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**Appointed examiner's audit of Exceptional Event Claim -
UK Power Networks (Eastern)
33kV Incident at Barnet Grid Substation
03 November 2013**



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Glossary

Abbreviation	Meaning
AE	Appointed Examiner
CB	Circuit-breaker
CI	Customer Interruptions per 100 connected customers
CML	Customer Minutes Lost per connected customer
DNO	Distribution Network Operator
EHV	Extra High Voltage – all voltages above 20kV up to but excluding 132kV
ep	energypeople
EPN	UKPN's Eastern Power Network licensed area
HV	High Voltage – all voltages above 1kV up to and including 20kV
QoS	Quality of Service
RIGs	Regulatory Instructions & Guidance
SCADA	Supervisory Control and Data Acquisition
SLD	Single Line Diagram
SoF	Statement of Facts
ToR	Terms of Reference
UKPN	UK Power Networks

Notes:

Within this document:

1. The term “higher voltage” is used to indicate all voltages greater than 1kV.
2. The calculations of CI and CML within this document are adapted from the annual calculations contained in the RIGs to reflect the CI and CML generated by the actual incidents being audited.

They are as follows:

CI: the number of interruptions to supply – the number of customers interrupted per 100 connected customers generated by the incidents being audited.

It is calculated as:

$$CI = \frac{\text{the sum of the number of customers interrupted for incidents being audited} * 100}{\text{the total number of connected customers}}$$

CML: the duration of interruptions to supply – the number of customers interrupted per connected customer generated by the incidents being audited.

It is calculated as:

$$CML = \frac{\text{the sum of the customer minutes lost for all restoration stages for incidents being audited}}{\text{the total number of connected customers}}$$

In both the formulae above, the total number of connected customers is as declared as at 30 September during the relevant reporting year. Any claims that occur and are audited prior to 30 September in the reporting year during which they occur will be audited using the total number of customers declared at 30 September in the previous reporting year.



Summary

1. Ofgem has commissioned energypeople as its Appointed Examiner (AE) to audit the submission made by UK Power Networks (UKPN) under the "one off" exceptional event mechanism that an incident which occurred at its Barnet Grid Substation at 11:09 on Sunday 03 November 2013 adversely affected the reported performance for its Eastern Power Networks (EPN) licensed area for the reporting year 2013/14.
2. The AE has visited UKPN to audit the claim against part 1 of the "one-off" exceptional event process and finds that it passes the exceptionality threshold in terms of both CI and CML.
3. The AE concludes that the event falls within the category of an "other event" as defined in paragraph 8.57 of Special Licence Condition CRC 8, including meeting the exceptionality requirements set out in Appendix 3 thereof.
4. The AE therefore proceeded to part 2 of the "one-off" exceptional event process, assessing UKPN's performance in mitigating the impact of the event upon its customers.
5. The AE concludes that UKPN's routine inspection and maintenance programmes at its Barnet Grid substation are up to date and that the company did all it could to ensure that its 33kV circuit-breakers and associated bushings are free from defects.
6. The AE commends UKPN's control engineers for analysing the alarms generated by the incident and for restoring all supplies as quickly as possible.
7. The AE concludes that UKPN had met the criteria of Appendix 4 to paragraph 8.58 of Special Licence Condition CRC 8 and that therefore the incident is deemed to be eligible for adjustment in the DNO's reported performance.
8. The AE therefore recommends that an adjustment to EPN's 2013/14 reported distribution system performance is made, in line with the part 1 audited CI and CML figures as shown in the following table:

	Audited number	Number above the threshold	Recommended adjustment
CI	1.66	0.96	0.96
CML	0.95	0.35	0.35



