Ampcontrol Mobile Switchroom Arc Fault Vent Type Testing

Mackay Qld

May-June 2014

Revision 1.1

REVISION HISTORY

Revision No.	Prepared	Reviewed	Authorised	Date
0.1	Ian Webster	Jemima Jackson	-	25/06/2014
1.0	Ian Webster	Andrew Cockbain	Ian Webster	26/06/2014
1.1	Ian Webster			11/07/2014

Disclaimer

This document provides general information only and cannot be relied upon as providing specific advice.

The location of arc vent covers on individual enclosures is critical to ensuring that the resulting system is as safe as reasonably practicable.

In general terms, the covers should be placed so as to ensure that all personnel are away from direct exposure to the exhausted arc flash gases while still enabling efficient operation of the covers.

The particular location of vent covers in the enclosure described in this report was selected for experimental and documentational efficiency. Personnel safety was ensured by evacuation during all testing.

Adopters of the technology must conduct their own assessments of vent placement, taking into account the unique operational environment for the particular enclosure, commensurate with the particular adopter's safe work practices.

INTRODUCTION

Ampcontrol conducted a program of arc fault vent testing at its Mackay Qld facilities between 28 April and 8 May 2014.

The program involved 18 separate tests verifying the ability of Ampcontrol's arc fault venting system to protect a standard mobile switchroom. The testing culminated in a public demonstration of the venting system to protect the switchroom from failure by over-pressurisation that results from an internal arc fault.

OBJECTIVE

The objective of the program of testing was to verify that the fitting of an engineered arc fault vent solution will protect an electrical enclosure from catastrophic failure in the case of an internal arc fault.

In this instance, the particular enclosure under test was Ampcontrol Qld's standard mobile switchroom – see Figure 1. The evaluation included both the integrity of the HV switchroom and the adjacent operator control room.

The primary criteria to be evaluated were:

- the ability of the enclosure to withstand the pressurisation associated with the onset of an arc fault without releasing arc products through seams or joints
- no projectiles to be released through parts or fittings becoming detached
- all doors latches and fittings to remain fixed or closed
- the switchroom as a safe environment for operators without the need to wear PPE

Figure 1: General configuration Ampcontrol Qld mobile switchroom.

METHOD

For the purposes of arc vent design and testing of a given enclosure and specified fault level, it is necessary to consider the pressure versus time characteristic impacting the enclosure.

The pressurisation associated with an arc fault of known magnitude in a given volume has been characterised in ACARP PROJECT C4032 report. In general, the internal enclosure pressure rises linearly with time until the energy source (the arc) is extinguished, or pressure is relieved by venting of the enclosure.

If the venting aperture is correctly designed (that is, of sufficient area to exhaust arc products at the rate of generation), then it is necessary only to consider the enclosure pressure for sufficient time for the vent to fully open to atmosphere.

Ampcontrol has developed a method of replicating the pressure rise due to an arc fault in a given enclosure using ‘energetic materials’. Using this method, arc faults can be simulated without the need for connection to electrical test power supplies. Figure 2 shows the energetic materials being installed in the HV room of a mobile switchroom.

Figure 2: Energetic materials used to generate pressure rise simulating nominated arc fault level.

Ampcontrol has previously developed an arc fault vent cover constructed of composite materials for use in conjunction with IP55 enclosures. Figure 3 shows a vent and cover fitted to a test enclosure. A series of tests during 2012-2013 using the method of energetic materials had refined the vent cover construction, enclosure design and required vent characteristics.

The IP enclosure with composite vent cover was subjected to successful actual arc fault testing at the Lane Cove Testing facility in NSW in December 2013. The general test arrangement is shown in Figure 4.

The testing covered 12.5kA and 20kA faults. These tests validated both the operation of the arc vents in relieving internal enclosure pressure, and the method of simulation using energetic materials through corroboration of pressure-time characteristics.

Figure 3: Arc fault vent fitted to IP55 enclosure.

