IEEE Power & Energy Society
Switchgear Committee
C37.20.7 Working Group Report
02-October-2012

The working group met on Tuesday, October 2, at 8:00AM.

Patents:
Those registered had to acknowledge the IEEE-SA rules on Patents, and therefore, review in this meeting is not required. Nevertheless, the chair displayed the Patents slides and reminded attendees of their obligations. The participants were reminded that anti-competitive issues are never allowed for discussions.

General:

The PAR for this project was approved by the IEEE-SA Standards Board on November 9, 2011.

Members introduced themselves, identified their company and their affiliation. Attendance included 28 working group members (of 31, with 1 absent and 2 excused, plus 35 guests. Attendance is as shown below:

Members / Affiliation	Members / Affiliation	Guests / Affiliation	Guests / Affiliation
C. Ball (P) – S&C	F. Mayle (P) - Technibus	H. Bannick (P) - KEMA	P. Leufkens (P) – KEMA
P. Barnhart (P) - UL	D. Mazumdar (P) - AZZ	J. Bowen (E) - Aramco	A. Livshitz (P) - Schneider
J. Baskin (P) – Federal Pacific	D. Mohla (P) – DCM Technical Consulting	M. Cannady (P) – Southern Company Services	R. Martinez (P) – CFE LAPEM
R. Boyce (P) - Eaton	A. Morse (P) - Eaton	C. Carne (P) - Schneider	R. Morris (P) - Eaton
R. Bugaris (E) - Rockwell	T. Olsen (P) - Siemens	R. Cohn (P) - Powercon	D. Moser (P) - ABB
E. Byron (P) - Schneider	M Orosz (P) - Schneider	M. Crooks (P) - Eaton	O. Parks (P) - ABB
J. Earl (P) - ABB	A. Patel (P) - GE	D. Dunne (P) - Schneider	E. Peters (P) - Powell
D. Edwards (P) - Siemens	C. Schneider (P) - Schneider	D. Elliott (P) - ABB	R. Puckett (E) – retired
M. Flack (P) – Southern Nuclear	J. Smith (P) - Eaton	L. Farr (A) - Eaton	M. Rodriguez (P) – CEPEL - Brazil
K. Flowers (P) - Siemens	P. Sullivan (P) - DuPont	B. Gerzeny (P) - Powell	A. Rowell (A) - Eaton
D. Gohil (P) - AZZ	C. Tailor (E) - Eaton	P. Gingrich (P) - AZZ	T. Schiazza (P) - Schneider
R. Hartzel (E) - Eaton	M. Valdes (P) - GE	L. Grahor (P) - Eaton	G. Schoonenberg (P) - Eaton
S. Hutchinson (P) - Shallbetter	M. Wactor (P) – Powell	J. Hansen (P) - Schneider	M. Seabrook (P) - GE
C. Kennedy (P) - Schneider	R. Warren (P) - KEMA	T. Hawkins (P) - Siemens	J. Swank (P) – Cooper
M. Lafond (P) - GE	J. Zawadzki (P) - Powertech	J. Hidaka (P) - UL	R. Tanner (P) – Schneider
D. Lemmerman (P) - Exelon		D. Hrncir (P) - Eaton	T. Tobin (P) – S&C
		A. Janssen (P) - Alliander	M. Williford (P) – Schneider
		H. Josten (P) - Siemens	L. Yacone (P) – IEEE-SA
		A. Jur (P) - Eaton	D. Yek (P) – PG&E
			L. Yonce (P) - Eaton

The minutes from the Spring, 2012 meeting were approved as distributed.

Draft 2 of the document was previously distributed. This draft is intended to cover these types of equipment:

- LV Metal-Enclosed Switchgear (C37.20.1)
- MV Metal-Clad Switchgear (C37.20.2)
- MV Metal-Enclosed Interrupter Switchgear (C37.20.3)
- Metal-Enclosed Bus (C37.23)
- MV Motor Controllers (UL 347)
- LV Motor Controllers (UL 845)
- LV Switchboard (UL 891)

Other equipment types, such as transformers, large motor drives, and others, have been suggested for inclusion. For the time being, we will focus on the types above.