1. Audit part 1

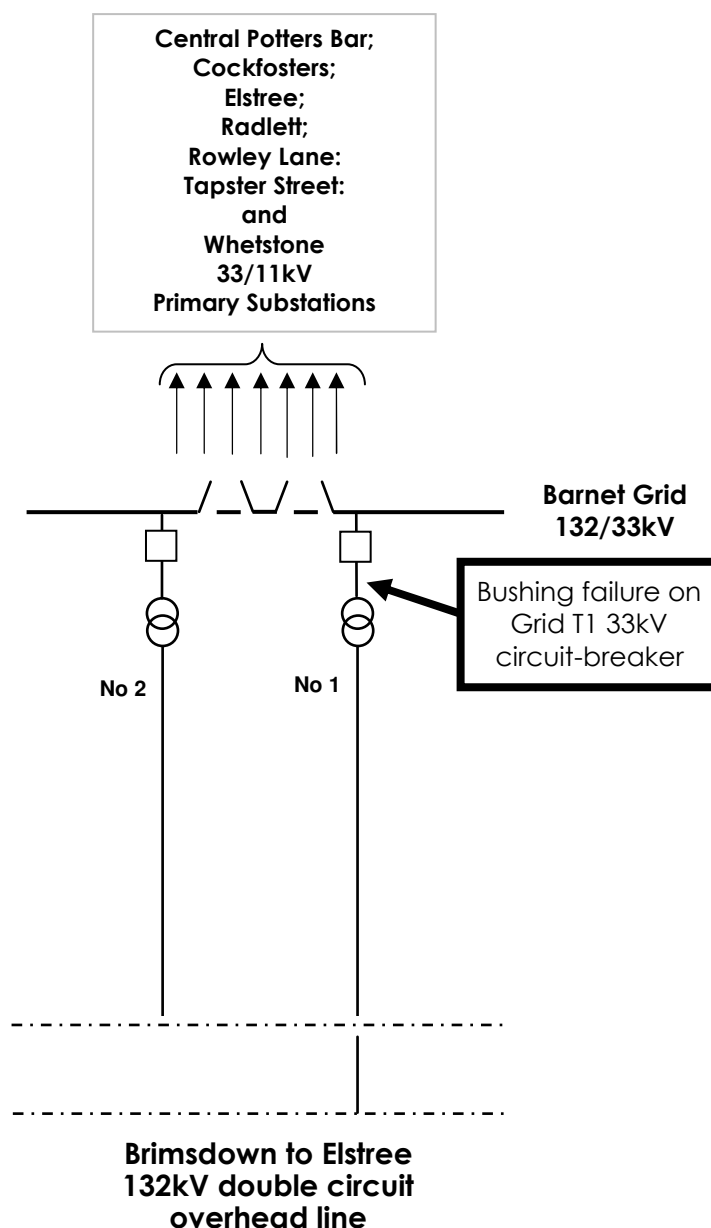
1.1 Summary of the main facts

9. The AE's headline information log for this event is set out in Table A-1 at Appendix A. In addition, the following paragraphs summarise the main facts of the event.
10. UKPN has provided photographic evidence to support its claim that a catastrophic failure of a bushing fitted to the number 1 33kV Grid Transformer circuit-breaker at its Barnet Grid Substation resulted in the loss of both 132kV infeeds to the site.
11. The incident resulted in the loss of 33kV infeeds to seven¹ of UKPN's 33/11kV Primary Substations, interrupting supplies to 59,206 of UKPN's customers fed from its 132/33kV Barnet Grid Substation.
12. UKPN's protection operated correctly to clear the incident from its distribution network, tripping the 132kV circuit-breakers controlling the Brimsdown to Elstree double-circuit 132kV overhead lines.
13. UKPN's 132kV distribution system was running normally at the time of the incident.
14. UKPN's control engineer used tele-controlled switching to restore supplies from alternative 11kV sources.
15. Following an inspection at Barnet Grid substation, the number 1 33kV circuit-breaker was isolated and the number 2 132kV infeed was restored via tele-controlled switching.
16. The damaged circuit-breaker was removed from site and its associated 33kV conductors strapped-through, thus enabling UKPN to restore the 132kV infeed to the number 1 132/33kV Grid Transformer and thereby maximise the security of supplies to its customers.
17. A simplified view of the sections of UKPN's 132/33kV networks affected by this event is shown in Figure 1.

