of underground cable, or overhead mains under light load conditions, and can cause potentially destructive over-voltages (up to five times system voltage).

The Ferranti Effect is a phenomenon that affects long transmission lines which draw a substantial quantity of charging current. If such a line is open circuited or very lightly loaded at the receiving end, the voltage at the receiving end may become greater than the voltage at sending end (up to twice system voltage). It is due to the voltage drop across the line inductance (due to charging current) being in phase with the sending end voltages.

Magnetic Field HV Induction refers to the way the magnetic fields associated with heavily loaded overhead lines can induce currents and create hazardous voltages in other nearby lines which run parallel to it.

Electric Field HV Induction refers to the way the electric fields associated with capacitively coupled HV overhead lines can create hazardous voltages in other nearby lines which run parallel to it or on metallic objects in the intervening air gap.

Backflash arises when a localised earth surge voltage appears and flashes over to energised conductors to reach remote earth. This arises in thunderstorms and/or in severe EHV switching surges, in places such as near EHV Feeder undercrossings.

These phenomena should always be avoided because of the potentially hazardous situations they create and the damage they can cause. This is particularly so where HV Live Line work is carried out. Designers should be careful to avoid designing lines with conditions which will lead to the above phenomena.

4.3 Separation Between LV and HV Mains

Network Standard NS126 calls for the following with regard to vertical separations between LV and HV mains:

- In areas where the 11kV network cannot be worked on using Live Line techniques, the separation between the CCT or bare HV mains and LV ABC or LV bare conductors should normally be a minimum 1200 mm.
- In areas where the 11kV network can be worked on using Live Line techniques the minimum separation between CCT or bare HV mains and LV ABC or LV bare conductors shall be 2500 mm to facilitate HV Live Line works.
- The separation to be used for any particular project shall be nominated by the local Ausgrid Live-Line service provider.

Where Live Line work can be carried out, the larger separation between HV and LV is necessary to permit typical EWP baskets [that are compliant with ISSC 25 1995 or AS1418.10(Int)-2004] to pass between the HV and LV mains, saving repositioning time for the EWP on both sides of the pole.

Although the separation between energized conductors can often be temporarily increased to facilitate HV Live Line work, by the use of HV Live Line Sticks and /or insulated cranes, the feasibility and cost effectiveness is limited at lower voltages and closer dressed clearances. Alternatively, the use of HV Live Line Bypass cable techniques can afford a temporary isolation opportunity.

The ability of Live Line crews to manoeuvre EWPs is constrained by the availability of appropriately tested insulation other Live Line equipment necessary to maintain Minimum Approach Distances (MAD), as required in Ausgrid's Electrical Safety Rules.

For Live Line work by Stick & Barrier or Glove & Barrier Methods, EWPs are fitted with HV insulation bucket inserts and chassis insulators, which are useful for controlling risks associated with inadvertent contact with live parts. Live Line crews using Glove & Barrier Method rely on this insulation and planned EWP movements to maintain set clearances in air. Lower voltage conductors and earthed structures, such as poles and crossarms, must have appropriate HV Live Line tested insulation applied, prior to any HV Live Line work being carried out.

Before commencing the design of any overhead mains the designer must liaise with Ausgrid's local Live Line service provider to determine whether Live Line separations are required, and design the line accordingly.

4.4 Pole Replacements

Subject to the live mains being able to be safely supported throughout, Live Line techniques can generally be used to replace in-line poles, with the new pole being installed in the same hole from which the old pole is removed. However differences between the old and new pole height and/or the pole-top construction type used impact on the ability to use Live Line techniques.

The use of Live Line techniques to replace angle poles is dependant upon mechanical loading calculations. Designers should calculate the design loadings in anticipation of the potential use of Live Line techniques.

The designer may also consider the position of the new pole such that the mechanical loading of conductors is eased and to avoid the need for additional conductor length during the changeover. Attention should also be given to positioning the new pole such that the Live Line EWP is able to be positioned so the Live Line crew can stay aloft and out of the unexpected collapse direction hazard zone.

4.5 Conductor Replacements

Provided the old conductor and associated connections are in good condition, Live Line techniques can be used to minimise the supply outage times associated with conductor replacement projects. Prior to any outages, it is possible to install conductor rollers, supported on existing pin insulators. The old conductor can be used as a draw rope for the new conductor. The new conductor must be installed under de-energised conditions, however Live Line techniques can be used to install permanent bonds, tie-offs, conductor ties, etc, and to remove rollers.

Before such techniques are used, however, it is necessary to check that the existing pole loadings are checked for dynamic tensioning (i.e. pre-stretch 10% over, etc).

It is also possible to replace LV conductors under energised HV conductors but only after a thorough risk assessment including assessment of conductor flashover risk.

4.6 Live Line Worksites within 30m of HV Surge Diverters

Porcelain or polymeric surge diverters **must not** be installed or removed from service using live line techniques: that is, it is **not acceptable** for Live Line lineworkers to be within 30m of any new surge diverters whilst they are being commissioned.

For this reason designers should allow for switching points, either permanent or HV Live Line temporary, at least 30m distant from any new untested surge diverters.

Particular attention should be given to surge diverters at CCT/Bare Conductor interfaces and at UG/OH poles.

