70570064-HVL 06-1071 2006-04-21

# Test on CT Analyzer for OMICRON, Austria.

# T E S T  R E P O R T

| | |
|---|---|
| Report no. | 70570064-HVL 06-1071 |
| Client | OMICRON electronics GmbH,<br>Klaus, Austria |
| Reference | |
| Concerning | test |
| Date | April and October 2005 |
| Place | High-Voltage Laboratory of KEMA<br>Nederland B.V., Arnhem, the Netherlands |
| Object | CT Analyzer |
| Type | BB 174 U |
| Manufacturer | OMICRON |

**REQUIREMENTS**

The requirements as specified in the following standards:

- IEC 60044-1 (1996) + amendment 1 (2000) + amendment 2 (2002)
- IEC 60044-6 (2002)
- ANSI C57.13 (1993)

**TEST PROGRAMME**

The programme was specified by the client and was as follows:

1 Verification checks of the analyzer test function for determination of winding resistance
2 Verification checks of the analyzer test function for the determination of current transformer transformation errors
3 Verification checks of the analyzer test function for the determination of magnetization curves of current transformers
4 Verification checks of the some additional analyzer test functions

**SUMMARY AND CONCLUSION**

The results obtained relate only to the work ordered and to the material tested.
For the summary and conclusion, reference is made to page 4 of this report.

Author R.C.A.M. Koevoets

KEMA Nederland B.V.

This report consists of:
24 pages
4 appendixes

P.G.A. Bus
KEMA T&D Testing Services
Managing Director

Arnhem, 21 April 2006

**MATERIAL DATA**

Test were carried out on the apparatus as under:

**CT Analyser**

| | |
|---|---|
| Manufacturer | OMICRON, Klaus, Austria |
| Serial No. | BB 174 U |
| Option | not applicable |
| Input | 110-240 V/50/60 Hz/6A |
| Output | 1 x 130 V/5 A/350 VA |
| Sampling procedure | by the Manufacturer |

For the purpose of the tests the following current transformers were utilized:

**CT OMICRON 1: KSO1811**
- Manufacturer: Ritz
- CT 2000/5A and 2000/1A
- Class 0,02% at 2,5 VA, Class 0,1% at 15 VA
- Core Type: Non gapped, measurement CT
- Omicron Ser. No.: 05 – 305
- Ser. No.: 05/596717

**CT OMICRON 2: KSO1812**
- Manufacturer: Ritz
- CT 1000/1A
- Class 0,2% at 1 VA
- Core Type: Non gapped, measurement CT
- Omicron Ser. No.: 02 – 195
- Ser. No.: 05/560150

**CT OMICRON 3: Special class TPY**
- Manufacturer: Koncar (Zagreb)
- CT 1000/1A
- Class TPY at Rb= 1,5 Ohm
- Core Type: gapped, protection CT
- Omicron Ser. No.: 05 – 319

**CT OMICRON 4: Special class TPZ**
- Manufacturer: Pfiffner (CH)
- CT 1200/1A
- Class TPZ
- Core Type: gapped, protection CT
- Ser. No.: Omicron 05 - 313

**CT OMICRON 5: KSO1811**
- Manufacturer: Ritz
- CT 2000/5A and 2000/1A
- Class 0,02% at 2,5 VA
- Core Type: Non gapped, measurement CT
- Ser. No.: 03/582927

**CT KEMA 01:**
- Manufacturer: Ritz
- NTRO 320, CT 5000/5 or CT 10000/5
- Class 0,01% at 10 VA
- Core Type: Non gapped, measurement CT
- KEMA HSL No 12.09 ORS 075392
- Ser. No.: 83/440308

**CT KEMA 02:**
- Manufacturer: Ritz
- NTTS
- Class 0,01% at 1 VA
- Core Type: Non gapped, measurement CT
- KEMA HSL No 12.07
- Ser. No.: 540 627

**PERSONS ATTENDING THE TEST**

| | |
|---|---|
| Mr F. Süss | OMICRON, Hardware Development |

**THE TEST WAS CARRIED OUT BY**

| | |
|---|---|
| Mr R.C.A.M. Koevoets | KEMA Nederland B.V. |
| Mr J. Mijnen | KEMA Nederland B.V. |

**PURPOSE OF THE TEST**

Purpose of the test was to verify whether the material complies with the specified requirements.

## SUMMARY AND CONCLUSION

### SUMMARY

- **General**

The functional operation and applicability of the OMICRON CT ANALYZER for testing of current transformers was verified by checks during determination of main characteristics of several current transformers. The OMICRON CT ANALYZER was under operation and control by the manufacturer, under supervision of KEMA. The results are valid only for the checks carried out together with the selected testing modes and should not be treated as results of type tests, routine tests, acceptance tests, or similar.

- **Verification checks of the analyzer test function for determination of winding resistance**

The functional operation during determination of winding resistance using the OMICRON CT ANALYZER did not give rise to remarks.
The numerical evaluation, during measuring of KEMA shunt resistor resistance values, showed differences of 0,1% or less, when compared with the calibration certificate values of the shunts.

- **Verification checks of the analyzer test function for the determination of current transformer transformation errors**

The functional operation during determination of current transformation errors using the OMICRON CT ANALYZER did not give rise to remarks. Tests were carried out in both selection modes, respectively for measurement CT's with non-gapped cores and for protection CT's with gapped cores.

- **Verification checks of the analyzer test function for the determination of magnetization curves of current transformers**

The functional operation during determination of current transformation magnetization curves using the OMICRON CT ANALYZER did not give rise to remarks.

- **Verification checks of the some additional analyzer test functions**

Since, as a result of the automatic and integrated operation of the OMICRON CT ANALYZER, several additional test functions came into operation during the checks and verifications performed, these functions resulted in output parameter values such as for FS, Ts, knee-point data, etc. In particular the determination of the knee-point data was verified. The results do not give rise to remarks.

### CONCLUSION

From the tests, verifications and measurements it has become obvious that the OMICRON CT-ANALYZER does a very accurate current ratio measurement on continuous ring cores (non gapped) (better than 0.02%/0.5min) and an adequate accurate current ratio measurement on gapped cores (TPY better than 0,2%/3min; TPZ better than 1%/5min).

Furthermore, the OMICRON CT-ANALYZER is able to determine in a fast and accurate way the magnetization curves and the related parameters.

## DESCRIPTION AND RESULTS OF THE TEST

### MEASUREMENT UNCERTAINTY

The last page of this report contains a table with measurement uncertainties. Unless otherwise indicated in the report, the measurement uncertainties of the results presented are as indicated in this table.

## INTRODUCTION

The applicability and output results of the OMICRON CT ANALYZER with its functions for testing of current transformers were compared with requirements and results of testing on the same current transformers however using other test equipment, that is applied normally by KEMA for the tests to be carried out on current transformers.
Based on the results of the comparison, conclusions may be drawn as to the applicability of the OMICRON CT ANALYZER for the tests on current transformers.

Although the OMICRON CT ANALYZER has capabilities for many other testing functions, the tests and checks, described in this report are related to the functions given in the test program only.

The testing activities (tests, checks, comparison and or verifications) cannot be considered as type tests or routine tests or acceptance tests or calibration tests. The results may serve as an important impression as to the applicability of several functions and results of the OMICRON CT ANALYZER for testing of current transformers.

## 1 VERIFICATION CHECKS OF THE ANALYZER TEST FUNCTION FOR DETERMINATION OF WINDING RESISTANCE

First in April 2005 and in October 2005 several checks were carried out in order to verify whether the OMICRON CT ANALYZER was able to perform its function: determination of winding resistance.

For the purpose of this verification some resistance values were determined in two ways: using the OMICRON CT ANALYZER and using a KEMA laboratory instrument.

Initially this verification was performed in a functional way on several current transformers, during resistance measurements of windings of some available current transformers. The results were compared with results obtained using other instruments at KEMA. It was not the intention to carry out accurate tests. The results of these checks are presented in appendix 1 page 1 of this report.
From the results it was concluded that the OMICRON CT ANALYZER did not cause any functional problem during the checks.

Subsequently, in order to gather more information as to the accuracy of the measurements, this verification was performed on two standard resistors, used as standard shunt in the KEMA laboratory. Since the calibration results of these shunts are available, a better check of this function of the OMICRON CT ANALYZER could be made. For this purpose the (known) resistance values of these shunts were determined using the OMICRON CT ANALYZER.

The results are presented in appendix 1 page 2 of this report.

From the results it can be concluded that the deviation between the results of the tests carried out using the analyzer and those carried out using other instruments is small.
Although the checks are not systematically covering the full range of the possibilities of the analyzer for the determination of winding resistance, it can be concluded that the results that were produced by the OMICRON CT ANALYZER were correct and precise for those resistance values that were determined.

## 2 VERIFICATION CHECKS OF THE ANALYZER TEST FUNCTION FOR THE DETERMINATION OF CURRENT TRANSFORMER TRANSFORMATION ERRORS

First in April 2005 and in October 2005 several checks were carried out in order to verify whether the OMICRON CT ANALYZER was able to perform its function: determination of current transformer transformation errors.

For this purpose accuracy tests were carried out in two ways: using the OMICRON CT ANALYZER and using a KEMA laboratory accuracy measuring bridge. The accuracy tests were carried out on several current transformers of various design and ratings. For the presentation and results four examples were selected from the many tests carried out.