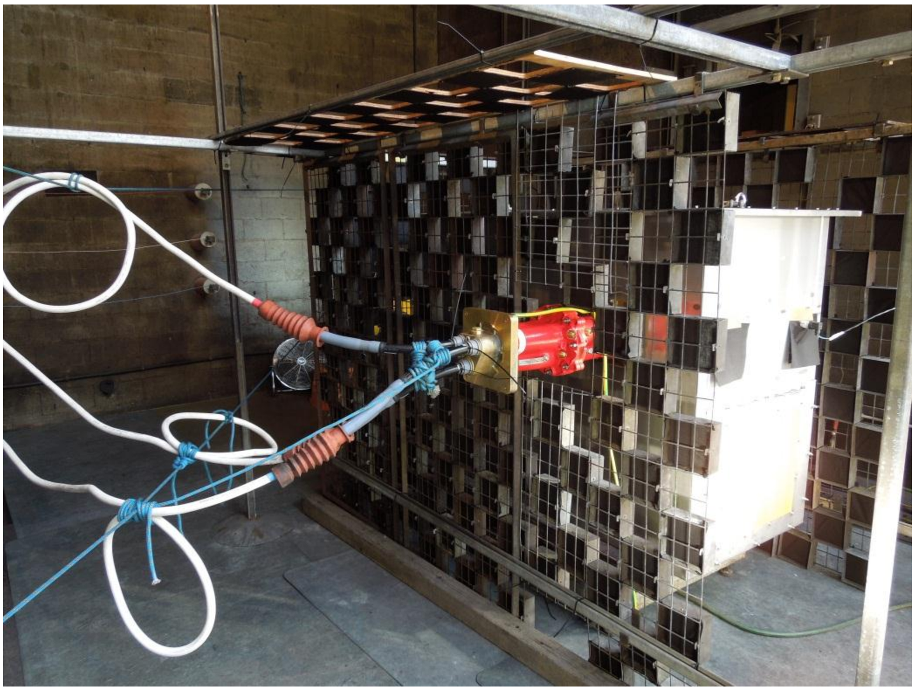

Figure 4: IP55 enclosure with arc fault vent undergoing testing at Lane Cove testing Station NSW. The cover is at bottom right.

The testing of the mobile switchroom in Mackay extended the previous IP enclosure results by enclosure volume (approximately $1m^3$ to $6m^3$), and by fault level (up to 30 kA).

The arc fault was simulated by igniting a calibrated quantity of energetic materials in the centre of the HV switchroom. High speed video footage of the enclosure under test was recorded, along with pressure versus time in the HV switchroom and in control cubicles.

RESULTS

The program of testing examined three key areas:

1. The performance of the enclosure with no arc venting provided.
2. The performance of the enclosure when engineered venting is fitted.
3. The integrity of the control room space under vented arc fault conditions.

Figure 5 shows the performance of the unvented mobile switchroom when subjected to a simulated 22.5 kA fault. The enclosure undergoes catastrophic failure, with the steel door becoming dislodged, and several steel fastenings failing under load.

Figure 5: Unvented switchroom with simulated 22kA fault.

Figure 6 shows the pressure versus time characteristics for the 22.5 kA simulated arc fault. Pressures inside the HV switchroom are seen to rise to approximately 13 kPA prior to the failure of the door. Pressures in the CB and control cabinets rise to approximately 4 kPa.

