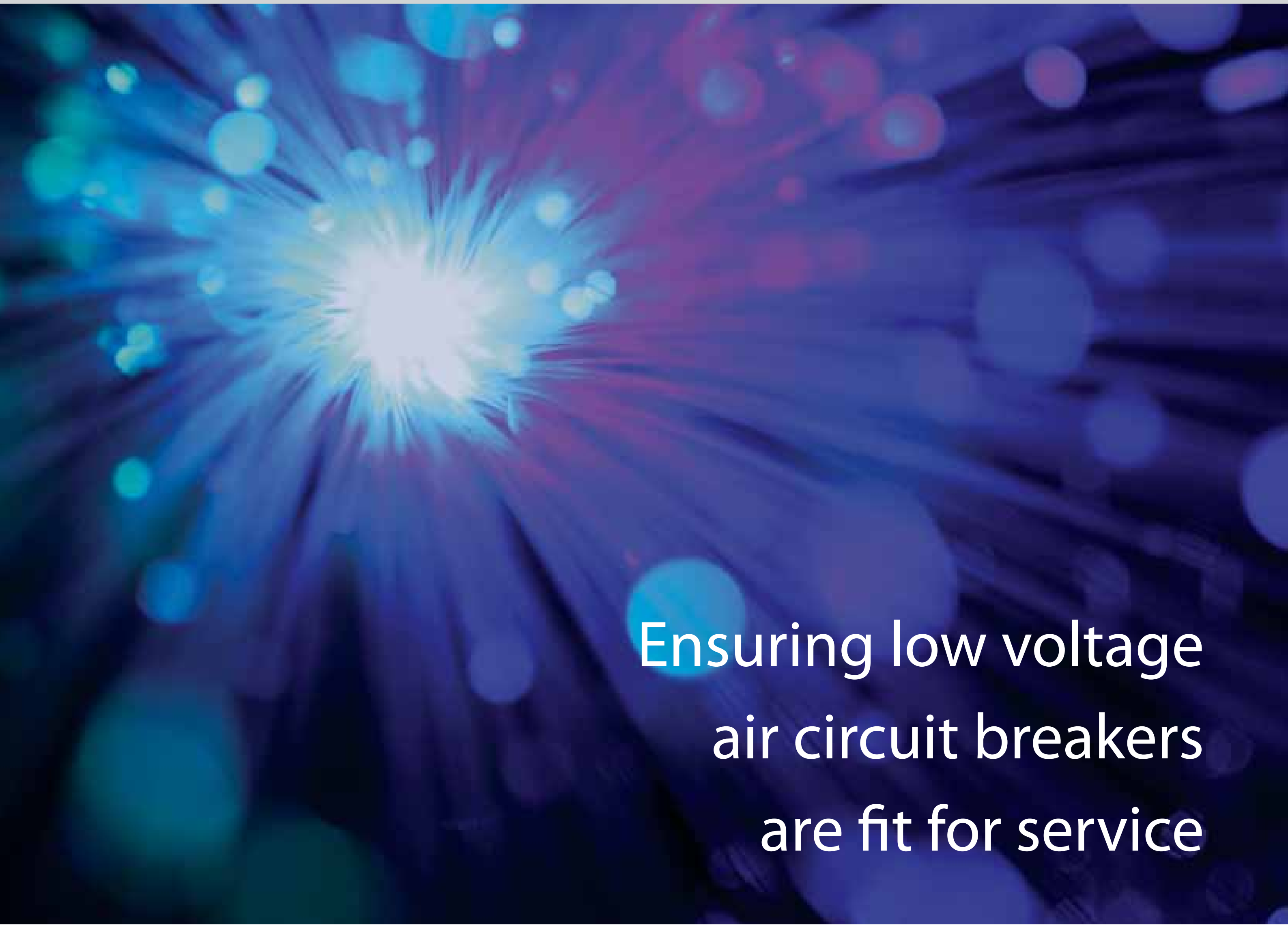
Issue #61 - October 2011

Technical News

INDUSTRIAL ELECTRICAL AND AUTOMATION PRODUCTS, SYSTEMS AND SOLUTIONS



Ensuring low voltage air circuit breakers are fit for service

Written by Nicholas Burley
Business Manager - Power Distribution

PLEASE CIRCULATE TO:

Air circuit breakers are common place in low voltage (LV) switchboards. Due to their typically passive operation they are a piece of equipment that is often forgotten about until there is a trip or circuit breaker failure leading to a power supply disruption. Importantly, many low voltage switchboards in service today are being protected by air circuit breakers that have been in operation for twenty, thirty or even forty years.