The transformation errors of four current transformers were measured using 1) the KEMA transformation error measuring bridge and 2) the OMICRON CT ANALYZER.

The transformation errors of the current transformers generally were determined at 50 Hz.

### 2.1 Determination of transformation errors for measuring purposes on CT OMICRON 05

The current error (%) and the phase displacement (min) were determined at rated current (2000 A) and respectively with burdens of 2,5 VA, COS(β) = 1,0 and of 1,25 VA, COS(β) = 1,0. In this case the measurements were carried out at both 50 Hz and 60 Hz.

### 2.2 Determination of transformation errors for measuring purposes on CT OMICRON 01

The current error (%) and the phase displacement (min) were determined at rated current (2000 A) and respectively with burdens of 2,58 VA, COS(β) = 1 and of 15,25 VA, COS(β) = 0,8 (15 VA is rated burden). The measurements were carried out at 50 Hz.

### 2.3 Determination of transformation errors for measuring purposes on CT OMICRON 02

The current error (%) and the phase displacement (min) were determined at rated current (1000 A) and respectively with burdens of 1,29 VA, COS(β) = 1 and of 14,9 VA, COS(β) = 0,8 (1 VA is rated burden). The measurements were carried out at 50 Hz.

### 2.4 Determination of transformation errors for measuring purposes on CT OMICRON 03 (with air gap)

The current error (%) and the phase displacement (min) were determined at rated current (1000 A) and respectively with burdens of 1,28 VA, COS(β) = 1 and of 14,8 VA, COS(β) = 0,8 (1,5 VA is rated burden). The measurements were carried out at 50 Hz.

### 2.5 Determination of transformation errors for measuring purposes on CT OMICRON 04 (with air gap)

The current error (%) and the phase displacement (min) were determined at rated current (1200 A) and respectively with burdens of 5,16 VA, COS(β) = 0,8 and of 7,50 VA, COS(β) = 0,8 and of 9,86 VA, COS(β) = 0,8 (5 VA is rated burden). The measurements were carried out at 50 Hz.

The results are presented in appendix 2 pages 1, 2 and 3 of this report.

From the results the following conclusions were drawn:

- The results of the determination of transformation errors, as carried out, on the current transformers and for the values of current and burden as indicated in this report, and measured using the OMICRON CT ANALYZER, do not differ significantly from those determined by the KEMA measuring bridge and instrumentation.

- Further reference is given in the appendixes A, B, C, D.

## 3 VERIFICATION CHECKS OF THE ANALYZER TEST FUNCTION FOR THE DETERMINATION OF CURRENT TRANSFORMER EXCITATION CURVES

In October 2005 several checks were carried out in order to verify whether the OMICRON CT ANALYZER was able to perform its function: determination of current transformer excitation curves.

For this purpose curves measuring tests were carried out in two ways: using the OMICRON CT ANALYZER and using a KEMA laboratory instruments. The measurements were carried out on several current transformers of various design and ratings. For the presentation and results four examples were selected from the many tests carried out.

The excitation curves of four current transformers were measured using 1) the KEMA laboratory instruments and 2) the OMICRON CT ANALYZER.
The excitation curves of the current transformers were determined at the rated frequency 50 Hz.

The results are presented in appendix 3 pages 1-8 of this report.

It has to be noted that the accuracy of the measurements by KEMA may have been affected by noise coming from neighboring tests. This, together with the nature of the selected instrumentation for measurement of voltage and current may have resulted in a higher level of uncertainty than normal.

It has to be noted too that the values in the tables, for the excitation current were taken at the voltage levels selected by KEMA. From the OMICRON CT ANALYZER the excitation currents at these voltage levels could be taken only after interpolation between other voltage levels, as selected by the OMICRON CT ANALYZER, within the appropriate range.

From the results the following conclusions were drawn:

- The results of the determination of excitation curves, as carried out, on the current transformers and for the values of voltage as indicated in this report, and measured using the OMICRON CT ANALYZER, do not differ significantly from those determined by the KEMA measuring instruments.
- Some differences, in individual numbers of current and voltage, in several cases, are mostly related to saturation effects that are visible in the curves and do not affect the overall curve and still allow the correct derivation of further quantities from these curves.

- Further reference is given in the appendixes A, B, C, D.

## 4 VERIFICATION CHECKS OF THE ANALYZER TEST FUNCTION FOR THE DETERMINATION OF SOME ADDITIONAL ANALYZER TEST FUNCTIONS

In April and in October 2005 several checks were carried out in order to verify whether the OMICRON CT ANALYZER was able to perform other test functions, additional to those mentioned in paragraphs 1, 2 and 3 of this report.

Since, as a result of the automatic and integrated operation of the OMICRON CT ANALYZER, several additional test functions came into operation during the checks and verifications performed, these functions resulted in output parameter values such as for Fs, Ts, knee-point data, etc.

The presentation of the results by the OMICRON CT ANALYZER seems trustworthy; however not all results were verified or checked by KEMA.

Since the magnetization curves had been determined for several current transformers, by KEMA and by the OMICRON CT ANALYZER as well, a comparison could be made for the resulting knee-point data.

The results are presented in appendix 4 page 1.

It has to be noted that the accuracy of the measurements by KEMA may have been affected by noise coming from neighboring tests. This, together with the nature of the selected instrumentation for measurement of voltage and current may have resulted in a higher level of uncertainty than normal.

Nevertheless, from the results can be concluded:

- that the knee-point data, determined by the OMICRON CT-ANALYZER, are quite similar to or better than those following from the measurements carried out by KEMA

- Further reference is given in the appendixes A, B, C, D.

Appendix 1 page 1

| | |
|---|---|
| Client | OMICRON, Klaus, Austria |
| Test object | CT Analyzer, manufactured by the client |
| Requirements | Functional impression only |
| Test date | 27 October 2005 |

## 1 RESULTS OF THE VERIFICATION CHECKS OF THE ANALYZER TEST FUNCTION FOR DETERMINATION OF WINDING RESISTANCE

**Atmospheric conditions**

| | | | | | |
|---|---|---|---|---|---|
| Ambient temperature | 20 | °C | Ambient air pressure | 1018 | hPa |
| Object temperature | 20 | °C | Humidity | 14 | $g/m^3$ |

| object tested | resistance measured using KEMA-laboratory ohm-meter (Ω) | resistance measured using OMICRON CT-ANALYZER (Ω) | deviation (%) | notes |
|---|---|---|---|---|
| CT OMICRON 01 winding 2000/1 | 8,90 | 8,847 | -0,6 | These values were measured in order to have an initial functional check only.<br><br>No functional problems occurred during the functional determination of winding resistance values.<br><br>The accuracy of the check is low for a numerical accuracy evaluation. |
| CT OMICRON 01 winding 2000/5 | 0,428 | 0,423 | -1,2 | |
| CT OMICRON 02 winding 1000/1 | 3,68 | 3,636 | -1,2 | |
| CT OMICRON 03 winding 1000/1 | 2,72 | 2,681 | -1,4 | |
| CT OMICRON 04 winding 1200/1 | 2,12 | 2,083 | -1,7 | |
| CT OMICRON 05 winding 2000/1 | 10,17 | 10,16 | -0,1 | |
| CT KEMA 01 winding 5000/5 | 1,30 | 1,281 | - 1,46 | |
| CT KEMA 01 winding 10000/5 | 2,81 | 2,767 | - 1,53 | |
| CT KEMA 02 winding 5000/5 | 1,96 | 1,969 | + 0,46 | |
| CT KEMA 02 winding 10000/5 | 4,75 | 4,726 | - 0,50 | |

| | |
|---|---|
| Client | OMICRON, Klaus, Austria |
| Test object | CT Analyzer, manufactured by the client |
| Requirements | Precise resistance measurement |
| Test date | 29 October 2005 |

## 1 RESULTS OF THE VERIFICATION CHECKS OF THE ANALYZER TEST FUNCTION FOR DETERMINATION OF WINDING RESISTANCE (continued)

**Atmospheric conditions**

| | | | | | |
|---|---|---|---|---|---|
| Ambient temperature | 20 | °C | Ambient air pressure | 1015 | hPa |
| Object temperature | 20 | °C | Humidity | 14 | $g/m^3$ |

| object tested | resistance measured as per KEMA-calibration certificate (mΩ) | resistance * measured using OMICRON CT-ANALYZER (mΩ) | deviation (%) | notes |
|---|---|---|---|---|
| KEMA shunt ORS 105412 | 10,00048 | 10,01 | 0,1 | see below |
| KEMA shunt ORS 105398 | 99,9974 | 100,0 | < 0,1 | |

* These values represent the average values of ten individual measurements. All ten individual results were equal to the average.

