IEEE Power & Energy Society
Switchgear Committee
C37.20.7 Working Group Report
11-October-2011

The working group met on Tuesday, October 11, at 8:00AM.

Patents:
IEEE-SA rules on Patents were reviewed prior to further discussions. The IEEE-SA patent slides of 2008 were shown and will govern the activities of the task force.

General:

This is a task force, as no PAR has been submitted yet. An objective of this meeting is to determine the scope of the PAR so that we can submit it to the IEEE-SA for consideration.

Members introduced themselves, identified their company and their affiliation. Attendance included 25 working group members (of 28), with 2 absent and 2 excused, plus 35 guests. Attendance is as shown below:

Members	Members	Members	Guests	Guests	Guests
C. Ball (P)	J. Giacetti (P)	T. Olsen (P)	G. Arce (P)	T. Hawkins (P)	R. Pawar (A)
P. Barnhart (P)	R. Hartzel (P)	M Orosz (P)	F. Beauchemin (P)	J. Hidaka (P)	E. Peters (P)
J. Baskin (P)	C. Kennedy (A)	A. Patel (P)	J. Bowen (P)	D. Hrncir (P)	R. Puckett (P)
R. Bugaris (P)	M. Lafond (P)	C. Schneider (P)	R. Boyce (P)	R. Hughes (P)	D. Riffe (A)
E. Byron (P)	D. Lemmerman (P)	J. Smith (P)	M. Cannady (P)	S. Hutchinson (P)	A. Rowell (A)
J. Earl (P)	F. Mayle (P)	P. Sullivan (P)	C. Carne (P)	A. Jivanani (P)	G. Schoonenberg (A)
D. Edwards (E)	D. Mazumdar (P)	C. Tailor (P)	R. Cohn (P)	H. Josten (P)	H. Song (P)
D. Gohil (P)	D. Mohla (E)	M. Wactor (P)	S. Dozier (P)	S. Kreichgauer (P)	J. Stacy (P)
M. Flack (A)	A. Morgan (P)	J. Zawadzki (P)	D. Dunne (P)	T. Lagerstrom (P)	T. Tobin (P)
K. Flowers (P)	A. Morse (P)		D. Elliott (P)	A. Livshitz (P)	J. Toney (A)
			R. Foster (P)	J. Mizener (P)	R. Warren (P)
			P. Gingrich (P)	R. Morris (P)	M. Williford (P)
			M. Glinkowski (P)	D. Moser (P)	G. Winstanley (P)
			L. Grahor (P)	P. Novak (A)	

P = present, E = excused, A = absent

Minutes for the Spring 2011 meeting were approved as published.

The task forces appointed at the Spring 2011 meeting submitted their suggested revisions to reflect their respective equipment categories. The focus of this meeting was to begin the review of these suggested changes with the objective of creating a new consolidated draft for further review.

- LV Metal-Enclosed Switchgear (C37.20.1) task group: H. Josten (leader)
- MV Metal-Clad Switchgear (C37.20.2) task group: J. Earl (leader)
- MV Metal-Enclosed Interrupter Switchgear (C37.20.3) task group: C. Ball (leader)
- Metal-Enclosed Bus (C37.23) task group: E. Peters (leader)
- MV Motor Controllers (UL 347) task group: A. Morse (leader)
- LV Motor Controllers (UL 845) task group: K. Flowers (leader)
- LV Switchboard (UL 891) task group: C. Schneider (leader)

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.

The suggestions for changes made by several of the task forces were in the form of marked-up copies of the complete draft, as distributed to the working group members by E-Mail dated October 5.

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 "equipment", with corresponding changes throughout the document.

The PAR has been submitted to IEEE-SA and is on the agenda for consideration at the NesCom telecon October 28. We will review the PAR at this meaning to confirm that it is what we want it to be.

<u>MV Metal-Enclosed Bus (C37.23)</u>:
The concept of accessibility type for metal-enclosed bus is different. Metal-enclosed bus is typically not mounted on the floor, and all areas of the bus are accessible. The general feeling is to define a specific accessibility type 2 for metal-enclosed bus in the metal-enclosed bus annex. We will also need to consider bus that mounted below 2 m in elevation as well as bus mounted above 2 m, horizontal and vertical mounting, elbows, length of bus for testing, and other issues. The possible arrangements of exhaust systems for metal-enclosed bus also need to be considered.