¹ The infeeds to Radlett Primary Substation are two 11kV feeders from Elstree Primary Substation



Figure 1 – Simplified Network Diagram of UKPN's 132/33kV distribution networks affected by the incident



Notes:

1. Only the salient items of switchgear are shown.
2. UKPN's network was running normally at the time of the incident.
3. UKPN's control engineer used tele-controlled switching to restore supplies via alternative 11kV sources.
4. The damaged circuit-breaker was isolated and the number 2 132kV infeed was re-energised.
5. The outgoing 33kV feeders from Barnet Grid Substation are shown schematically.

2. Exceptionality requirements

2.1 Does the event qualify for exclusion

18. The AE considers that the event falls within the category of an “other event” as defined in paragraph 8.57 of Special Licence Condition CRC 8, and meets the exceptionality requirements set out in Appendix 3 thereof.
19. The AE therefore considers that, subject to satisfying the requirements of Appendix 4 to CRC 8, the event qualifies for possible exclusion under the “one-off” exceptional events process.

2.2 Exceptionality test results

20. The number of incidents attributed to the event is shown in Table 1.

Table 1 – The number of incidents attributed to the event

Number of incidents attributed to the event	Claimed number	Audited number
132kV	0	0
EHV	1	1
HV	0	0
LV	0	0
Total	1	1

21. The results calculated by the AE to test this claim against Ofgem's exceptionality criteria are shown in Appendix A. A summary of the results is shown in Table 2.

Table 2 – Summary of exceptionality test results

Test	Threshold	Claimed number	Audited number	Pass / Fail	Amount above threshold
CI exceptionality	0.7	1.66	1.66	Pass	0.96
CML exceptionality	0.6	0.95	0.95	Pass	0.35

Notes:

1. Ofgem's CI and CML exceptionality criteria are set out in the AE's ToR².
2. The audited CI and CML used in the exceptionality test have been determined from the number of incidents attributed to the event.
3. Where the event passes either or both the exceptionality thresholds, the amount(s) above the threshold(s) is/are carried forward into the Audit part 2 assessment of DNO performance.
4. In accordance with guidance from Ofgem, the AE's calculations use the threshold values contained in the current Distribution Price Control and the number of customers connected to the DNO's network relevant to the date on which the incident occurred.

² Audits of Electricity Distribution Network Operators' one-off Exceptional Events Claims for 2012/13 to 2014/15

3. UKPN's views of its performance

3.1 Dealing with the incident

22. UKPN's Barnet 132/33kV Grid Substation is normally supplied via a dual infeed from its Brimsdown to Elstree 132kV double-circuit overhead line.
23. At the time of the incident, the system was running normally with both 132kV infeeds to Barnet Grid Substation on load.
24. At 11:09 on 03 November 2013, a catastrophic failure of a 33kV bushing fitted to the 33kV circuit-breaker associated with the number 1 132/33kV Grid Transformer at Barnet Grid Substation resulted in the tripping of the circuit-breakers controlling the dual 132kV infeeds and the consequential loss of all customers' supplies fed from the site.
25. UKPN considers that its protection operated correctly to clear the incident from the system.
26. UKPN considers that its duty control engineer reacted well in assessing the alarms generated by the event and restoring all supplies via tele-controlled switching on the 11kV network by 12:26 on 03 November 2013.
27. UKPN also considers that, having received a report from site confirming the irreparably damaged 33kV equipment, its control engineer acted well in restoring the number 2 132kV infeed to Barnet Grid Substation.

3.2 UKPN's answers to questions on its performance

28. Within the last three years, the AE has reviewed UKPN's design standards, construction methods and maintenance procedures during previous visits to audit exceptional event claims and found them fit for purpose.
29. The AE confirms that UKPN's emergency procedures provide for the type of event being examined here.
30. To aid understanding of the background to UKPN's Statement of Facts (SoF), the AE prepared a list of initial questions regarding this incident. These questions were used as the basis for the examination of UKPN's claim.
31. The initial questions were discussed during the AE's visit to UKPN's Ipswich Control Centre on 16 September 2014, when the records of UKPN's SCADA system, the incident report and other information were made available.
32. UKPN has provided answers to the AE's initial list of questions. For ease of reference, the AE's questions are printed in bold font with UKPN's answers being printed in normal font.