Appendix 2 page 1

| | |
|---|---|
| Client | OMICRON, Klaus, Austria |
| Test object | CT Analyzer, manufactured by the client |
| Requirements | IEC 60044-1(1996) + amendment 1(2000) + amendment 2(2002) |
| Test date | 5 April 2005 |

## 2 RESULTS OF THE VERIFICATION CHECKS OF THE ANALYZER TEST FUNCTION FOR DETERMINATION OF CURRENT TRANSFORMER TRANSFORMATION ERRORS

**Atmospheric conditions**

| | | | | | |
|---|---|---|---|---|---|
| Ambient temperature | 20 | °C | Ambient air pressure | 1014 | hPa |
| Object temperature | 20 | °C | Humidity | 12 | $g/m^3$ |

### 2.1 Transformation errors for measuring purposes on CT OMICRON 05 at 50 Hz

| **CT OMICRON 05 ratio 2000/1 at 2000 A** | | **measured with KEMA measuring bridge** | | **measured with OMICRON CT ANALYZER** | |
|---|---|---|---|---|---|
| burden | | ratio error | phase displacement | ratio error | phase displacement |
| (VA) | COS(β) | (%) | (min) | (%) | (min) |
| 2,5 | 1,0 | - 0,015 | + 0,5 | - 0,004 | + 0,3 |
| 1,25 | 1,0 | - 0,015 | + 0,5 | - 0,003 | + 0,2 |

### 2.2 Transformation errors for measuring purposes on CT OMICRON 05 at 60 Hz

| **CT OMICRON 05 ratio 2000/1 at 2000 A** | | **measured with KEMA measuring bridge** | | **measured with OMICRON CT ANALYZER** | |
|---|---|---|---|---|---|
| burden | | ratio error | phase displacement | ratio error | phase displacement |
| (VA) | COS(β) | (%) | (min) | (%) | (min) |
| 2,5 | 1,0 | - 0,015 | + 0,5 | - 0,002 | + 0,2 |
| 1,25 | 1,0 | - 0,015 | + 0,5 | - 0,001 | + 0,2 |

| | |
|---|---|
| Client | OMICRON, Klaus, Austria |
| Test object | CT Analyzer, manufactured by the client |
| Requirements | IEC 60044-1(1996) + amendment 1(2000) + amendment 2(2002) |
| Test date | 27 October 2005 |

## 2 RESULTS OF THE VERIFICATION CHECKS OF THE ANALYZER TEST FUNCTION FOR DETERMINATION OF CURRENT TRANSFORMER TRANSFORMATION ERRORS (Continued)

**Atmospheric conditions**

| | | | | | |
|---|---|---|---|---|---|
| Ambient temperature | 20 | °C | Ambient air pressure | 1018 | hPa |
| Object temperature | 20 | °C | Humidity | 14 | $g/m^3$ |

### 2.3 Transformation errors for measuring purposes on CT OMICRON 01 at 50 Hz

| **CT OMICRON 01 ratio 2000/1 at 2000 A** | | **measured with KEMA measuring bridge** | | **measured with OMICRON CT ANALYZER** | |
|---|---|---|---|---|---|
| burden | | ratio error | phase displacement | ratio error | phase displacement |
| (VA) | COS(β) | (%) | (min) | (%) | (min) |
| 15,25 | 0,8 | - 0,024 | + 0,1 | - 0,022 | + 0,05 |
| 2,58 | 1,0 | - 0,01 | + 0,3 | - 0,01 | + 0,27 |

### 2.4 Transformation errors for measuring purposes on CT OMICRON 02 at 50 Hz

| **CT OMICRON 01 ratio 1000/1 at 1000 A** | | **measured with KEMA measuring bridge** | | **measured with OMICRON CT ANALYZER** | |
|---|---|---|---|---|---|
| burden | | ratio error | phase displacement | ratio error | phase displacement |
| (VA) | COS(β) | (%) | (min) | (%) | (min) |
| 14,9 | 0,8 | - 0,07 | + 0,4 | - 0,05 | + 0,17 |
| 1,29 | 1,0 | - 0,02 | + 0,9 | - 0,017 | + 0,53 |

| | |
|---|---|
| Client | OMICRON, Klaus, Austria |
| Test object | CT Analyzer, manufactured by the client |
| Requirements | IEC 60044-1(1996) + amendment 1(2000) + amendment 2(2002) |
| Test date | 27 October 2005 |

## 2 RESULTS OF THE VERIFICATION CHECKS OF THE ANALYZER TEST FUNCTION FOR DETERMINATION OF CURRENT TRANSFORMER TRANSFORMATION ERRORS (continued)

**Atmospheric conditions**

| | | | | | |
|---|---|---|---|---|---|
| Ambient temperature | 20 | °C | Ambient air pressure | 1018 | hPa |
| Object temperature | 20 | °C | Humidity | 14 | $g/m^3$ |

### 2.5 Transformation errors for measuring purposes on CT OMICRON 03 at 50 Hz

| **CT OMICRON 01 ratio 1000/1 at 1000 A** | | **measured with KEMA measuring bridge** | | **measured with OMICRON CT ANALYZER** | |
|---|---|---|---|---|---|
| burden | | ratio error | phase displacement | ratio error | phase displacement |
| (VA) | COS(β) | (%) | (min) | (%) | (min) |
| 14,75 | 0,8 | - 0,97 | + 58,6 | - 1,060 | + 57,58 |
| 1,28 | 1,0 | + 0,16 | + 16,9 | + 0,030 | + 16,89 |

### 2.5 Transformation errors for measuring purposes on CT OMICRON 04 at 50 Hz

| **CT OMICRON 01 ratio 1200/1 at 1200 A** | | **measured with KEMA measuring bridge** | | **measured with OMICRON CT ANALYZER** | |
|---|---|---|---|---|---|
| burden | | ratio error | phase displacement | ratio error | phase displacement |
| (VA) | COS(β) | (%) | (min) | (%) | (min) |
| 9,86 | 0,8 | - 4,13 | + 218 | - 3,59 | + 222 |
| 7,50 | 0,8 | - 3,00 | + 179 | + 2,62 | + 182 |
| 5,16 | 0,8 | - 1,94 | + 138 | - 1,658 | + 142 |

Appendix 3 page 1

| | |
|---|---|
| Client | OMICRON, Klaus, Austria |
| Test object | CT Analyzer, manufactured by the client |
| Requirements | IEC 60044-1(1996) + amendment 1(2000) + amendment 2(2002) |
| Test date | 28 October 2005 |

## 3 RESULTS OF THE VERIFICATION CHECKS OF THE ANALYZER TEST FUNCTION FOR DETERMINATION OF CURRENT TRANSFORMER EXCITATION CURVES

**Atmospheric conditions**

| | | | | | |
|---|---|---|---|---|---|
| Ambient temperature | 20 | °C | Ambient air pressure | 1016 | hPa |
| Object temperature | 20 | °C | Humidity | 13 | $g/m^3$ |

### 3.1 Excitation curve measured on CT OMICRON 01

| | **measured with KEMA instruments** | **measured with OMICRON CT ANALYZER** |
|---|---|---|
| **voltage across terminals (V)** | **excitation current (A)** | **excitation current (A)** |
| 92,02 | 1,982 | 2,0806 |
| 85,9 | 1,047 | 1,08686 |
| 82,95 | 0,5432 | 0,58272 |
| 81,42 | 0,2657 | 0,31688 |
| 80,56 | 0,1082 | 0,16880 |
| 79,78 | 0,016 | 0,05315 |
| **(V)** | **(mA)** | **(mA)** |
| 76,9 | 4,31 | 4,41936 |
| 70,07 | 1,57 | 1,59109 |
| 60,26 | 0,625 | 0,64075 |
| 50,22 | 0,454 | 0,42985 |
| 39,89 | 0,368 | 0,33294 |
| 29,89 | 0,280 | 0,25201 |
| 20,38 | 0,208 | 0,18633 |
| 10,35 | 0,129 | 0,11375 |

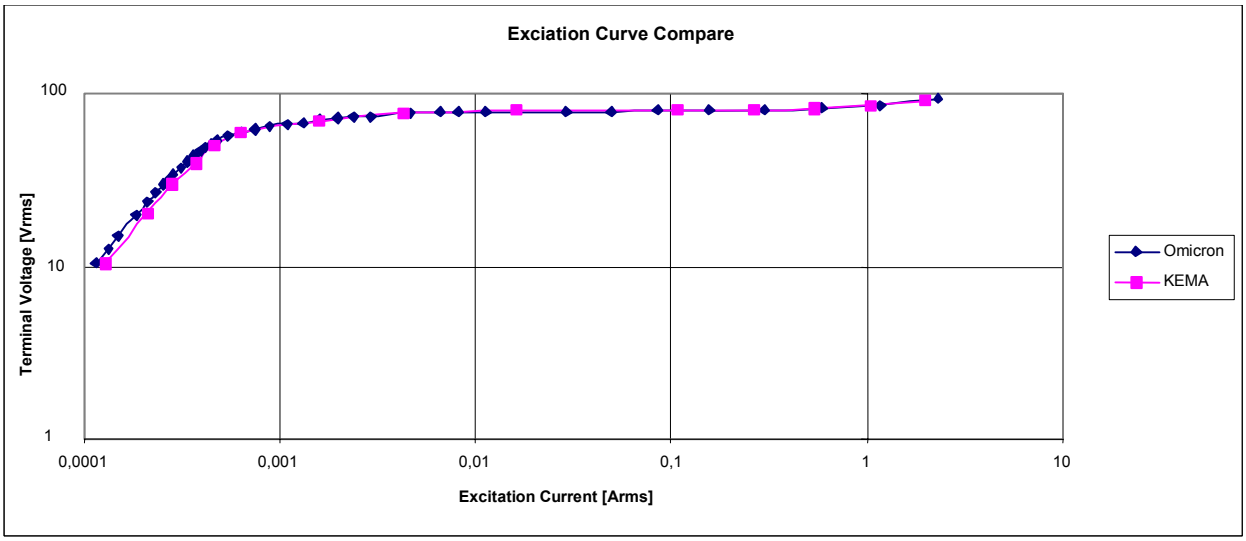
| | |
|---|---|
| Client | OMICRON, Klaus, Austria |
| Test object | CT Analyzer, manufactured by the client |
| Requirements | IEC 60044-1 (1996) + amendment 1 (2000) + amendment 2 (2002) |
| Test date | 28 October 2005 |