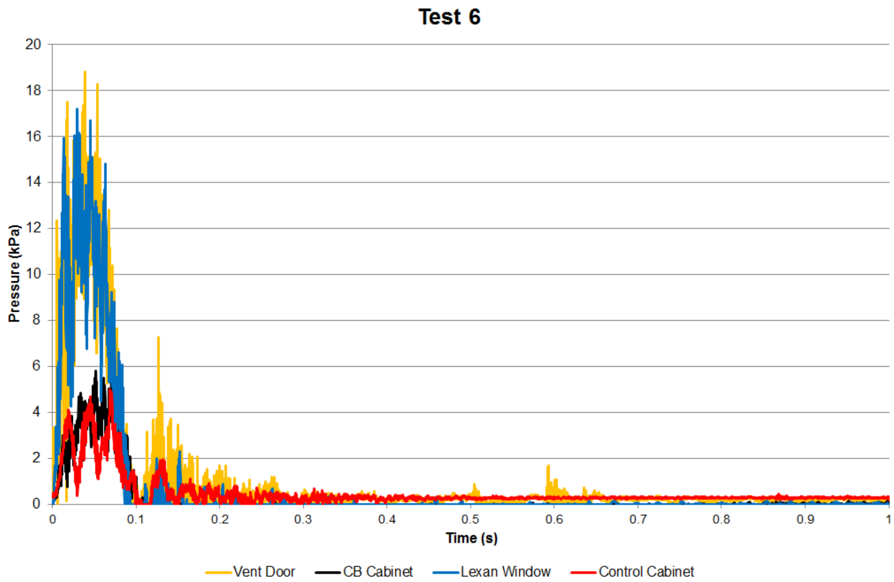

Figure 6: HV switchroom and control room pressures for test shown in Figure 5.

The same test was repeated with a single composite vent cover fitted to the HV switchroom external door - see Figure 7. The grill shown behind the vent provides mechanical support to the cover from external forces.

In the ensuing experiment, the vent cover was ruptured, opening the vent aperture to atmosphere, and protecting the enclosure from mechanical failure. Figure 8 shows the resulting pressure versus time characteristic. In that figure, the operation of the vent is clearly evident, rapidly relieving pressure at approximately 7.5 kPa.

Figure 7: Ampcontrol arc vent fitted to switchroom door.

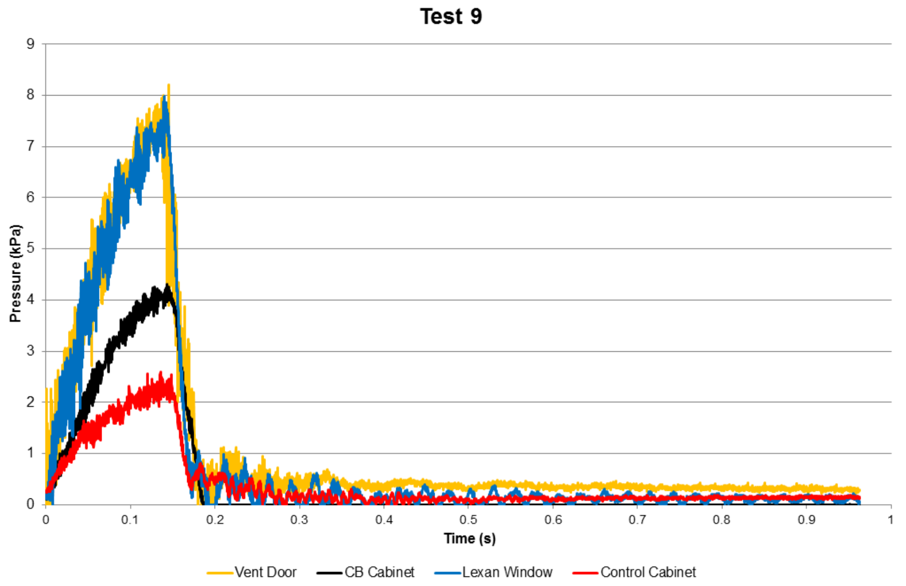

Figure 8: HV switchroom and control room pressures for 22.5 kA test in vented enclosure.

A similar experiment was conducted with the same enclosure, this time simulating a 30 kA fault (by increasing quantity of energetic materials). Two composite vent covers were fitted to accommodate the increased fault level. Figure 9 shows the moment of rupture of the (upper) vent. Figure 10 shows the corresponding pressure versus time characteristic.

Figure 9: Arc vent rupture during simulated 30 kA fault.