<u>LV Motor Controllers (UL 845)</u>:
The revisions suggested by the task force were reviewed. The mark-up from the task force also specifically identified text in the existing document that is not applicable to LV motor controllers, which supports the previously agreed concept that each equipment type will be covered in a dedicated annex. 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. There was a suggestion that additional assessment criteria from the IEC standard for motor controllers be incorporated, and this will be held for future consideration.

<u>MV Metal-Clad Switchgear (C37.20.2)</u>:
This was previously discussed. The suggested changes will go into the next draft.

<u>MV Metal-Enclosed Interrupter Switchgear (C37.20.3)</u>:
This was previously discussed. The suggested changes will go into the next draft.

<u>LV Switchboard (UL 891)</u>:
Changes proposed by the NEMA switchboard group will be incorporated in the next draft.

<u>PAR</u>:
The PAR, as submitted to NesCom for consideration October 28 was reviewed. It was agreed that the PAR as displayed is what we wish it to be.

<u>Effect of neutral grounding</u>:
Mr. Wactor discussed test results from recent testing concerning grounding. For reference, the following is an excerpt from the Spring 2011 minutes discussing data presented by Mr. Schoonenberg:

> IEC limits current to ground to 100A or less during arcing tests. IEEE requires that the enclosure be connected to the source in such a manner that there is no significant limitation on ground current. Significant discussion occurred relative to which testing arrangement produces the most onerous conditions. Several report that testing with solid grounding produces more dramatic results during testing. Others report that testing with limited ground current forces the arcing to remain as three-phase arcing and produces the highest pressure on the enclosure
>
> Gerard Schoonenberg presented some information relative to the grounding issue, from the view of IEC. Recently, KEMA-Chalfont conducted tests at 64kA and about 10% of the current appeared in the ground connection. KEMA-Arnhem conducted tests in February 2011 to explore differences with grounded neutral and tests with neutral floating with test current of 18kA. These were tests with a custom test enclosure that could be reused, not like an ordinary test specimen to C37.20.7. A metal bracket was arranged relatively close to the phase electrodes, so that it was readily involved in the

arcing. Whether this was representative of a real test unit is open to question. Arc voltages were of the order of 300 volts.

Pressures measured were relatively in the same area for each test voltage. The arcing energies were also in the same range. Tests were conducted for 0.3 seconds with test voltages of 6kV and 24kV, with neutral grounded and with neutral floating.

Mr. Schoonenberg will request permission to make the material presented available to the participants, and if so, the material will be provided with the minutes.

Mr. Wactor did some testing at a laboratory familiar with IEC testing practices, and had discussions with Dr. Smeets of KEMA. These discussions suggested that the severity of the test has less to do with the grounding than it does with the balance of currents between the phases. Mr. Glinkowski showed some summary data (same as presented in Spring, 2011) which shows ground current ranging from about 2% up to about 10% of the phase current. Mietek proposed that this issue be raised at STL, and that the laboratories investigate the effect of grounding (and unbalance) with a view towards determining the “right way” to conduct tests, to resolve the disagreement between IEEE (test grounded) and IEC (test with limited ground current).

The meeting adjourned at 11.59AM.

Report submitted by: M. Wactor, WG Chair

Eaton / Kema basic internal arc tests

Arnhem, NL, 9 February 2011

G. Schoonenberg, R. Smeets

Discussion test set up for internal arc tests MV switchgear

Two different visions:

- **IEEE standard C37.20.7: neutral supply to be connected to earthing system testobject (enclosure)**

- IEC 62271-200: neutral supply to be floating or high impedance <100 A (covers all practice situations of neutral treatment)

IEEE C.37.20.7 cl.5.2.6:

The neutral of the supply system must be grounded or connected to the ground bus of the switchgear assembly by a separate bus. If the neutral is grounded, the ground bus of the switchgear assembly must be grounded. If the neutral of the supply system is connected to the switchgear assembly by a separate bus, the switchgear assembly may be isolated from ground as required by the laboratory.

NOTE—This requirement recognizes that test laboratories may not allow the flow of intentional ground fault current due to safety and/or instrumentation concerns.

IEC 62271-200 cl. A.5.1 (2003)

If applicable, the supply circuit shall be three-phase, except for tests on switchgear and controlgear with segregated phases, if no mutual influence between the segregated phase compartments is likely. The neutral point of the supply circuit may be either isolated or earthed through an impedance, in such a way that the maximum earth current is less than 100 A. In this situation, the arrangement covers all situations of neutral treatment.