## 3 RESULTS OF THE VERIFICATION CHECKS OF THE ANALYZER TEST FUNCTION FOR DETERMINATION OF CURRENT TRANSFORMER EXCITATION CURVES

**Atmospheric conditions**

| | | | | | |
|---|---|---|---|---|---|
| Ambient temperature | 20 | °C | Ambient air pressure | 1016 | hPa |
| Object temperature | 20 | °C | Humidity | 13 | $g/m^3$ |

### 3.1 Excitation curve measured on CT OMICRON 01



| | |
|---|---|
| Client | OMICRON, Klaus, Austria |
| Test object | CT Analyzer, manufactured by the client |
| Requirements | IEC 60044-1 (1996) + amendment 1 (2000) + amendment 2 (2002) |
| Test date | 28 October 2005 |

## 3 RESULTS OF THE VERIFICATION CHECKS OF THE ANALYZER TEST FUNCTION FOR DETERMINATION OF CURRENT TRANSFORMER EXCITATION CURVES (continued)

**Atmospheric conditions**

| | | | | | |
|---|---|---|---|---|---|
| Ambient temperature | 20 | °C | Ambient air pressure | 1016 | hPa |
| Object temperature | 20 | °C | Humidity | 13 | $g/m^3$ |

### 3.2 Excitation curve measured on CT OMICRON 02

| | **measured with KEMA instruments** | **measured with OMICRON CT ANALYZER** |
|---|---|---|
| **voltage across terminals (V)** | **excitation current (A)** | **excitation current (A)** |
| 160 | 2,377 | 2,656 |
| 154 | 0,218 | 0,343 |
| **(V)** | **(mA)** | **(mA)** |
| 152,7 | 30,6 | 61,2 |
| 148,2 | 7,10 | 7,45 |
| 138,9 | 3,04 | 3,516 |
| 125,8 | 2,246 | 2,473 |
| 96,24 | 1,650 | 1,653 |
| 55,33 | 1,068 | 1,010 |
| 28,11 | 0,659 | 0,616 |
| 11,92 | 0,378 | 0,346 |
| 4,247 | 0,191 | 0,179 |
| 2,734 | 0,143 | 0,134 |

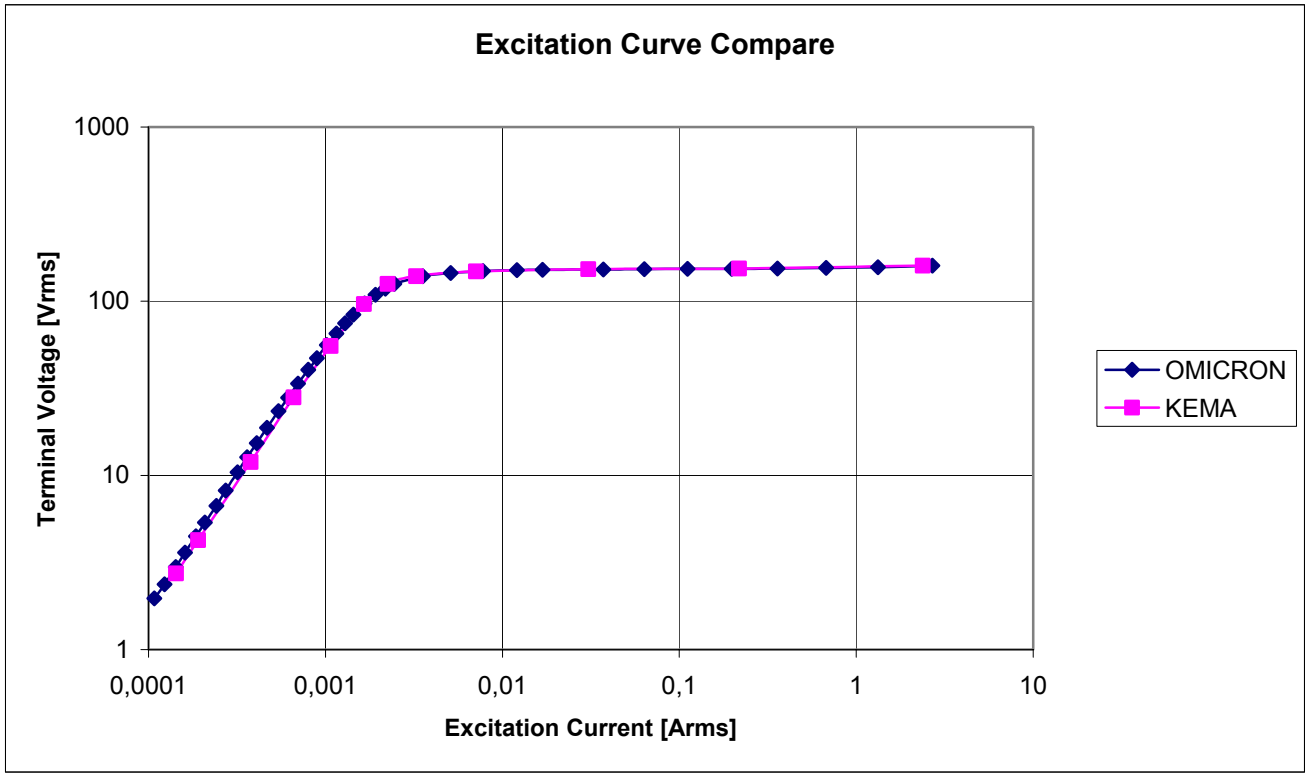
| | |
|---|---|
| Client | OMICRON, Klaus, Austria |
| Test object | CT Analyzer, manufactured by the client |
| Requirements | IEC 60044-1 (1996) + amendment 1 (2000) + amendment 2 (2002) |
| Test date | 28 October 2005 |

## 3 RESULTS OF THE VERIFICATION CHECKS OF THE ANALYZER TEST FUNCTION FOR DETERMINATION OF CURRENT TRANSFORMER EXCITATION CURVES (continued)

**Atmospheric conditions**

| | | | | | |
|---|---|---|---|---|---|
| Ambient temperature | 20 | °C | Ambient air pressure | 1016 | hPa |
| Object temperature | 20 | °C | Humidity | 13 | $g/m^3$ |

### 3.2 Excitation curve measured on CT OMICRON 02



| | |
|---|---|
| Client | OMICRON, Klaus, Austria |
| Test object | CT Analyzer, manufactured by the client |
| Requirements | IEC 60044-1 (1996) + amendment 1 (2000) + amendment 2 (2002) |
| Test date | 28 October 2005 |

## 3 RESULTS OF THE VERIFICATION CHECKS OF THE ANALYZER TEST FUNCTION FOR DETERMINATION OF CURRENT TRANSFORMER EXCITATION CURVES (continued)

**Atmospheric conditions**

| | | | | | |
|---|---|---|---|---|---|
| Ambient temperature | 20 | °C | Ambient air pressure | 1016 | hPa |
| Object temperature | 20 | °C | Humidity | 13 | $g/m^3$ |