To ensure on-going power supply integrity and to improve safety for those working within the vicinity of low voltage switch gear such as air circuit breakers six criteria, should be considered;

1) Appropriate circuit breaker commissioning and documentation;

2) Periodic review of protection settings;

3) On-going end user practical training;

4) Through life service requirement;

5) Retrofit options for air circuit breakers;

6) Utilisation of new technology to improve switchboard safety.

INTRODUCTION

Air circuit breakers (ACBs) are a special type of switchgear that are typically used as a main switch, outgoing feeder and bus-tie switch within switchboards (refer figure 1.0). Continuous current ratings for ACBs range from 800A up to 6300A and they can typically weigh between 50 to 180kgs. Robustness and mechanical strength are key attributes of a high performance ACB as they are designed to withstand the extreme thermal stress and mechanical forces generated under a short circuit condition.

Switchboards and the installed switchgear must be capable of functioning under varying operational and environmental conditions and withstanding damage associated with electrical faults. An ACB is a key component of any large scale low voltage (LV)network and while they normally lead a dormant life their ability to clear a range of electrical faults at any given moment is of high importance.

It is common to find legacy LV switchboards containing operating switchgear that has reached the end of its service life and in many cases it is working beyond it! Apart from the increased risk of failure to clear short circuit currents, aging ACBs commonly exhibit functional defects such as:

- Inability to manually open or close
- Cluster and main contacts overheating
- Burning out of accessories such as shunt open coils and charging motors
- Degradation of insulation on 'live' and 'earthed' components.

The consequence of a low level ACB trip can lead to a simple loss of supply power which normally can be restored after a qualified person (usually an engineer or electrician) has deemed it safe to do so.

In contrast, equipment failure is far more significant as it can result in major loss of production, safety issues for workers, lengthy shut downs and complicated insurance claims. Industries such as mining and large scale manufacturing often face the dilemma of balancing a minimum number of 'production shut downs' for maintenance while not neglecting the servicing requirements of key devices such as ACBs.

By understanding the process of managing new and legacy ACBs it is possible for facilities managers and site engineers to apply a set of criteria which together help to form a plan underpinning workplace safety, uninterrupted production and equipment dependability.

CRITERIA 1: APPROPRIATE CIRCUIT BREAKER COMMISSIONING AND DOCUMENTATION

Commissioning is an essential process for any newly installed ACB as it allows on-site engineers to formally document and test the ACB's trip protection settings, check that the ACB is damage free and confirm it is fit for service. At the most basic level, ACB commissioning should include:

- Confirmation that a full test report has been supplied by the ACB manufacturer, showing serial numbers and protection settings;
- Visual confirmation of protection settings;
- Confirm the on-site wiring diagrams and single line diagrams (SLDs) are correct;
- Confirmation of accessory functionality (i.e. charging motors, shunt coils etc) at applicable voltages;
- Unit not damaged and free of dirt / contaminates.

Trip protection settings should be a primary focus for commissioning engineers. Whether commissioning a new ACB, or re-evaluating an existing unit, consideration must be given to the overload and short circuit protection characteristics.

ACBs typically built within the last thirty years will feature an integrated trip unit, commonly referred to as an over-current release, or OCR. The OCR allows the setting of overload and short circuit trip pickup levels and intentional time delays (refer figure 2.0).

Overload and short circuit settings should be configured to achieve two objectives;

1) During a fault it is necessary to protect downstream conductors against overheating and mechanical damage.

2) It is also necessary to provide 'reliability of supply' or 'selectivity' with upstream and downstream devices in accordance with AS/NZ3000:2007.