NOTE 1 Internal arc faults with a directly grounded neutral are less severe.

- ed.2 to come(2011): note1 will be skipped in cl. AA.5.1.1
  (3 phase tests)

Discussion regarding IEEE approach:

Pro:

- Also at 3 phase tests it appears that a neutral current of appr 10% of the 3-phase value flows (test results Kema USA)
- More chance on burn-through (?)

Contra:

- Part of the current is not forced back to other pole through plasma
  - no contribution to heating

To be investigated:

- neutral current is result imperfections testsetup?
- Influence arc voltage vs testvoltage, (testvoltage is often lower than rated voltage)

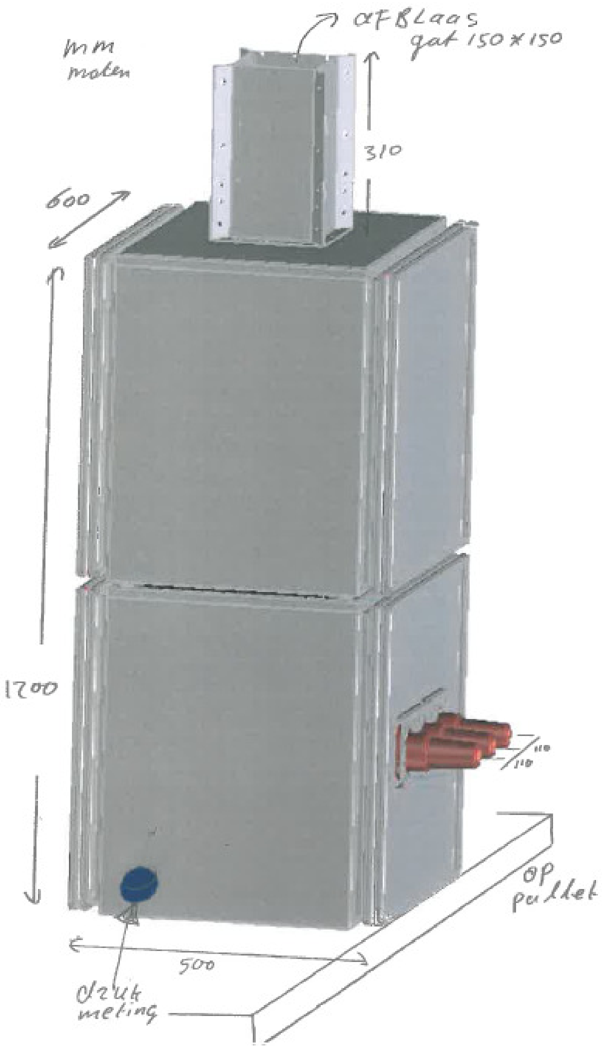
Discussion regarding IEEE approach:

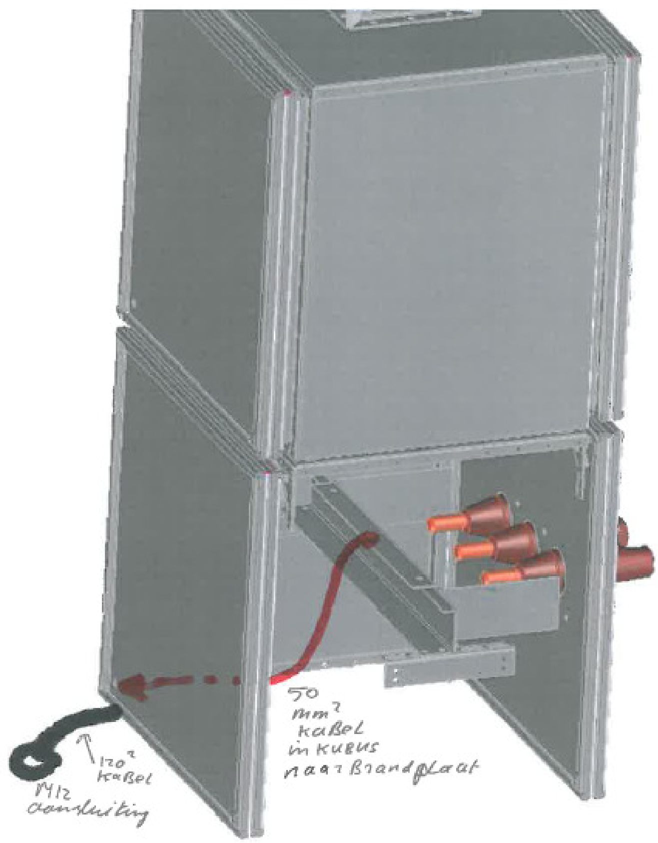
Examples I3E tests

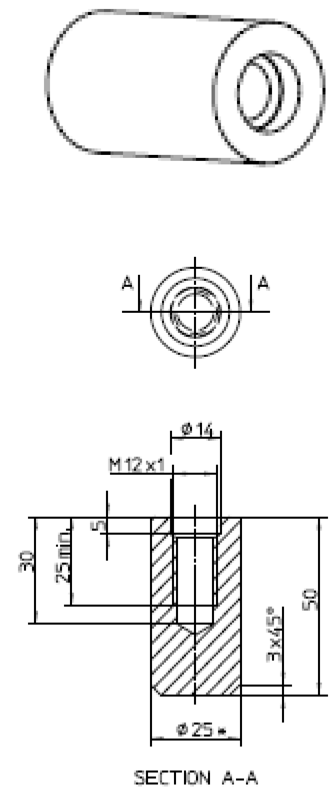
- Internal arc tests on 15kV switchgear, Kema Chalfont
- 63 kA (rms), 500 ms with testvoltage 8 kV
- Neutral supply connected (via cable)
- Scale oscillogrammes 10% of the scale of the phase currents.
- Result: see next slide, appr 10% rms of set phase value as neutral current

IEEE test: 8 kV, 63 kA (rms), 500 ms

Test object Kema NL feb 2011







Test set up

Test set up

3-phase Tests performed Kema NL feb 2011

Supply (kV)	IEEE (N earthed)	IEC (N floating)
24	A	B
6	D	C

- 3phase current set at 18 kA 0.3 s

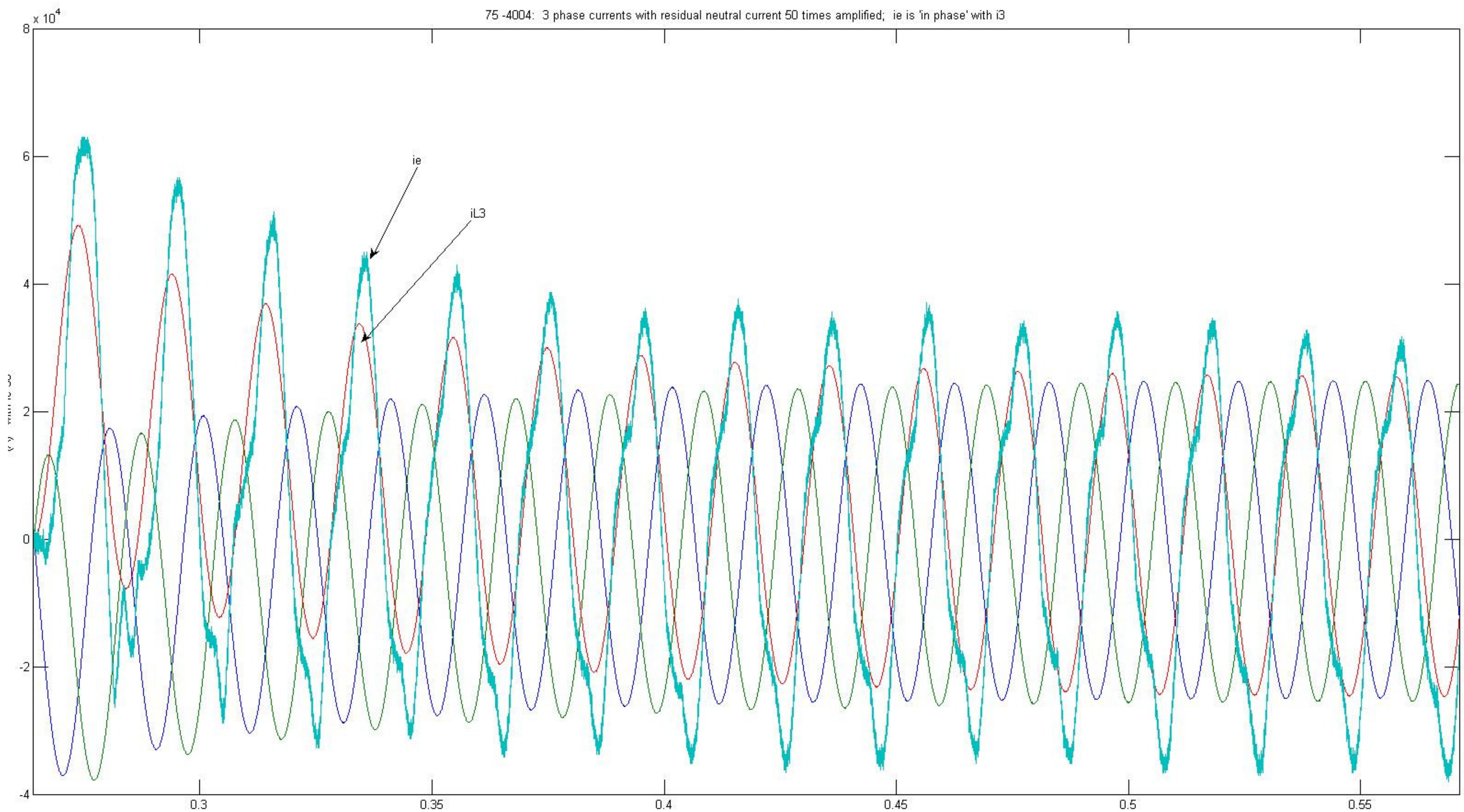
  (Z-Neutral defined by 1 phase current set at 17 kA)