In previous meetings, we had agreed that we would put the special requirements germane to a particular type of equipment in a specific normative annex for that type of equipment. To encompass other types of equipment, we have re-titled the document from covering “metal-enclosed switchgear” to “switchgear”, with corresponding changes throughout the document. This was discussed and it was agreed that the generic term “switchgear” can be used.

Jim Bowen will be requested to seek input from API with respect to the recommended arcing duration for LV MCCs.

Paul Sullivan will serve as liaison between the C37.20.7 working group and the PCIC standards subcommittee.

A philosophical discussion of the direction to be pursued in the document with respect to testing of various kinds of products ensued. The minutes have been rearranged so that the various products are sequenced by their location in the document, not in the order actually discussed in the meeting.

Annex C (LV Switchgear)
- No specific discussions.

Annex D (MV MC Switchgear)
- No specific discussions.

Annex E (MV MEI Switchgear)
- No specific discussions.

Annex F (Outdoor equipment)
- No specific discussions.

Annex G (LV MCCs)
- Preferred duration of arcing. The suggested duration from the task force is 0.05 s, corresponding to the short-circuit duration for MCCs. It was suggested that 0.05 s might be the minimum duration, with a recommended duration that is longer. We need to consider the time duration for associated equipment, such as LV Switchgear (C37.20.1), to which the MCC may be directly connected.
- For historical purposes, the following is excerpted from the Fall 2011 minutes:

  > Preferred duration - this is 0.5 seconds for most equipment but for LV motor control, it is 0.050 seconds to correspond to the short-time rating of LV motor control. This suggests that UL 845 needs a test for the main bus for a short-time current duration to match equipment to which it may be connected (e.g., LV metal-enclosed switchgear). This is outside the scope of C37.20.7.

  It has been previously been suggested that a reasonable recommended duration based on the clearing time of upstream protective device (the backup protection) be used. This approach might be used for other equipment types (and in fact, this was the basis of the original 0.5 s duration for medium voltage equipment. H. Josten (LVS), E. Peters (C37.23), A. Morse (MVC), J. Earl (MV MC), C. Ball (MV MEI), K. Flowers (MCCs), C. Schneider (Switchboards) will look at this issue.
- Discussion of the relative “arc rating” of the indicators used in internal arcing tests took place. At present, we do not have an equivalent “arc rating” for the indicators. It also needs be recognized that the indicator distance is 4” in C37.20.7 whereas the normal distance used in NFPA 70E is 18”.

Annex H (MV MVCs)
- No specific discussions. The present text needs editorial revision but is technically adequate.

Annex I (LV Switchboards)

- Formal request to add LV Switchboards to the document has not been received but is believed to be in process. C. Schneider has provided draft text. Discussion is still needed as to preferred arcing duration.

Annex J (Metal-Enclosed Bus)

- There are major issues with respect to the practicality of having arc-resistant metal-enclosed bus. The definition of test specimen arrangement (elbows, tee taps, terminations, orientation, location of exhaust outlet, etc.) is a major topic. The task group leans toward excluding metal-enclosed bus from C37.20.7. Even if we elect to exclude it, we do need to consider the ramifications of connecting non-arc-resistant metal-enclosed bus to arc-resistant equipment.

  Do we need to address metal-enclosed bus as an entity (i.e., arc-resistant bus duct) or only the connection to non-arc-resistant bus duct? By a vote of 32 to 10 of those present (including WG members and guests), we should continue working to create a means to perform internal arcing tests on metal-enclosed (C37.23) bus.

General

- Accessibility type B – we need to have a clear marking of compartments that are accessibility type B. This is particularly important for LV equipment.