Appling AS/NZS 3000 – 2.5.7.2.3, in conjunction with OCR trip curves (refer figure 2.0) engineering consultants can undertake the necessary selectivity analysis to determine suitable settings. Furthermore AS/NZS 3000, clause 2.5.5, defines the process to set the OCR to limit the harmful effects of a switchboard internal arcing fault. However, it appears to be a growing trend where many new switchboard installations are commissioned without adequate time being devoted to determining the 'best' OCR protection settings for the power reticulation system.

Careful consideration of these settings provides the best level of protection for the switchboard and the conductors connected to the ACB, which increases the level of safety for anyone working within the local area.

Circuit breaker manufacturers recommend that OCR trip setting adjustment be confirmed via a calibrated secondary injection (S.I.) test device (refer figure 2.1).

Secondary injection testing kits typically consist of a hand held device made by the circuit breaker manufacturer specifically for use with their ACB. A S.I. test proves that the trip pick up points and protection curve tolerances are within specification.

Circuit breaker manufacturers can provide end users with blank test forms / software and a written test method. Documentation of the test results, including relevant identifying information such as ACB serial numbers and switchboard cell names should be included on the test forms.

Figure 1.0: Modern Low voltage Air Circuit Breaker

CRITERIA 2: PERIODIC REVIEW OF PROTECTION SETTINGS;

Over time, the structure of the incoming supply and the outgoing loads may change. For example, a supply transformer may be upgraded, or additional loads may be added to the outgoing circuits. It is important to review the tripping characteristics of affected ACBs in order to achieve the desired outcomes described in Criteria 1. Adjustments should be verified as per the ACB manufacturer's recommendations and documentation should be updated.

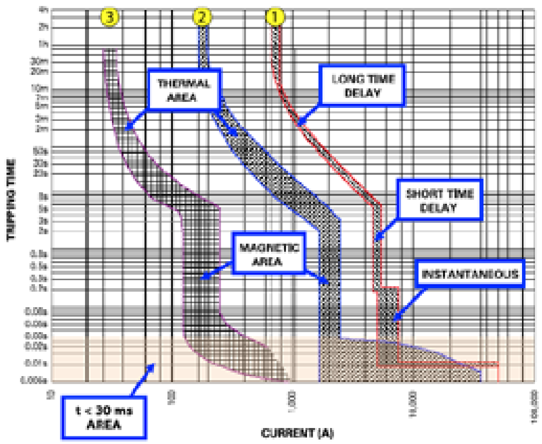


Figure 2.0: OCR trip curves used in a selectivity study.

Figure 2.1: An OCR and secondary injection tester.

CRITERIA 3: ON-GOING END USER PRACTICAL TRAINING;

Documented ACB handling, operating and troubleshooting procedures should be provided to 'on-site' equipment operators and maintenance workers. While this is a constant challenge for many workplaces, electrical site supervisors need to ensure that workers are fully prepared to interact with the installed switchgear confidently and safely. It is reasonable to conclude that equipment operators and maintainers should insist on a structured, ongoing training program for all on-site switchgear. Switchgear manufacturers will often supply documented procedures relating to transportation, handling, operation and troubleshooting of the device.

Training sessions which display the switchgear and explain the manufacturers documented procedures ensures the best level of learning outcomes are achieved. Safety standards can be maintained or improved.

Product training can often be enhanced by involving the equipment supplier (refer figure 3.0). Suppliers are usually keen to provide training material and demonstration samples to customers. This provides them with the opportunity to highlight the products key features, answer any questions and therefore leave the trainees feeling confident with the product.

Figure 3: NHP ACB demonstration and training.

CRITERIA 4: THROUGH LIFE SERVICE REQUIREMENTS;

Often once closed, ACBs will remain totally inactive year after year. The truth of the matter is that occasional 'exercise' helps to maintain the correct operation of the ACB's breaking mechanism and contact assembly. Many circuit breaker manufacturers recommend that end users perform five off load open and close operations during a shutdown every six months. This simple procedure helps re-distribute lubrication between the moving internal parts, particularly in modern ACBs between the finger clusters and the pivot point of the fixed contact (refer figure 4.0).