Q1. What, if any, changes has EPN made to its emergency plans and procedures since the Appointed Examiner (AE) last visited to audit the exceptional event claim concerning the incident that occurred 07 June 2010 which affected EPN's customers supplied from its Great Yarmouth Grid Substation?

- A1. Following a review of this incident and the normal review cycle no changes have been made to UK Power networks' emergency plans or procedures for single 'one-off' events.

Q2. EPN's Statement of Facts (SoF) for the incident at Barnet Grid Substation on 03 November 2013 indicates that the cause was attributed to the failure of a bushing on the 33kV circuit-breaker (1TO) associated with the number 1 132/33kV Grid Transformer. What photographic evidence is available to support EPN's claim that this was the cause of this incident?

A2. Photographs of the failed circuit breaker have been provided to the auditor. *[AE's note: UKPN's photographs clearly show the irreparably damaged bushing].*

Q3. When were the 33kV busbars and switchgear commissioned at EPN's Barnet Grid Substation?

A3. This equipment was commissioned in 1965.

Q4. When was the failed bushing associated with 33kV circuit-breaker 1TO commissioned?

A4. The bushing that failed is an integral part of the 33kV circuit-breaker and therefore was commissioned at the same time: 1965.

Q5. Regarding the circuit-breaker 1TO:

a. Who was/were the manufacturer(s);

A5(a). Crompton Parkinson

and

b. What type of switchgear is (was) it?

A5(b). OE7 Oil circuit-breaker

Q6. Regarding the failed bushing:

a. Who was/were the manufacturer(s);

A6(a). Crompton Parkinson

b. What type of bushing was it (e.g. oil-filled);

A6(b). Porcelain

c. What is UKPN's policy for testing this type of bushing;

A6(c). Every 6 months as part of Major/Minor inspection:

1. Carry-out an ultrasonic survey of plant - Ultra-Tev/Mini-Tev, Ultraprobe 2000 or Karousel – Ensure plant is discharge free; and
2. Carry-out a temperature sweep – Using heat gun carry-out a temperature sweep on switchboard.

and

d. What has UKPN's done to ensure other bushings of this type are not prone to failure?

A6(d). UK Power Networks has carried-out visual inspections and the tests referred to in A6(c) above.

Q7. What is EPN's experience of the reliability of this type of switchgear and its associated bushings?

A7. UK Power Networks has no evidence of this type of failure in the past.

Q8. What is the UK's reported experience of the reliability of this type of switchgear and its associated bushings as reported via the ENA's National Equipment Defect Reporting Scheme (NEDeRS®)?

A8. The only report in NEDeRS relating to a Crompton Parkinson OE7 Oil circuit-breaker failure relates to the UK Power Networks entry for the Barnet failure.



Q9. What is EPN's policy for the routine inspection and maintenance of this type of apparatus?

A9. The following sets out UK Power Networks' maintenance and inspection routine for its 33kV Circuit Breakers:

1. 1 year minor inspection;
2. 1 year major inspection;
3. 12 year full maintenance; and
4. 6 year mechanism maintenance.

Q.10. When was the last inspection carried-out on 1TO and its associated bushings prior to the incident occurring?

A10. The last full maintenance on the failed circuit-breaker was carried-out on 24 May 2011; the last minor inspection was carried-out on 06 June 2013; and the last major inspection was carried-out on 08 February 2013. *[AE's note: the results of the inspections were discussed with UKPN. UKPN confirmed that the bushing showed no signs of damage or distress and that there was no reason to believe it would fail].*

Q11. What was the content of the associated report(s)?