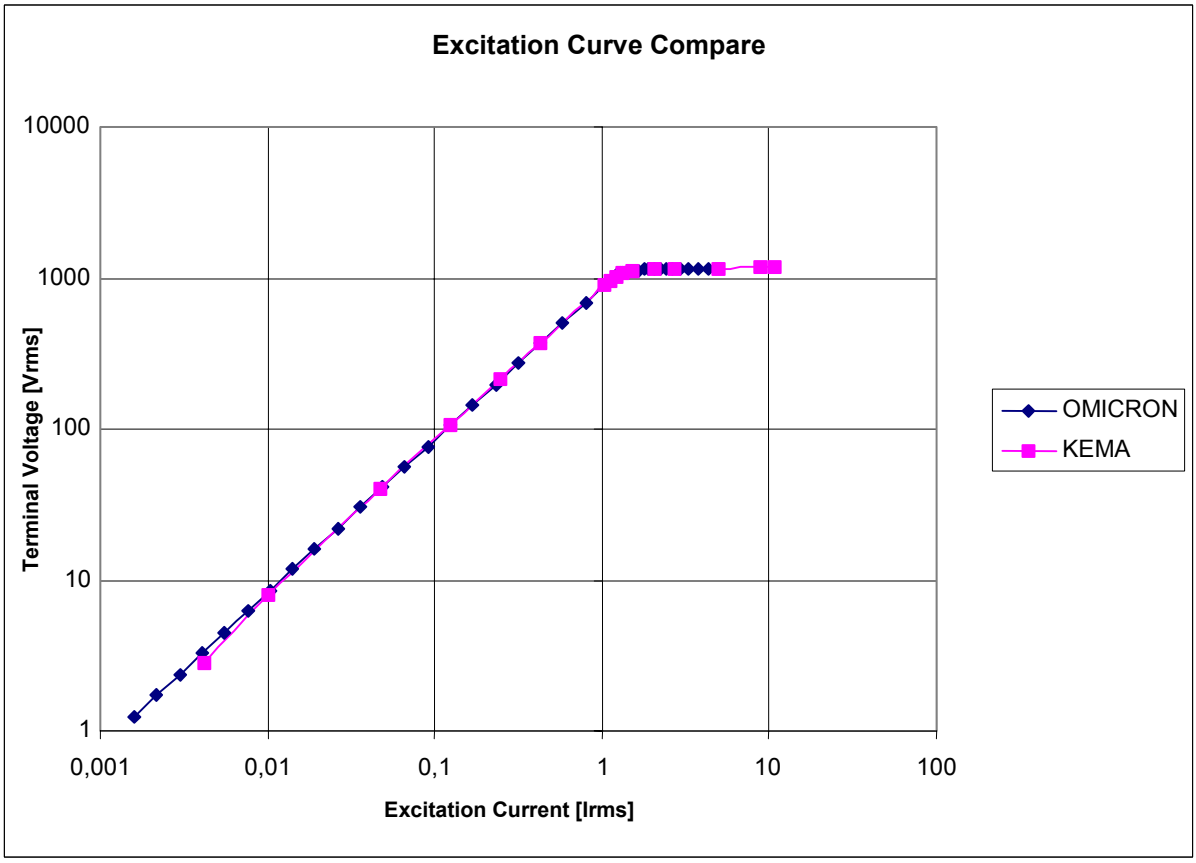
### 3.3 Excitation curve measured on CT OMICRON 03

| | **measured with KEMA instruments** | **measured with OMICRON CT ANALYZER** |
|---|---|---|
| **Voltage across terminals (V)** | **Excitation current (A)** | **Excitation current (A)** |
| 1149 | 2,739 | 2,526 |
| 1140 | 2,054 | 2,019 |
| 1113 | 1,506 | 1,519 |
| 1079 | 1,323 | 1,331 |
| 1027 | 1,210 | 1,215 |
| 964 | 1,124 | 1,126 |
| 886 | 1,028 | 1,031 |
| **(V)** | **(mA)** | **(mA)** |
| 368 | 426 | 426 |
| 213 | 248 | 248 |
| 105 | 124 | 124 |
| 40,0 | 47,8 | 47,5 |
| 7,98 | 10,0 | 9,67 |
| 2,82 | 4,20 | 3,51 |

| | |
|---|---|
| Client | OMICRON, Klaus, Austria |
| Test object | CT Analyzer, manufactured by the client |
| Requirements | IEC 60044-1 (1996) + amendment 1 (2000) + amendment 2 (2002) |
| Test date | 28 October 2005 |

## 3 RESULTS OF THE VERIFICATION CHECKS OF THE ANALYZER TEST FUNCTION FOR DETERMINATION OF CURRENT TRANSFORMER EXCITATION CURVES (continued)

### 3.3 Excitation curve measured on CT OMICRON 03



| | |
|---|---|
| Client | OMICRON, Klaus, Austria |
| Test object | CT Analyzer, manufactured by the client |
| Requirements | IEC 60044-1 (1996) + amendment 1 (2000) + amendment 2 (2002) |
| Test date | 28 October 2005 |

## 3 RESULTS OF THE VERIFICATION CHECKS OF THE ANALYZER TEST FUNCTION FOR DETERMINATION OF CURRENT TRANSFORMER EXCITATION CURVES (continued)

**Atmospheric conditions**

| | | | | | |
|---|---|---|---|---|---|
| Ambient temperature | 20 | °C | Ambient air pressure | 1016 | hPa |
| Object temperature | 20 | °C | Humidity | 13 | $g/m^3$ |

### 3.4 Excitation curve measured on CT OMICRON 04

| | **measured with KEMA instrument** | **measured with OMICRON CT ANALYZER** |
|---|---|---|
| **Voltage across terminals (V)** | **Excitation current (A)** | **Excitation current (A)** |
| 997 | 6,70 | 6,515 |
| 713 | 4,80 | 4,810 |
| 327 | 2,20 | 2,202 |
| 169 | 1,13 | 1,14 |
| **(V)** | **(mA)** | **(mA)** |
| 55,1 | 374 | 372 |
| 13,7 | 89,7 | 89,1 |
| 2,82 | 19,5 | 19,2 |

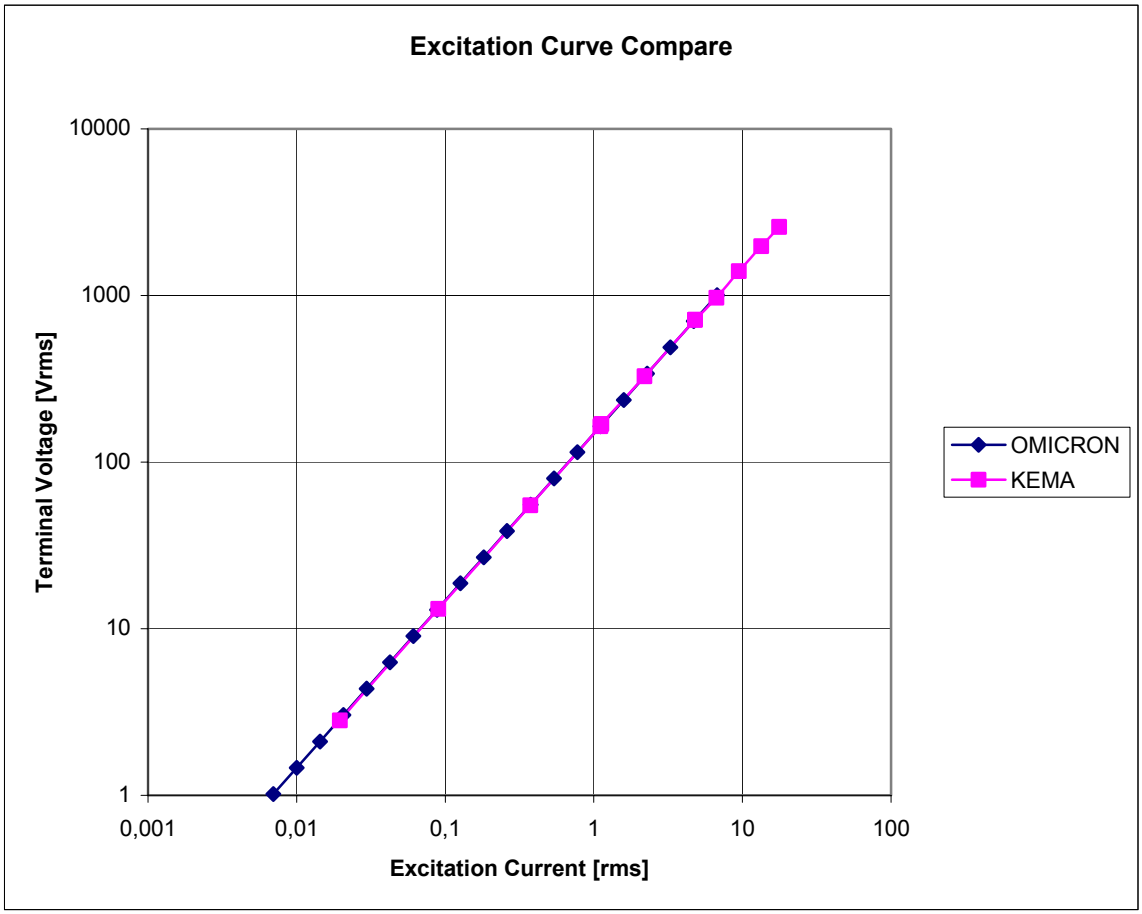
| | |
|---|---|
| Client | OMICRON, Klaus, Austria |
| Test object | CT Analyzer, manufactured by the client |
| Requirements | IEC 60044-1 (1996) + amendment 1 (2000) + amendment 2 (2002) |
| Test date | 28 October 2005 |

## 3 RESULTS OF THE VERIFICATION CHECKS OF THE ANALYZER TEST FUNCTION FOR DETERMINATION OF CURRENT TRANSFORMER EXCITATION CURVES (continued)

**Atmospheric conditions**

| | | | | | |
|---|---|---|---|---|---|
| Ambient temperature | 20 | °C | Ambient air pressure | 1016 | hPa |
| Object temperature | 20 | °C | Humidity | 13 | $g/m^3$ |

### 3.4 Excitation curve measured on CT OMICRON 04



The measurement uncertainties in the results presented are as specified below unless otherwise indicated.