- Accessibility type C – extensive discussions occurred about accessibility type C and the meaning of such a rating. Some users think that a type C rating would mean that the equipment would be functional with minimal rework after an arcing event (disconnection of the faulted section, cleanup of insulation, etc.). The manufacturers (in general) disagree with this, as the collateral damage to other sections after a fault in a section is quite substantial and the level of rework not minimal. Therefore, the question becomes one of constructing a valid test for type C and education of users as to what type C means and what it does not mean.

  Previously, the WG had asked Mr. Bowen to query users on their demand for type C. He could not attend this meeting but at the IEEE PCIC meeting in New Orleans the week of September 24-27 that industrial users in the US see no demand for type C accessibility. It should be recognize that his discussions with users represent a small sampling but that his contacts in the petroleum and chemical industry are quite extensive. Therefore, it is felt that considerable “weight” can be applied to his information.

  Discussion of whether to keep type C occurred, or whether to reconstruct type C requirements in some fashion.

  Mr. Wactor will send out proposals for additional or different extended ratings for consideration by the working group.

- Mr. Mohla raised concern about NFPA 70E. The revisions in work now will essentially say that any electrical equipment, when all doors and covers are closed, is “safe” and therefore that no PPE is needed around such equipment. He disagrees with this and wants users and manufacturers to offer comments. The NFPA 70E schedule (in brief) is appended to these minutes.

Grounding during internal arcing tests discussion

Mr. Leufkens presented results of comparative internal arcing tests conducted with a grounded source versus tests with ungrounded source. The tests indicated that the test neutral currents are more affected by voltage imbalance between the phases (and impedance imbalance) than by the method of grounding. A question was raised relative to the implications of this on the amount of damage that is possible to the enclosure. The IEEE view has been that testing with solid grounding is needed so that there is reasonable exposure to enclosure burn-through.

Mr. Leufkens’ presentation is attached to these minutes.

After extensive discussion, no conclusion was reached as to whether the tests should be grounded or ungrounded. The discussion will continue at subsequent meetings.

Participants are requested to provide comments on draft 3 to the chair by November 1. It will include changes from the Spring, 2012 and Fall, 2012 meetings, including the switchboard submittal and a draft of extended ratings.

The meeting adjourned at 11:45AM.

Report submitted by: M. Wactor, WG Chair

NFPA 70E revision schedule:

Information provided by Mr. Mohla.

Here is the link for NFPA 2015 available on the NFPA website. I have highlighted two key dates in **yellow highlighted bold red font** **below. Please suggest everyone to submit comments if they agree or disagree with the language in the First Draft**

http://www.nfpa.org/AboutTheCodes/AboutTheCodes.asp?docnum=70E&tab=nextedition

First Draft Report Posting Date: **2/22/2013**
Public Comment Closing Date: **5/3/2013**

Revision cycle information
Revision Cycle: Annual 2014
Revised Edition Date: 2015
This A2014 document will be processed under the new Regulations. For further information please see Special Notice on NFPA Regulations

First Draft (previously Report on Proposals (ROP))
Public Input Closing Date: 6/22/2012
First Draft Report Posting Date: **2/22/2013**

First Draft Meeting Notices (previously ROP Meeting Notices)
Electrical Safety in the Workplace, August 18-25, 2012, Denver, CO (PDF, 132.0 KB)
Pre-First Draft, March 16, 2012, Teleconference

First Draft Meeting Agendas (previously ROP Meeting Agendas)
pre-First Draft, March 16, 2012, Teleconference (PDF, 20.4 KB)
First Draft, August 20-24, 2012, Denver, CO (PDF, 4.3 MB)

Second Draft (previously Report on Comments (ROC))
Public Comment Closing Date: **5/3/2013**
Second Draft Report Posting Date: 1/3/2014

Notice of Intent to Make a Motion (NITMAM)

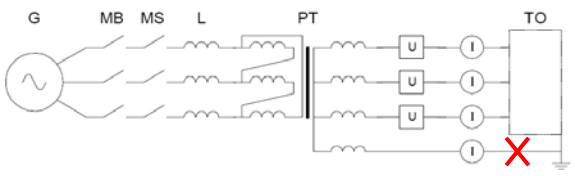
NITMAM Closing Date:	2/7/2014
NITMAM Posting Date:	4/4/2014

Internal arcing and extended neutral

Experience you can trust.