Like all electro-mechanical devices that are subjected to heat and in some cases arduous environmental conditions, ACBs need service and maintenance typically every two to three years. Most circuit breaker manufacturers will supply general servicing requirements for the ACB.

However, due to the inherent complexity of modern trip mechanisms and the high degree of electronics contained within the ACBs OCR and accessories, seeking out a third party service company that has been accredited by the ACB manufacturer is advisable.

Poorly maintained ACBs can lead to catastrophic product failure during operation, fires within switchboards or injury to human operators if working within close proximity to the device. The consequence of this type of failure can be lost production and significant downtime, costly repairs, and / or financial penalties from government safety authorities if on-site personnel are injured.

Regular documented maintenance not only ensures that the ACB is fit and safe for service, but in the event of an insurance claim due to an electrical fault, site managers can refer to past service reports to demonstrate that steps had been taken to keep the ACBs in good working order.

Servicing of ACBs should always include;

1) Removal of dirt and contaminates;

2) Restoring resistance of main contact to within specification and undertake insulation strength test;

3) Check operation of tripping and latching levers;

4) High temperature grade grease to be applied to finger clusters;

5) Test accessories (ie. Shunt coils, motors etc) at specified minimum and maximum rated voltages;

6) Secondary injection test of OCR and trip circuit;

7) Primary injection test of OCR and CT circuit.

All results should be fully documented.

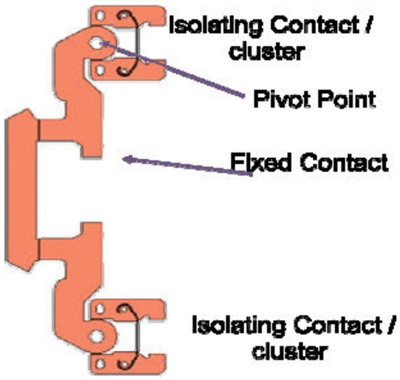


Figure 4.0: Terasaki AR ACBs have a unique 'double break' contact mechanism as shown above.

Figure 4.1: Service engineer inspecting an ACB.

CRITERIA 5: RETROFIT OPTIONS FOR AIR CIRCUIT BREAKERS

Problems with aging ACBs are typically mechanical in nature. 'Failure to open or close', 'finger clusters suffering heat stress', 'the integral trip unit is out of calibration' are typical issues with legacy ACBs. Often replacement parts are no longer manufactured or the cost of employing specialist maintenance tradesmen to provide a 'bandaid' repair is prohibitive. Throughout the 1960's, 70's and 80's in Australia, ACBs from manufacturers such as the Nilsen (refer figure 5.0), UNELEC / CROMPTON PARKINSON and the WESTINGHOUSE (refer figure 5.1) along with many other types were installed in a plethora of industrial and commercial developments.

Many of these ACB which are still installed today are operating beyond their intended service life. As previously described, the consequence of ACB failure can be financially costly and potentially dangerous to people. To help address this issue, some circuit breaker manufacturers and smaller specialist third party companies have devised 'retro-fit kit' solutions which allow end users to modernise their ACBs (refer figure 5.2) with minimal downtime.

Retro-fit kits are designed to allow the existing switchboard to remain fundamentally unchanged, with only the obsolete ACB being replaced. Existing busbars and cables remain unaltered, therefore simplifying the installation process and reducing downtime.

Retro-fitting ACBs in the method described above is generally considered 'switchboard maintenance'. Providing the retro-fit kit has been designed with relevant Australian standards in mind and recognised industrial practices, the use of such kits can lead to the controlled removal of ACBs that are obsolete and potentially dangerous.

Figure 5.0: Obsolete NILSEN ACB

Figure 5.1: Obsolete Westinghouse LA50 ACB

Figure 5.2: Modern new Terasaki ACB

CRITERIA 6: UTILISATION OF NEW TECHNOLOGY TO IMPROVE SWITCHBOARD SAFETY

Modern ACBs and complementary protection relays compared to their predecessors provide a greater range of performance features that can bolster overall switchboard longevity and safety. Minimising the damage caused by 'arc faults' is a topic under frequent discussion within many large scale industrial workplaces.