| **measurement** | **measurement uncertainty** |
|---|---|
| dielectric tests<br>and impulse current tests | peak value: ≤ 3%<br>time parameters: ≤ 10% |
| capacitance measurement<br><br>tan δ measurement | 0,3%<br><br>± 0,5% ± $5x10^{-5}$ |
| partial discharge measurement | < 10 pC : 2 pC<br>10 - 100 pC : 5 pC<br>> 100 pC : 20 % |
| measurement of impedance<br>ac-resistance measurement | ≤ 1% |
| measurement of losses | ≤ 1% |
| measurement of insulation resistance | ≤ 10% |
| measurement of dc resistance | 1 μΩ - 5 μΩ : 1%<br>5 μΩ - 10 μΩ : 0,5%<br>10 μΩ - 200 μΩ : 0,2% |
| radio interference test | 2 dB |
| calibration of current transformers | 2,2 x $10^{-4}$ Ii/Iu and 290 μrad |
| calibration of voltage transformers | 1,6 x $10^{-4}$ Ui/Uu en 510 μrad |
| measurement of conductivity | 5% |
| measurement of temperature | -50 °C - -40 °C : 3 K<br>-40 °C - 125 °C : 2 K<br>125 °C - 150 °C : 3 K |
| tensile test | 1% |
| sound level measurement | type 1 meter as per IEC 651 and<br>ANSI S1.4.1971 |
| measurement of voltage ratio | 0,1% |

| | |
|---|---|
| Client | OMICRON, Klaus, Austria |
| Test object | CT Analyzer, manufactured by the client |
| Requirements | IEC 60044-1 (1996) + amendment 1 (2000) + amendment 2 (2002) |
| Test date | 28 October 2005 |

## 4 RESULTS OF THE VERIFICATION CHECKS OF THE ANALYZER TEST FUNCTION FOR DETERMINATION OF KNEE-POINT DATA

**Atmospheric conditions**

| | | | | | |
|---|---|---|---|---|---|
| Ambient temperature | 20 | °C | Ambient air pressure | 1016 | hPa |
| Object temperature | 20 | °C | Humidity | 13 | $g/m^3$ |

| CT | knee point found by OMICRON CT-ANALYZER | knee point found by KEMA measurement | result |
|---|---|---|---|
| OMICRON 1 KSO1811 | 59,26V / 574µA | between 50V-60V<br>between 454µA – 625µA | the knee-point found by the OMICON CT-ANALYZER is between the values found by KEMA measurement |
| OMICRON 2 KSO1812 | 128,81V / 2,68mA | between 125,8V – 138,9V<br>between 2,25mA – 3,25mA | the knee-point found by the OMICON CT-ANALYZER is between the values found by KEMA measurement |
| OMICRON 3 TPY | 1031,5V / 1,222A | between 1079V – 1113V<br>between 1,323A – 1,506A | the knee-point found by the OMICON CT-ANALYZER is close to the values found by KEMA measurement |
| OMICRON 4 TPZ | not reached | not reached | The OMICRON CT-ANALYZER correctly found that the knee-point criteria were not met |

**APPENDIX A**

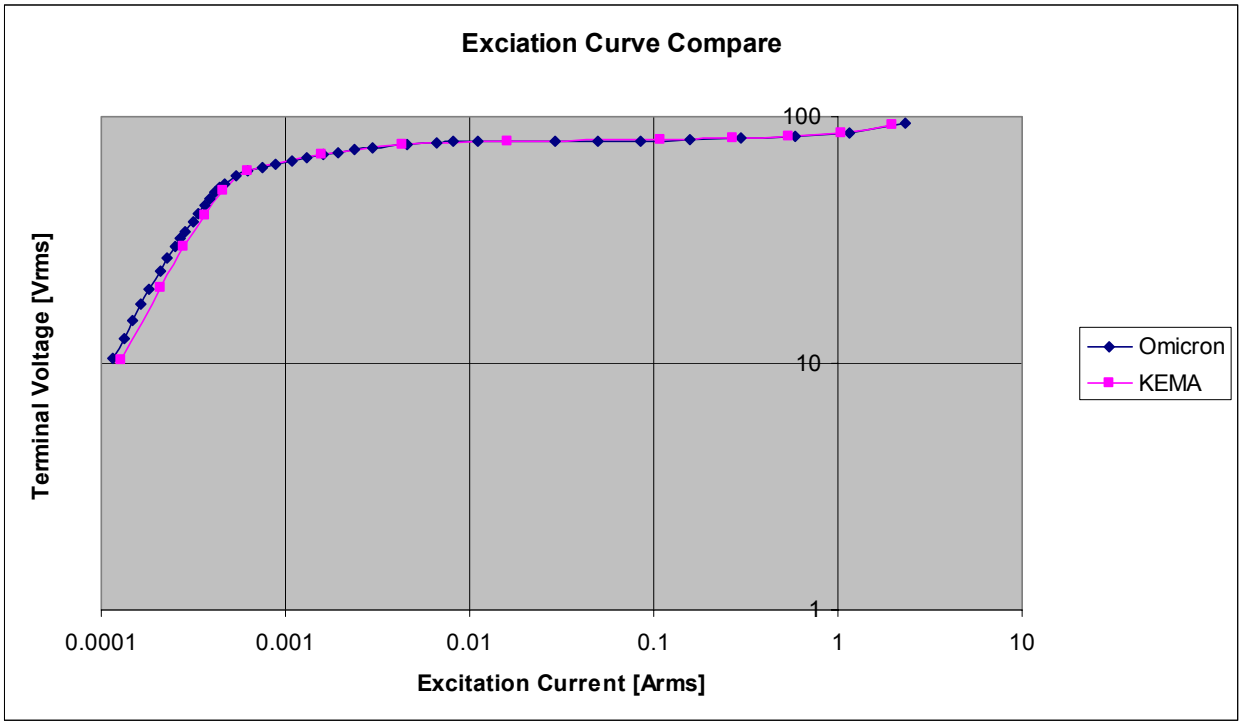
## FURTHER ASSESMENT INFORMATION AS PRESENTED BY THE MANUFACTURER

**(4 pages)**

Tested CT (Current Transformer): **CT OMICRON 1** (see Material Data)

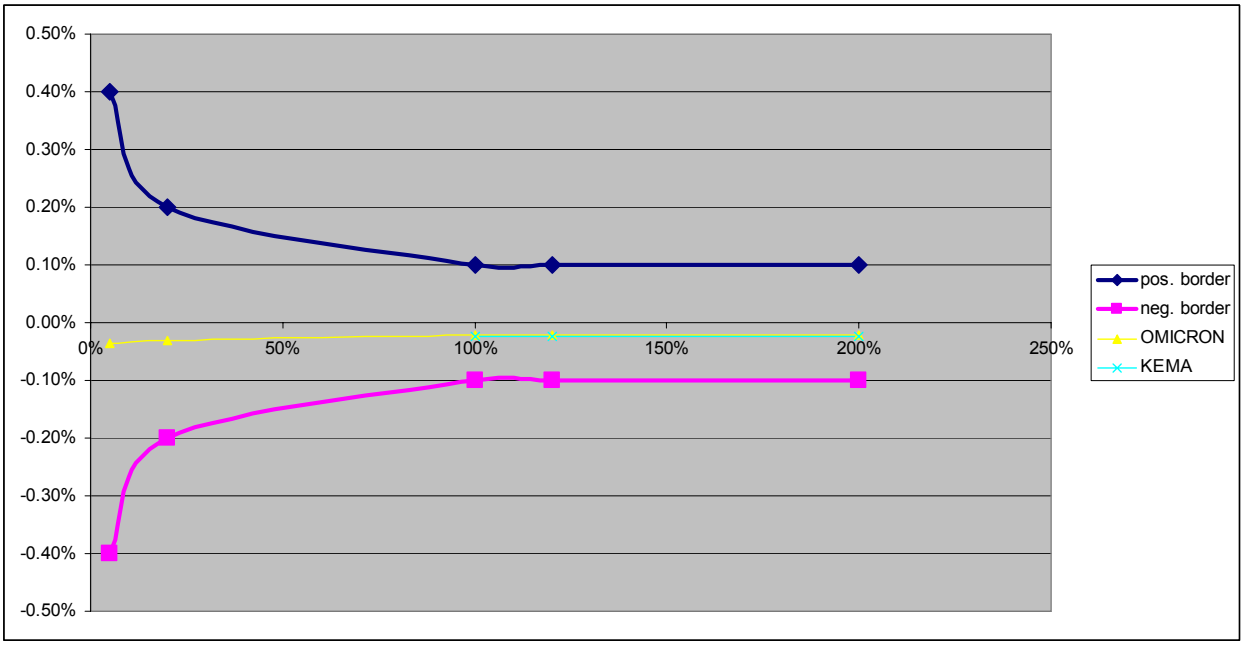
## Excitation Curve Comparison between measurement from Omicron and KEMA

The graph below shows the excitation curve taken with KEMA equipment (pink) and the OMICRON CT Analyzer.