Aim of this presentation

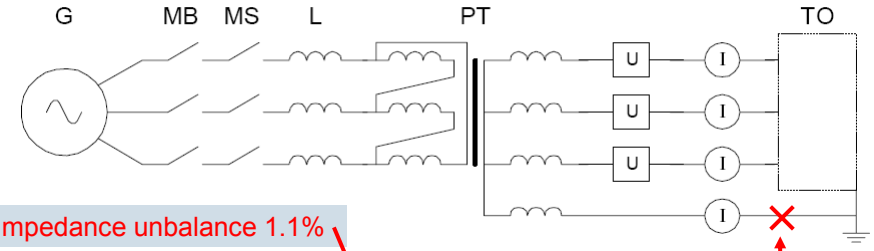
- Provide input to discussion on effect of grounding of enclosure in internal arc testing
- IEC: Enclosure grounded to lab only is most severe situation
  IEEE: Connecting enclosure to source neutral with “low” impedance is most severe situation
  - based on test experience and low-voltage practice (paper Dunki-Jacobs 1972)



Content

1. Direct comparison with/without extended neutral in 24 kV / 18 kA circuit with impedance unbalance 1.1%
2. Evaluation from 12 tests > 50 kA with extended neutral in two KEMA labs
3. Simulation study
4. General conclusions

1: 24 kV, 18 kA 3 phase, 300 ms



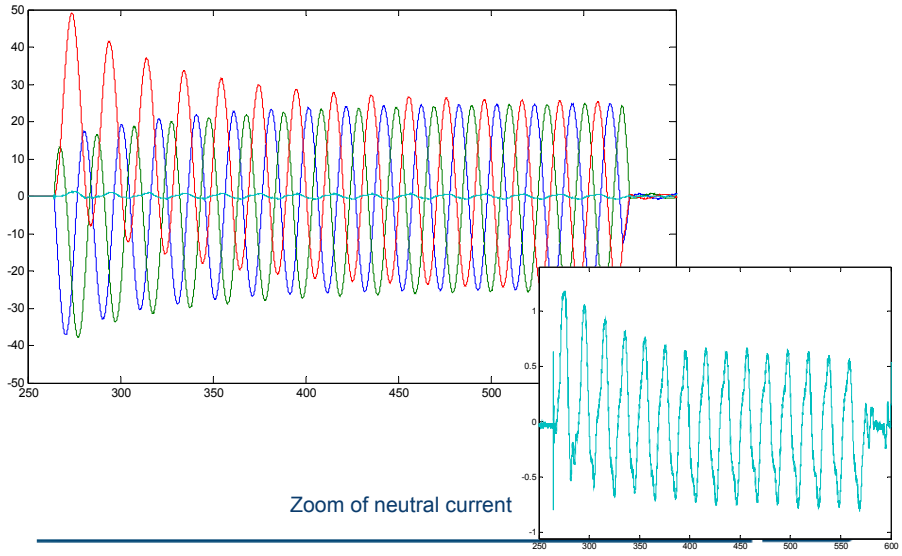
impedance unbalance 1.1%

Power	MVA	748
Frequency	Hz	50
Phase(s)		3
Voltage	kV	24
Current	kA	18
Impedance	Ω	0,77
Zero Impedance	Ω	0,77
Power factor		< 0,1
Neutral		earthed