A11. UKPN's Health Index used to measure the condition of assets is based on Condition Ratings (CR) and enables a particular component to be graded according to its condition or performance as follows;

- CR1 - No measurable or detectable degradation;
- CR2 - Measurable or detectable degradation, which is considered normal ageing and has no significant effect on the probability of failure;
- CR3 - Significant degradation, considered to increase probability of failure in the medium term (the next maintenance cycle); or
- CR4 - Serious degradation, considered to significantly increase the current probability of failure.

For the circuit-breaker type in question there are 18 condition rating points: 10 are internal to the circuit-breaker and therefore are only assessed when maintenance is carried out.

The other 8 condition rating points are assessed during annual inspection and, for the last 6 years, the circuit-breaker external bushing condition rating has been 2.

Q12. What protection schemes are installed on:

a. The 33kV busbars at Barnet Grid Substation?

A12(a). Details of the protection schemes will be provided during the AE's visit.

b. The 33kV sides of Grid Transformers 1 and 2 at Barnet Grid Substation?

A12(b). Details of the protection schemes will be provided during the AE's visit.

and

c. The circuit-breakers controlling the 132kV sides of Grid Transformers 1 and 2?

A12(c). Details of the protection schemes will be provided during the AE's visit.

Q13. What settings are applied to the above protection schemes?

A13. Details of the protection settings will be provided during the AE's visit.

Q14. What protection operated when supply was lost?

A14. Details of the protection that operated will be provided during the AE's visit.



Q15. Inspection of EPN's SLD's indicates that there is no 33kV bus-section circuit-breaker installed at its Barnet Grid Substation. What network design studies and risk assessments has EPN carried-out to justify this running arrangement?

A15. This is an historic design and would be reconsidered when the switchgear is due for replacement and as there are no ongoing issues with the way the network operates - it is not cost-effective to change before then.

Q16. What has EPN done to replace circuit-breaker 1TO?

A16. A replacement vacuum circuit-breaker has been installed and is in the process of being commissioned.

Q17. What learning points have EPN incorporated into its procedures as a result of this incident?

A17. This type of switchgear is intrinsically reliable and as a result of this incident no additional information has come to light that would change UK Power Networks' current processes and procedures or its replacement policy.

Q18. What further learning points should be considered as a result of the application of the current one-off Exceptional Event Claims process?

A18. UK Power Networks consider that it is always good practice to review incidents as close to the incident date as possible to ensure availability of information and the clarity of events.

33. During the discussion of this claim it was concluded that a visit to UKPN's Barnet Grid Substation would be unnecessary; the AE was satisfied with UKPN's date-stamped audit trail and UKPN's photographic evidence.

34. UKPN also provided further information both during and subsequent to the audit visit. This includes:

- Information to show that the affected section of UKPN's network is P2/6 compliant;
- Information to show that; prior to the current incident, UKPN's Barnet Grid Substation has been free from incidents due to this cause;
- UKPN's photographs of the irrepealably damaged 33kV bushing and the general layout of its Barnet Grid Substation;
- UKPN's control room log for this incident;
- UKPN's incident report from which it calculated the CI and CML attributed to this incident;
- The details of UKPN's SCADA alarms generated by this incident;
- A representation of the incident on UKPN's SCADA system; and
- Copies of UKPN's protection schemes and associated relay settings for its 132kV and 33kV feeders affected by this event.