One technology that is gaining support within the mining and manufacturing sectors is the 'arc detect' relay (refer figure 6.1). Arc detect relays use a network of fibre optic sensors (refer figure 6.2) distributed throughout the switchboard which respond to sudden changes in light intensity caused by the ignition of an electric arc.

The arc detect relay responds to this event by closing an internal alarm contact which can be used to trigger the shunt trip coil of an incoming ACB. This type of technology including the relay and the fibre optic sensors lend themselves to retro-fit applications as they can easily be installed at the same time as the new ACB. By combining arc detect relay technology with a modern super fast tripping ACB it is possible to dramatically reduce the amount of energy released by the arc fault, therefore minimising the level of damage to the switchboard and lowering the risk of personal injury to electrical maintenance workers.

Industrial automation is another area that can assist in improving the safety of switchgear and switchboards. A Human Machine Interface or HMI is generally understood to be a touch screen / display with an imbedded PLC that can run software to perform tasks. Traditionally this form of technology would be supplied by automation gurus or Systems Integrators (SIs).

Many circuit breaker manufacturers however are now producing HMI based systems for the purpose of monitoring and controlling their ACBs within switchboards. Typically using communications protocols such as MODBUS RTU, HMI's allow the user to clearly interrogate the ACBs, revealing all relevant details such as close or tripped status, current, voltage, power parameters and trip history logs. Furthermore complete open / close control is normally possible. Safety of workers is greatly improved because the HMI can be situated outside the switch room providing complete separation.

Figure 6.1: Arc detect relay

Figure 6.2: Arc detect fibre optic sensor

SUMMARY

Low voltage air circuit breakers are a vital component in industrial power systems. Often they lead uneventful lives but during an electrical fault they may be required to respond, clearing the fault quickly and safely to minimise damage to the power reticulation system.

ACBs are highly engineered, complex devices that require careful handling by users and regular maintenance is necessary to ensure longevity and reliability. Poorly maintained ACBs can catastrophically fail during operation resulting in loss of production and significant down time, costly repairs and injury to maintenance workers.

Modern ACBs can in many cases be easily retro-fitted into existing switchboard to replace obsolete models, and when combined with contemporary arc fault protection relays and HMI solutions, substantial value to the integrity and safety of the switchboard can be achieved.

If you would like previous copies of Technical News, please complete the following form and **fax to NHP on (03) 9429 1075** to the attention of the **Marketing Department**.

Name: .... Title: .... Company: ....

☐ **Please post to:** address ....

....

Telephone: (   ) .... Fax: (   ) ....

☐ **Please email to:** ....

Other issues currently available.

Please tick those you would like to receive.