Phase		L1	L2	L3
Applied voltage	kV	13,9	13,9	13,9
Applied voltage, between phases	kV	24,1		
Making current, peak	kA	-37,1	-37,8	49,2
Symmetrical current, beginning	kA	17,8	17,9	18,0
Symmetrical current, middle	kA	17,6	17,7	17,7
Symmetrical current, end	kA	17,6	17,7	17,7
Symmetrical current, average	kA	17,8	17,9	17,9
Average				
Duration	s	0,307	0,307	0,307
Total energy	MJ	4,01		
Thermal equivalent based on prospective current		17,7kA during0,307 s		

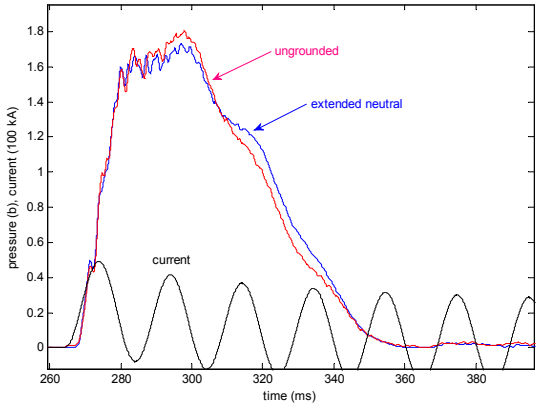
tests with and without extended neutral

Neutral current in extended neutral situation (3 phase arc initiation)



Zoom of neutral current

Pressure rise ungrounded and extended neutral



No significant difference in pressure pattern with/without extended neutral

KEMA

Conclusions part 1

1. Direct comparison in 24 kV / 18 kA circuit with impedance unbalance 0.6%
   Results:
   - Neutral current < 3%
   - Similar pressure rise with and without extended neutral
   Conclusion:
   - At this voltage no difference in severity with/without extended neutral
2. Evaluation from 12 tests at 63 kA with extended neutral in two KEMA labs
3. Simulation study

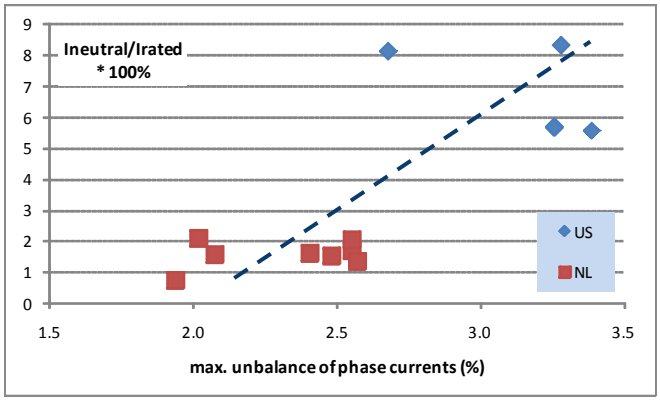
KEMA

2: Comparison of 12 tests in US/NL labs with extended neutral (> 50 kA)

KEMA lab	Usupply	avg phase current	phase current deviation from avg (%)			max dev	Ineutral	Ineutral / laverage
	kV	kA RMS	A (%)	B (%)	C (%)	%	**kA RMS**	**%**
US	8.0	61.36	-1.28	2.11	-0.83	3.39	**3.40**	**5.5**
US	8.0	62.42	-1.24	2.02	-0.78	3.26	**3.53**	**5.7**
US	7.2	51.61	0.71	0.99	-1.69	2.68	**4.20**	**8.1**
US	7.9	64.88	0.31	1.49	-1.80	3.28	**5.40**	**8.3**
NL	15.0	53.31	0.90	0.13	-1.04	1.94	**0.40**	**0.8**
NL	15.0	56.60	-0.44	1.42	-0.98	2.40	**0.91**	**1.6**
NL	15.0	56.68	-0.41	1.48	-1.07	2.55	**0.96**	**1.7**
NL	15.0	56.75	-0.89	1.59	-0.70	2.48	**0.89**	**1.6**
NL	15.0	56.82	-0.46	1.24	-0.78	2.02	**1.21**	**2.1**
NL	15.0	56.63	-0.27	1.42	-1.15	2.57	**0.77**	**1.4**
NL	15.0	56.67	-0.63	1.35	-0.72	2.07	**0.89**	**1.6**
NL	15.0	56.78	-0.58	1.57	-0.99	2.55	**1.16**	**2.0**