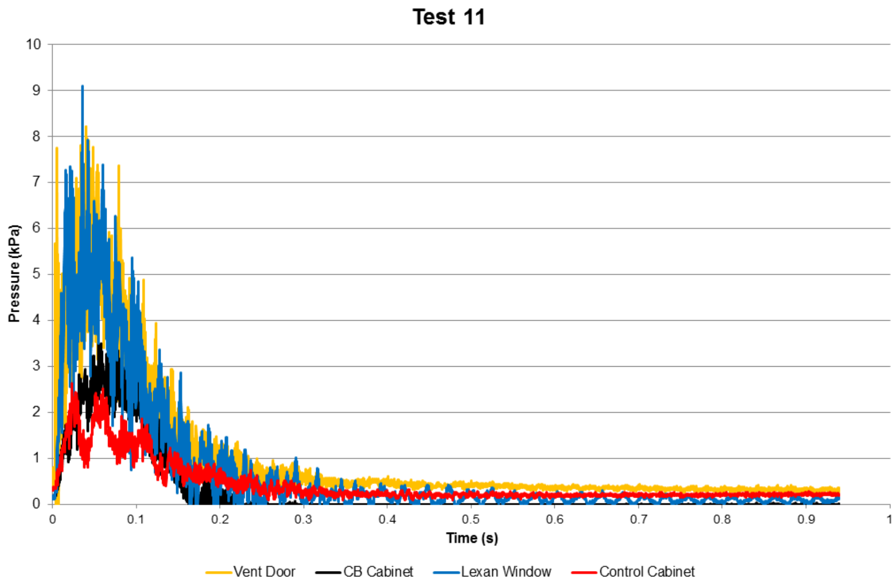

Figure 10: HV switchroom and control room pressures during simulated 30 kA fault.

Four observations are noted:

1. The enclosure survives the simulated arc fault without incurring any structural damage or failure of fastenings and fittings.
2. The pressure rise in the CB and control cabinets is limited to 3 kPA.
3. Only one of two vent covers ruptured.
4. The pressure characteristic exhibits an oscillatory response.

Figure 11 shows the enclosure after the simulated 30 kA test. The cracking of the upper vent cover across both diagonals is just visible. (That the covers 'close' after rupture is a convenient but not warranted attribute.) The lower cover remains intact.

Examination of the control room, and the various cabinets, fittings and fasteners after the test revealed no compromises in operator safety: all doors remained closed, latches and door operations remained functional, relays and buttons fitted to cabinet doors remained soundly fastened. Figure 12 shows a general view of the control area after the test. A video recorded inside the control room during the simulated arc fault revealed no uncontrolled behaviours.

While the combined aperture provided by two vents is needed to exhaust the products of a sustained 30 kA fault in this enclosure, the rupturing of only the first cover in this instance is sufficient to relieve the pressure generated by the simulation of the onset of the fault (approximately 100 msec).

The oscillatory response of the measured pressure characteristic correlates with the 'ringing' of the second vent cover visible in high speed footage of the test. The second cover is clearly subjected to the pressures measured, but does not rupture after pressure is relieved by the first cover rupturing.

Figure 11: Switchroom from Figure 5 after simulated 30 kA test. The upper vent has ruptured, and then closed once pressure released.

Figure 12: Control room end of mobile switchroom after simulated 30 KA fault.

CONCLUSION

The standard Ampcontrol Qld mobile switchroom (without arc fault venting) was subjected to a simulated 22.5 kA arc fault. The enclosure suffered catastrophic failure of the HV switchroom door.

The same switchroom, when fitted with suitably sized composite arc vents and composite covers, suffered no damage in the same scenario.

The vented switchroom was then subjected to a simulated 30 kA arc fault, and again no damage was sustained.

It is concluded that the fitting of proprietary composite arc vent covers, suitably sized for the given enclosure volume, enclosure strength and arc fault rating, provide an elevated level of safety for operational personnel by protecting both the enclosure from mechanical failure, and by providing a control room able to withstand the pressure rises resulting from venting of the switchroom.