4.7 HV Parallel Circuits

HV Live Line crews need to be made aware of situations where HV parallel circuits are utilised, since it is important that checks be made that conductor/connection ratings are adequate for the way load currents are shared in all three phases of all parallel circuits. This is particularly important in situations where the rectification of high resistance joints may be involved. The checks are made through directly measuring HV currents, or through thermal measurements of connections in the proximity of the worksite.

When designing HV parallel circuits, the arcing fault energy let-through (fault clearing time * (fault current)*2) must be minimised. It should be noted that for parallel circuits, the fault clearing time is often faster and fault currents are higher, than for non-parallel arrangements. Phase to earth faults are of primary concern, as HV Live Line crews generally work on only one phase at a time, with other circuits and phases being covered, separated and mechanically secured.

4.8 Ergonomic and Apparatus Handling Limits

Designers must take into account the safe weight lifting limits for lineworkers including the affects of leverage when HV Live Line stick work is involved.

Consideration should also be given to pole placement where conductor bridges and bonds may be excessively long, which can render the particular construction or maintenance job beyond the scope of HV Live Line techniques or necessitate the use of more time-consuming and expensive Live Line techniques than would otherwise be necessary. For example, the length of necessary bridges/bonds should be limited to those which are compatible with the standard HV Live Line Bypass Cables, etc - it should be noted that at 66kV the use of Live Line stick methods limit the length of bridges/bonds to 2m. Similarly the calculated weight of conductors to be moved by HV Live Line techniques can dictate the range of procedures which can be used, and if the conductor movement loading is too high the available techniques are limited and may add to the time and effort to achieve the intended result. Careful consideration of these issues at the design stage can significantly improve efficiencies.

4.9 Fault Levels

Network configuration/switching arrangements can greatly influence the fault level at any particular Live Line work-site and consequently the safety and feasibility of carrying out Live Line work. The impact of Live Line work-site incidents can be significantly reduced through lower fault levels. In the case of through-faults, higher fault levels (which generally exist in urban areas) can cause problems at Live Line work sites where the resulting violent conductor movements can dislodge conductors and temporary insulation i.e. mechanical and insulation “bucking-off” risks.

Such risks can be minimised through the careful selection of network configuration/switching arrangements which result in lowest prospective fault currents. For example: arranging for the network to be supplied from only one power transformer rather than two operating in parallel.

4.10 Earth Potentials

Placement of additional earth planes, such as a street lights and riser brackets, on same poles which also carry HV mains, can limit the use of HV Live Line procedures on that pole.

4.11 Whole-of-Life Asset Costs and Site Specific Issues

If new network apparatus are intended to be maintained throughout its life utilising HV Live Line techniques, the compatibility of the apparatus and available Live Line techniques must be assessed early in the design phase.

Some apparatus choices may not be as appropriate for HV Live Line techniques as some others, both in short term and longer term based on service life span. For example two pole mounted 66kV ABS are not erectable by HV Live Line techniques, and if installed on timber poles and timber crossarms, warping of the timber with time, will necessitate adjustment of the contacts, with outages on both sides of the 66kV ABS; by contrast a single pole mount switch can be both installed and maintained using Live Line techniques, and its installation using metal crossarm would prevent warping and help minimise the need for ongoing adjustments.

Similarly, if a requirement of a specific installation is that it must be maintained throughout its life using Live Line techniques then careful consideration must be given at the design stage to selecting apparatus that is appropriate.

The risk of mechanical failure of energised HV conductors or conductor connections must be controlled and avoided at all times. This includes bare, covered or insulated conductor bridges which must not be bent beyond their minimum bending radii at any time, to avoid failures through work-hardening/ fatigue. The flexibility of bridges etc. must therefore be compatible with the Live Line working methods which may be used.

4.12 Direct Liaison with Live Line Crews

The HV LL Manual provides for rehearsal and audit review mechanisms for ongoing innovation and improvement of HV Live Line techniques and procedures

Wherever doubt exists regarding designs that facilitate the use of Live Line techniques, direct liaison with Live Line crews and/or other experienced staff should not be overlooked; i.e. when in doubt – ask!

4.13 HV Live Line Commissioning of HV Network Assets

Before commissioning any new HV network assets using HV Live Line techniques, the assets should be pressure tested as a pre-commissioning HV stress check, particularly when HV Live Line personnel are working in close proximity to the new assets.

Ideally, such pre-commissioning tests should be carried out close to the time and place where the Live Line commissioning is taking place. However, depending upon the HV asset equipment type and the degree of handling necessary to transport the equipment to site such HV pre-commissioning tests may be carried out at location remote from the worksite prior to installation. Such testing may include Factory Acceptance Tests (FATs). In all instances, the asset must be carefully secured and delivered to site and once on site the asset need only be subject to visual checks.

It should be noted that HV Live Line crews routinely carry out HAZOP visual inspection and/or test, as appropriate, new HV assets intended for live line installation if not tested prior.

For safety reasons some untested new assets may not be able to be connected and commissioned when in close proximity to HV Live Line crews.

Revision History	
Initial issue:	18/11/2008
Last issue:	
Current issue:	

Document Control	
Authorised By: Terry Lampard	Date: 18/11/2008
Manager - Standards & Communications	
Document Number:	NS214