KEMA

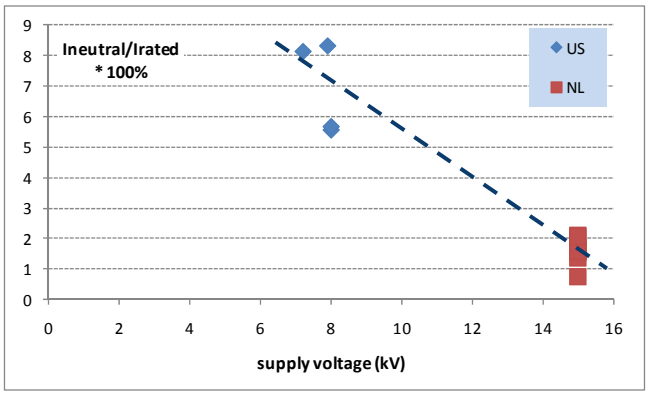
Larger neutral current with larger unbalance of phase currents



Max. neutral current 8.3% (5.4 kA)
Max. circuit unbalance 3.5% (|min-max|/avg)

KEMA

Smaller neutral current with higher supply voltage



Higher supply voltage cancels out unbalance in arc voltages

KEMA

Conclusions part 2

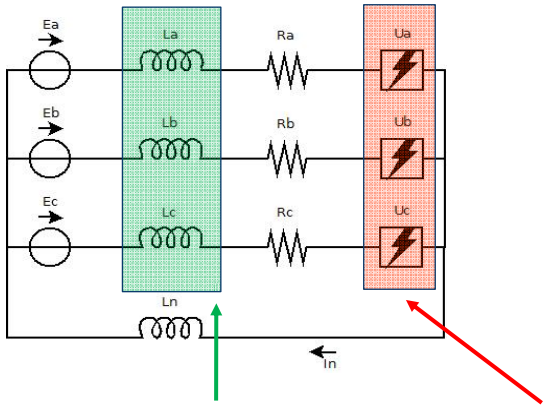
1. Direct comparison in 24 kV / 18 kA circuit with impedance unbalance 0.6%
   Results:
   - Neutral current < 3%
   - Similar pressure rise with and without extended neutral
   Conclusion:
   - At this voltage no difference in severity with/without extended neutral

2. Evaluation from 12 tests > 50 kA with extended neutral in two KEMA labs
   Results:
   - Neutral current in all cases < 8.5% of the average phase current
   - Higher neutral current in cases of larger unbalance of phase currents
   - Higher neutral current at lower supply voltage
   Conclusion:
   - Unbalance in phase impedances cause neutral current
   - Arc voltage unbalance causes neutral current, the more so at lower supply voltage

3. Simulation study

KEMA

3: Simulation study



Influence of unbalance of La,Lb,Lc and unbalance of Ua,Ub,Uc on In for different values of Ea=Eb=Ec