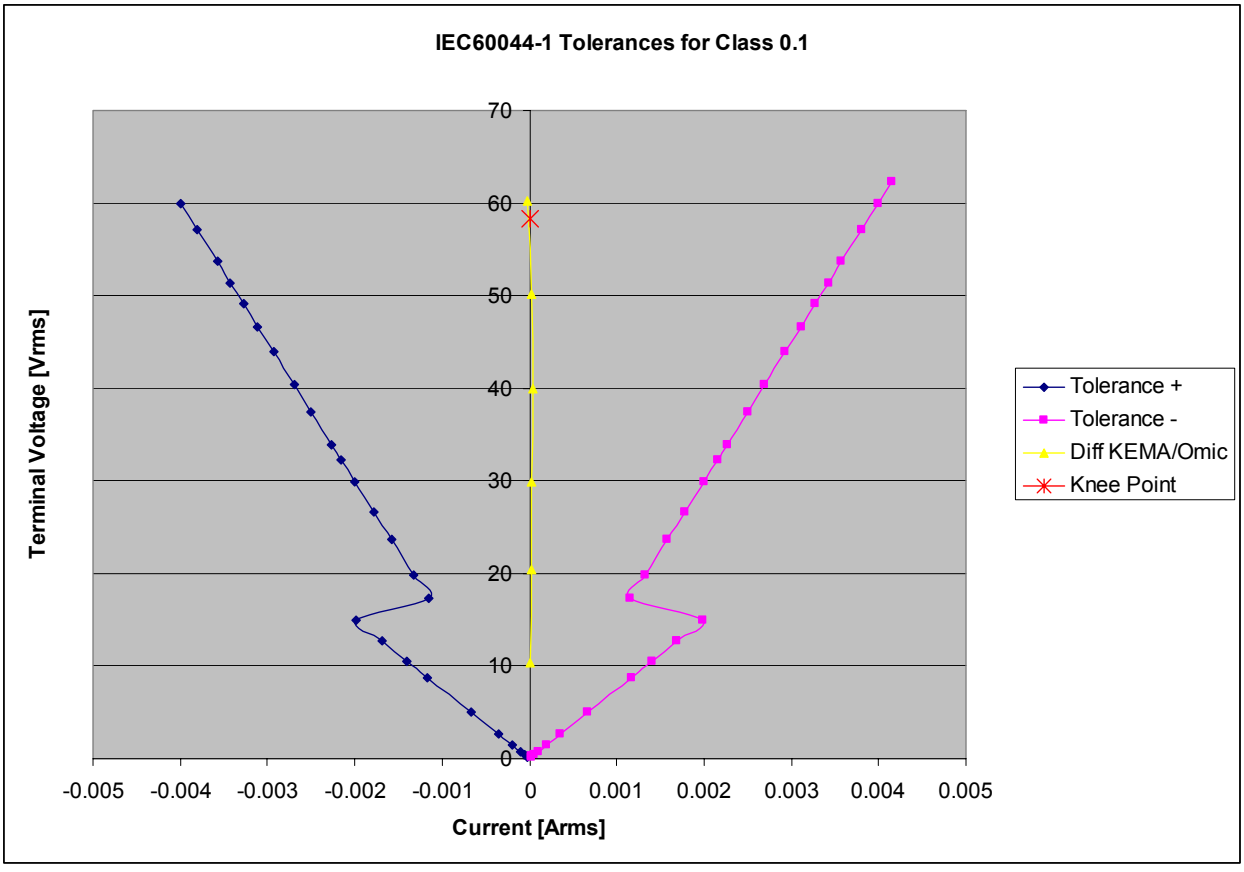
## Comparison of Current Errors in IEC Borders

The graph below shows the difference of the current error calculated from the excitation graph between the excitation measurement from KEMA and the excitation measurement with OMICRON CT-Analyzer.
The used burden was 15VA, Inom = 1A. This graph shall show the influence of the measurement error of the excitation measurement and not the absolute error. It can be seen that a small error in the excitation measurement has practical no influence to the absolute error.



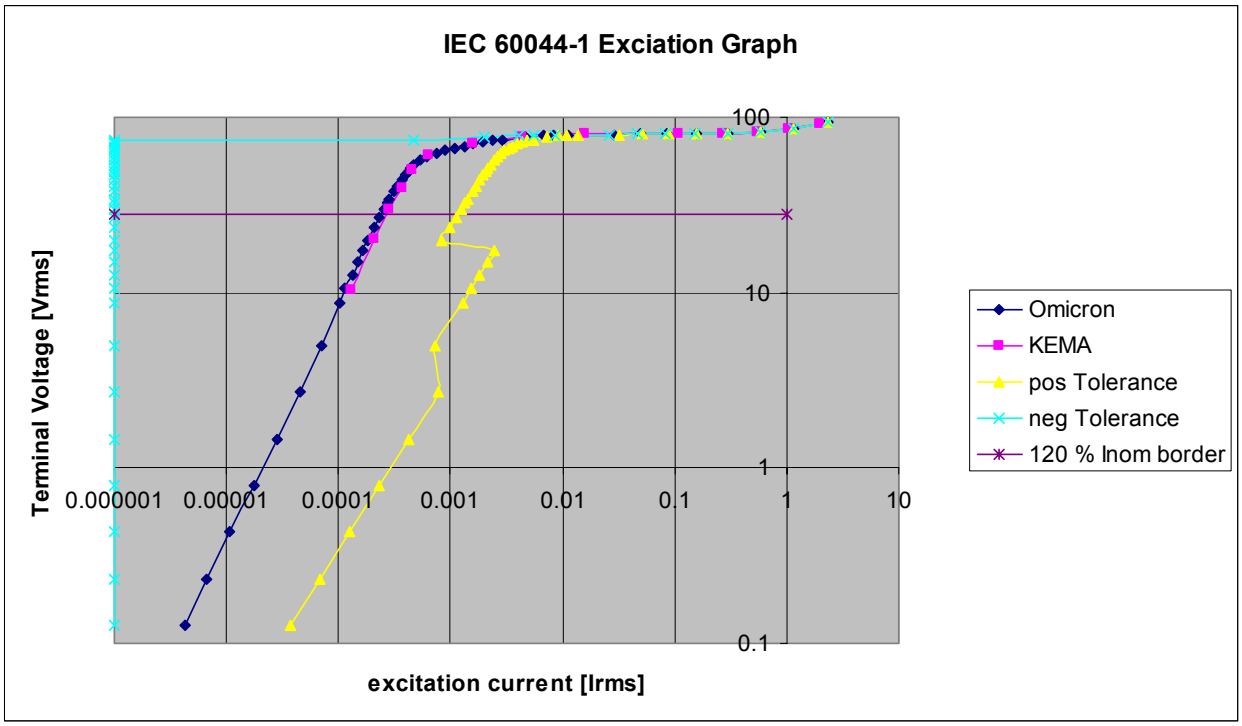
## Comparison of Current deviation up to Knee Point:

The graph below shows the maximum current tolerance to keep the current error within 0,1% and shows the deviation (not absolute values) of current between the measurement with KEMA equipment and the OMICRON CT-Analyzer.
The graphs are only shown up to the knee point. Above the knee point the deviation between the two curves can no more be calculated properly because of the steep current rise. In this area a small deviation in voltage would result in a large current deviation.



## Excitation Curves and Maximum Tolerance Curves

The graph below shows the positive tolerance border (yellow) and the negative tolerance border for IEC 60044-1 as also the two measured excitation curves. The logarithmic scale does not allow the negative tolerance border properly therefore the negative value was limited to 1µA. The IEC60044-1 has defined the tolerances only up to 120% of nominal current in this graph the 0.1% tolerance was used for all currents above 20% I nom.



**APPENDIX B**

## FURTHER ASSESMENT INFORMATION AS PRESENTED BY THE MANUFACTURER

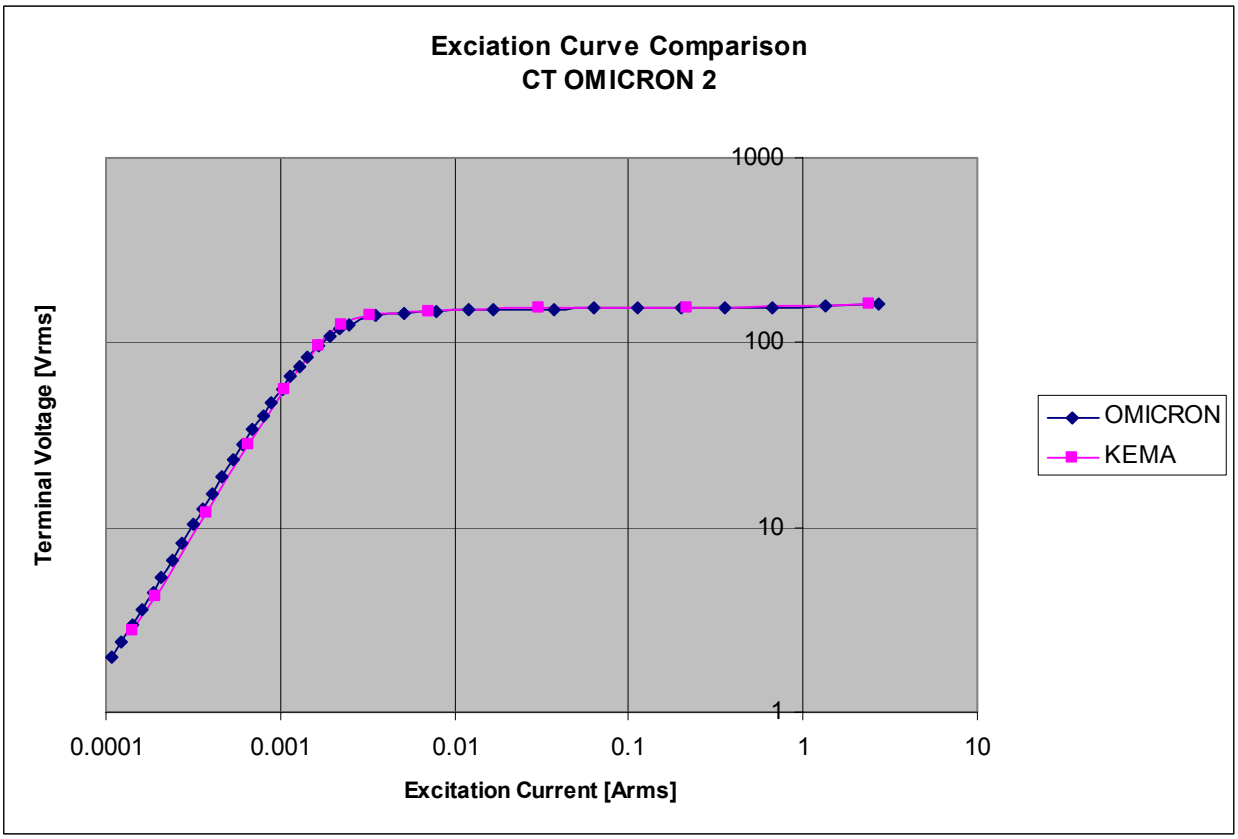
(4 pages)