- ☐ 1. First edition (Latched and delayed contactors)
- ☐ 2. Non-standard contactor applications (Parallel and series connections of contacts varying frequencies)
- ☐ 3. Contactor failure (Reasons for the failure)
- ☐ 4. Soft start for generator loads (Advantages of electronic soft starters)
- ☐ 5. Set the protection (MCCB breakers and application)
- ☐ 6. Contactor operating speed (Difference between AC and DC systems)
- ☐ 7. Quick guide to fault levels (Calculating the approximate fault levels)
- ☐ 8. IP ratings what do they mean? (IP Ratings, use and meaning)
- ☐ 9. Utilisation categories (Electrical life of switches)
- ☐ 10. AC variable frequency drives and breaking (Regenerative energy)
- ☐ 11.Don't forget the motor protection (Motor protection devices and application)
- ☐ 12. Electrical life of contactors (How and why contactors are tested)
- ☐ 13. Liquid resistance starter developments (For large slipring motors)
- ☐ 14. Taking the 'hiss' out of DC switching (DC switching principles)
- ☐ 15. Start in the correct gear (Application of different motor starters)
- ☐ 16. Application guide to lamp selection (Industrial pushbutton controls)
- ☐ 17. Electrical surges can be expensive (Electrical surges)
- ☐ 18. Putting the PLC in control (advantages of the PLC)
- ☐ 19. The thinking contactor (The development of the contactor)
- ☐ 20. Some don't like it hot (Temperature rise in electrical switchgear)
- ☐ 21. Pollution of the airwaves (Unwanted signals and their effects on motor protection devices)
- ☐ 22. What's different about safety? (Safety devices and their application)
- ☐ 23. Talk about torque (Motors and torque)
- ☐ 24. Power factor what is it? (Power factor and correction equipment)
- ☐ 25. Terminations, good or bad? (Terminals)
- ☐ 26. RCDs are saving lives (Earth leakage protection; RCDs)
- ☐ 27. The quality switchboard(Switchgear and protection devices for Switchboards)
- ☐ 28. How does electrical equipment rate (Understanding ratings of electrical equipment)
- ☐ 29. EMC - what's all the noise about (Understanding EMC)
- ☐ 30. Controlling high short circuit currents with current limiting circuit breakers (Short circuit co-ordination KT 7)
- ☐ 31. Another step in electrical safety (Changes to electrical safety)
- ☐ 32. Keep your cables cool (New requirements on cable protection)
- ☐ 33. A leak to earth can be electric (RCDs)
- ☐ 34. Keep Cool (Derating)
- ☐ 35. Improving star-delta protection (Overload and short circuit protection)
- ☐ 36. Does your CT measure up? (Selecting the correct current transformer)
- ☐ 37. Is your copper flexible? (Flexible busbars)
- ☐ 38. Where did the 10 volts go? (World uniform voltages)
- ☐ 39. Motor protection and wiring rules (overload protection)
- ☐ 40. Confused about which RCD you should be choosing?
- ☐ 41. Circuit breakers working together
- ☐ 42. Keeping in contact
- ☐ 43. Is your switchboard in good form?
- ☐ 44. Automation in a technological world
- ☐ 45. Thermal simulation of switchgear
- ☐ 46. Cable Considerations
- ☐ 47. Output chokes for use with variable speed drives
- ☐ 48. VSD Installation Techniques
- ☐ 49. The modern Scada System
- ☐ 50. 50th Edition Special
- ☐ 51. Electrical design considerations for commercial buildings
- ☐ 52. Terminal temperatures - how hot are they?
- ☐ 53. Causes of premature failure
- ☐ 54. Control voltages for contactors
- ☐ 55. Will it turn you off? (Electrical switchgear welding)
- ☐ 56. Electrical Arcs - Beauty and the Beast
- ☐ 57. The Power of Copper
- ☐ 58. Industrial networking with Ethernet IP

TNL is available as a download from NHP's Online Resource Centre (ORC), visit **nhp-online.com.au.** The ORC provides members with up-to-the-minute technical information and powerful product tools, all at the click of a mouse button. Register for membership today!

Editorial content: Please address all enquiries to: The Editor - 'NHP Technical News' PO Box 199, Richmond, Victoria, 3121.

NHP Electrical Engineering Products Pty Ltd

A.B.N. 84 004 304 812

NTNL61AUS 1011

AUSTRALIA
nhp.com.au
1300 NHP NHP

VICTORIA
Melbourne
+61 3 9429 2999
Laverton
+61 3 9368 2901
Albury/Wodonga
+61 2 6049 0600
Dandenong
+61 3 8773 6400

TASMANIA
Hobart
+61 3 6228 9575
Launceston
+61 3 6345 2600

NEW SOUTH WALES
Sydney *
+61 2 9748 3444
Newcastle *
+61 2 4960 2220
Wollongong *
+ 61 2 4272 5763

ACT
Canberra
+61 2 6280 9888

QUEENSLAND
Brisbane *
+61 7 3909 4999
Townsville
+61 7 4779 0700
Rockhampton
+61 7 4927 2277
Toowoomba *
+61 7 4634 4799
Cairns
+61 7 4035 6888

SOUTH AUSTRALIA
Adelaide
+61 8 8297 9055

WESTERN AUSTRALIA
Perth
+61 8 9277 1777

NORTHERN TERRITORY
Darwin
+61 8 8947 2666

NEW ZEALAND
nhp-nz.com
0800 NHP NHP
Auckland
+64 9 276 1967
Hamilton
+64 7 849 0257
Napier
+64 6 843 6928
New Plymouth
+64 800 NHP NHP
Wellington
+64 4 570 0634
Christchurch
+64 3 377 4407