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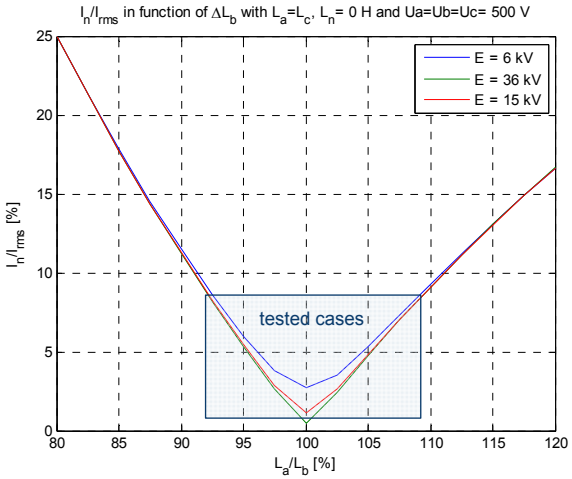
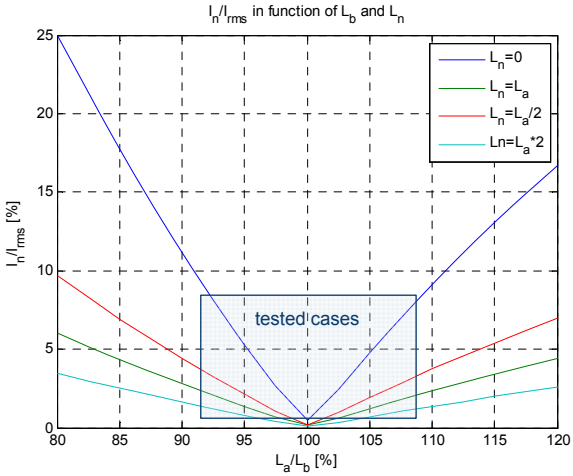
Variation of phase impedance unbalance with balanced arc voltage



Variation: 3 values of supply voltages

Conclusion: Supply voltage not relevant for In

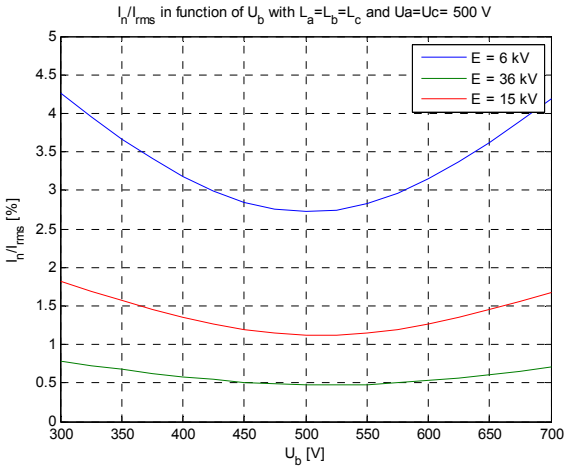
Variation of phase impedance unbalance with balanced arc voltage



Variation: 4 values of neutral impedances

Conclusion: Neutral impedance strongly reduces In

Variation of arc voltage unbalance with balanced circuit impedances



Variation: 3 values of supply voltage

Conclusion: Lower supply voltage increases In

KEMA

Conclusions part 3

1. Direct comparison in 24 kV / 18 kA circuit with impedance unbalance 0.6%

2. Evaluation from 12 tests at 63 kA with extended neutral in two KEMA labs
   Results:
   - Neutral current in all cases < 8.5% of the average phase current
   - Higher neutral current in cases of larger unbalance of phase currents
   - Higher neutral current at lower supply voltage
   Conclusion:
   - Unbalance in phase impedances cause neutral current
   - Arc voltage unbalance causes neutral current, the more so at lower supply voltage

3. Simulation study
   Results:
   - Combined influence of phase impedance unbalance and arc voltage unbalance
   - Phase impedance unbalance seems to have stronger effect
   - Confirmation of tested results
   - Neutral impedance can decrease neutral current significantly

KEMA

4. General conclusions

- There is a difference between laboratories regarding neutral current in internal arc testing with extended neutral
- Neutral current is driven by:
  - unbalance in phase impedance. Its effect is only slightly depending on supply voltage.
  - unbalance in arc voltage. Its effect is depending on supply voltage. The ratio Uarc/Usupply is the key factor. This is the reason that in low-voltage testing much larger neutral currents are observed than at medium voltage.
- In the 12 cases studied, with max. impedance unbalance of 3.5% a max. neutral current of 8.5% (= 5.4 kA) was observed with the lowest supply voltage of 7.2 kV.
- Reducing supply voltage has stronger effect on neutral current than phase unbalance

KEMA

KEMA

End sheet

Thank you for your attention.

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