4. Audit part 2

4.1 UKPN's performance in preventing the event

35. In viewing UKPN's performance in preventing this Incident, the AE has considered what more UKPN could have reasonably been expected to have done to ensure that its 33kV equipment at Barnet Grid Substation was safeguarded from incidents caused by bushing failures.
36. The AE has discussed UKPN's policy on its inspection and preventative maintenance procedures and the AE considers that the measures applied are in accordance with good UK practice.
37. UKPN's photograph 1, taken at the time of the incident shows 33kV circuit-breaker 1TO and the irreparably damaged bushing.
38. UKPN's photograph 2 shows a close-up of the irreparably damaged bushing.
39. The damage to the porcelain bushing is clearly seen in both photographs, as are the additional rubber shields fitted to the 'sheds' of the bushing in order to protect it from such things as vandal damage, (stone throwing and shotgun pellets).
40. A general view of Barnet Grid Substation can be gauged from UKPN's photograph 3, taken from "Google Earth".
41. UKPN's measurement systems clearly show the loss of 132kV infeeds to its Barnet Grid Substation when the circuit-breakers controlling them tripped at 11:09 on 03 November 2013.
42. UKPN's measurement systems also confirm the restoration of supplies via tele-controlled switching from 11kV alternative sources; the final customers being restored at 12:26 on 03 November 2013.
43. UKPN's measurement systems also confirm the restoration of the number 2 132kV infeed to Barnet Grid Substation at 12.52 on 03 November 2013.
44. An examination of UKPN's measurement systems and a SCADA representation of its distribution network confirm that UKPN did all it could to restore supplies as expeditiously as possible.
45. The AE concludes that, prior to this incident occurring, UKPN had done all it could reasonably have been expected to do in considering that its outdoor 33kV equipment at its Barnet Grid Substation was free from defects in accordance with accepted good practice within the UK electricity supply industry.

4.2 UKPN's performance in mitigating the effects of the event

46. The irreparably damaged 33kV bushing is consistent with an internal fault developing that would not be detected despite UKPN's comprehensive non-invasive routine inspection and preventative maintenance measures.
47. The AE has studied the running arrangements of UKPN's 132/33kV distribution network supplying its Barnet Grid Substation and concludes that UKPN's protection systems worked correctly to clear the incident from UKPN's distribution system.
48. The AE commends UKPN's control engineers for analysing the situation, and for restoring supplies as rapidly as possible, thereby minimising the duration of the interruption.



4.3 Recommended performance adjustments

49. The AE's recommendations to Ofgem are shown in Table 3.

Table 3 – Recommended performance adjustments

	Amount above threshold	Audit part 2 recommendation
CI	0.96	0.96
CML	0.35	0.35

4.4 Detailed justification

50. In reaching a judgement on a recommendation, the AE has firstly considered whether or not UKPN could have reasonably taken any different course of action that would have prevented the internal fault developing in the 33kV bushing.
51. In viewing UKPN's performance in preventing this event, the AE has taken into account his personal knowledge of the United Kingdom's distribution system practice and that of his colleagues who have considerable operational experience of incidents due to many causes.
52. The AE notes that UKPN has no previous records of incidents of this type at its Barnet Grid Substation and that it therefore had no cause to consider any additional measures other than those consistent with good UK practice.
53. The AE considers that UKPN was mindful of maximising the security of supplies to its customers by restoring the number 1 132kV infeed to Barnet Grid substation once the damaged 33kV circuit-breaker had been removed and the conductors strapped-across. This was achieved by 14 November 2014, thus allowing UKPN to re-energise grid transformer number 1 at its Barnet Grid Substation.
54. In considering UKPN's restoration strategy, the AE is conscious that UKPN's duty control engineer acted with commendable skill and speed in analysing the SCADA alarms and indications generated by this incident; and, using tele-control restored supplies as rapidly as possible.
55. The AE is satisfied that UKPN's distribution network supplying its Barnet Grid Substation complies with the requirements of Security of Supply Standard P2/6 (109.7 MVA firm).
56. The Appointed Examiner therefore concludes that UKPN's claim is justified and recommends to Ofgem that the amounts of CI and CML above the threshold values should be excluded from EPN's performance for reporting year 2013/14.