After every test, new electrodes were mounted

Testresults performed Kema NL feb 2011

High speed video

Test A with Ie *50



After 18 kA- 0.3s

Testresults performed Kema NL feb 2011

	U (kV)	neutral	current (kArms) L1	L2	L3	ie (A)	E (MJ)	Pressure pe (Bar,rel) up	down	Arcvoltage (V-rms) L1	L2	L3	Cu electrode Burnt material (g) L1	L2	L3	6,1 MJ/kg total (g)	MJ needed for CU elctr.eva-poration
A	24	e	17,8	17,9	17,9	**486**	3,98	1,75	1,75	214	316	280	47,2	48	49,9	145	0,88
B	24	**f**	17,9	18	17,8	26	3,89	1,82	-	197	304	274	48,3	48	49,6	146	0,89
	24	e	17,6	17,6	17,7	**480**		**solid shortcircuit as check of A)**									0,00
C	6	**f**	17,6	17,5	17,7	19	3,49	1,33	1,3	187	275	259	44,8	47	46,8	138	0,84
D	6	e	17,6	17,5	17,7	**294**	3,5	1,56	1,54	186	276	259	44,9	45	47	137	0,84

Testresults performed Kema NL feb 2011

			current (kArms)					Pressure pe (Bar,rel)		Arcvoltage (V-rms)			Cu electrode Burnt material (g)			6,1 MJ/kg	MJ needed for CU elctr.eva-poration
	U (kV)	neutral	L1	L2	L3	ie (A)	E (MJ)	up	down	L1	L2	L3	L1	L2	L3	total (g)	
A	24	e	18	18	17,9	486	**3,98**	1,75	1,75	214	316	280	47,2	48	49,9	145	0,88
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- tests at 24 kV give appr 15% more energy than at 6kV (4 to 3,5 MJ);
  - Also pressures are 0,4 Bar higher at 24 kV
  - No significant differences for arcing Energy between (e) and (f)
- Pressures at 6 kV higher for (e) compared to (f); opposite expected
  - at 24 kV expected direction but only slightly different
- At 6kV (e) Ie = 294A rms while at 24 kV Ie= 486A; opposite expected?
- Check with solid s.c. Gives the same Ie, so no arcing matter

CONCLUSION from tests performed

3 phase arc testing with earthed neutral gives a neutral current because of imperfections in the 3 phase system, so testlab dependent !

- 63 kA at 8kV gives Ie =10%
- 17,9 kA at 24 kV gives Ie=2,7%
- 17,6 kA at 6 kV gives Ie = 1,7%

Neutral Grounding for Internal Arc Fault testing

Mietek Glinkowski

IEC

CONCLUSION from tests performed:

- **3 phase arc testing with earthed neutral gives a neutral current because of "imperfections" in the 3 phase system, so it is testlab dependent !**
  - 63 kA at 8kV gives Ie =10%
  - 17,9 kA at 24 kV gives Ie=2,7%
  - 17,6 kA at 6 kV gives Ie = 1,7%

Next steps

- Ask KEMA and other labs (via STL?) to investigate differences in test circuits and the resulting neutral currents due to 3-ph unbalance.
- Investigate what degree of unbalance the actual power systems have (TF?).
- Decide what are the worst case conditions and how to test.