Appendix A - Record of Audit part 1

Table A-1: Appointed Examiner's Information Log

"One-Off" Exceptional Event	Reporting Year 2013/14
Licensed Area	UKPN(EPN)
Date of event	03 November 2013
Cause	Irreparable damage to a 33kV bushing
Notification to Ofgem	04 November 2013
SoF received	30 April 2014
SoF information	<ul style="list-style-type: none"> • UKPN's distribution system at its Barnet Grid was running normally at the time of the incident with both 132kV infeeds being on load; • At 11:09 on Sunday 03 November 2013 the 132kV circuit-breakers controlling the two infeeds tripped, thus losing all supplies from Barnet Grid ; • Supplies to 7 of UKPN's 33/11kV Primary Substations fed from Barnet Grid were interrupted (59,206 customers); • UKPN's Radlett Primary substation is supplied via two 11kV circuits from its 33/11kV Elstree Primary Substation; and • UKPN personnel were sent to Barnet Grid and reported an irreparably damaged bushing on the 33kV circuit-breaker associated with Grid Transformer GT1.
Additional pre-visit information provided	Based on the SoF the AE drew up a list of initial questions. These were discussed during the audit visit. This initial list of questions, together with UKPN's responses, is contained in paragraph 32 of the report.
Location of audit visit	UKPN's Ipswich Control Centre
Date of audit visit	16 September 2014
Visiting Auditor	Geoff Stott (ep)
UKPN's Representatives	Bill D'Albertanson and Stuart Plant.
Information provided during and subsequent to the audit visit	<p>Comprehensive documentation / information including:</p> <ul style="list-style-type: none"> • A discussion of the protection arrangements on the 132/33kV circuits at UKPN's Barnet Grid; • The settings applied to the above protection schemes; • A copy of UKPN's switching programme for the incident which shows the loss of supplies from UKPN's Barnet Grid at 11: 09 on 03 November 2013; • Sight of UKPN's switching programmes showing the restoration of the supplies to the affected Primary Substations via tele-controlled switching on the 11kV network; • Copies of the relevant 132kV and 33kV SLDs; • Sight of the printout from UKPN's SCADA system that shows the alarms generated by the event;



	<ul style="list-style-type: none"> • A copy of UKPN's fault report that shows: <ul style="list-style-type: none"> ◦ the number of customers affected by the incident to be 59,206; and ◦ the customer minutes lost due to the incident to be 3,390,461; • The AE confirms that these figures agree with those quoted in UKPN's SoF; • Using EPN's total connected customers at 30 September 2013 of 3,565,115 the number of customers affected equates to a CI of 1.66 $[59,206 \times 100 / 3,565,115]$ • Similarly, the customer minutes lost for this event equate to a CML of 0.95 $[3,390,461 / 3,565,115]$; • UKPN's photographs of the damaged 33kV bushing and an aerial view of Barnet Grid Substation taken from "Google Earth"; • No need to visit Barnet Grid Substation to clarify anything; • Discussed post-fault learning points, including anything to affect UKPN's future policy on shrouding bushings; • Confirmed P2/6 compliant (109.7 MVA firm (winter)); • UKPN provided answers to the initial questions plus additional information both during and subsequent to the audit visit; and • Okay regarding compliance with Appendix 4 of Paragraph 8.58 of CRC 8.
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Table A-2: Impact on CI and CML

	CI		CML	
Voltage (DNO's incident reference)	Claimed	Audited	Claimed	Audited
132kV	0	0	0	0
EHV (FREP-665496-H)	1.66	1.66	0.95	0.95
HV	0	0	0	0
LV	0	0	0	0
Total	1.66	1.66	0.95	0.95
UKPN (EPN) Threshold (total)	0.7		0.6	
Part 1 Exceptionality Test	Pass		Pass	
Part 1 Precondition of eligibility (meets App 3 to paragraph 8.57 of CRC 8)	Pass			

NOTE: UKPN's measurement systems are subject to QoS audits for accuracy of reporting and it is not within the AE's ToR to repeat that work as part of the examination of exceptional event claims, although any consequential adjustments to reporting accuracy will be reflected in Ofgem's final adjudication of reported performance for the regulatory reporting year 2013/14.



Appendix B - UKPN's photographs

Photograph 1 – The irreparably damaged bushing and its associated 33kV circuit-breaker





Photograph 2 – Close-up of the irreparably damaged bushing





Photograph 3 – Aerial view of Barnet Grid Substation taken from “Google Earth”