Tested CT (Current Transformer): **CT OMICRON 2** (see Material Data)

## Excitation Curve - Comparison between Measurement by Omicron and KEMA

Tested CT (Current Transformer):

| | |
|---|---|
| Name: | CT OMICRON 2 (see Material Data) |
| Type: | Measurement core with continuous ring core |
| Class: | 0.02% |
| Burden: | 14.9VA/CosPhi 0.8 |

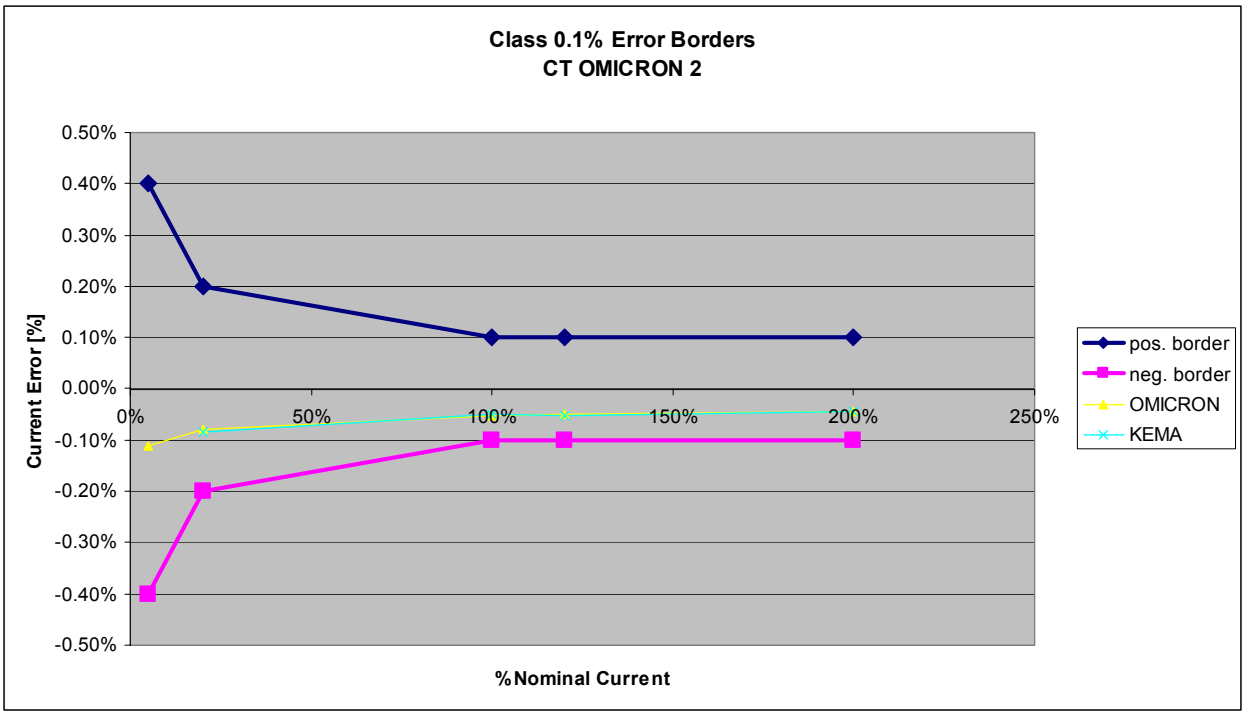



Blue line: Measurement with Omicron CT-Analyzer.
Pink line: Measurement with KEMA equipment.

## Comparison of Current Errors in Tolerance Borders acc. to IEC 60044-1

The graph below shows the current error within the class 0.1 % tolerance borders according to IEC 60044-1. It shows the difference of the current error calculated from the excitation graph measured with the OMICRON *CT Analyzer* and the KEMA test equipment. The calculation was done under the assumption only the excitation current would influence the ratio error, therefore, no excitation current would result in a ratio error of zero.

The used burden was 15 VA, Inom = 1 A. The graph is supposed to show the influence of the measurement error of the excitation measurement and not the absolute ratio error.

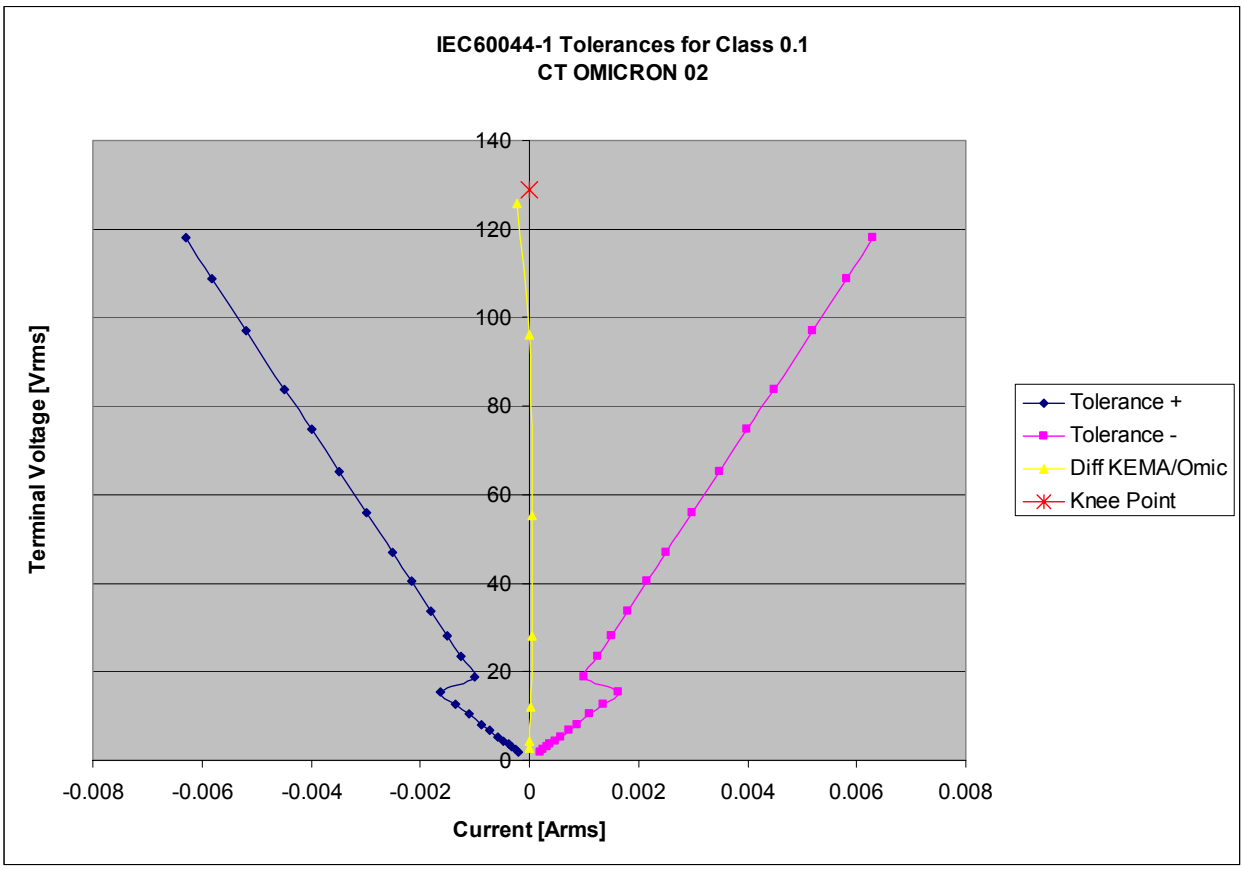


## Comparison of Current Deviation up to Knee Point:

The graph below shows the maximum current tolerance to keep the current error within class 0.1 %. It furthermore shows the deviation (not the absolute values) of current between the measurement with the KEMA equipment and the OMICRON *CT Analyzer* (measurements from KEMA would be 0 $A_{rms}$).

The graphs are shown up to the knee point only. Above the knee point, the deviation between the two curves cannot be calculated properly anymore because of the steep current rise. In this area, a small deviation in voltage would result in a large deviation in current.

Only two tolerance borders were used: a tolerance of 0.2 % below 20 % of $I_{nom}$, and a tolerance of 0.1 % above 20 % of $I_{nom}$.



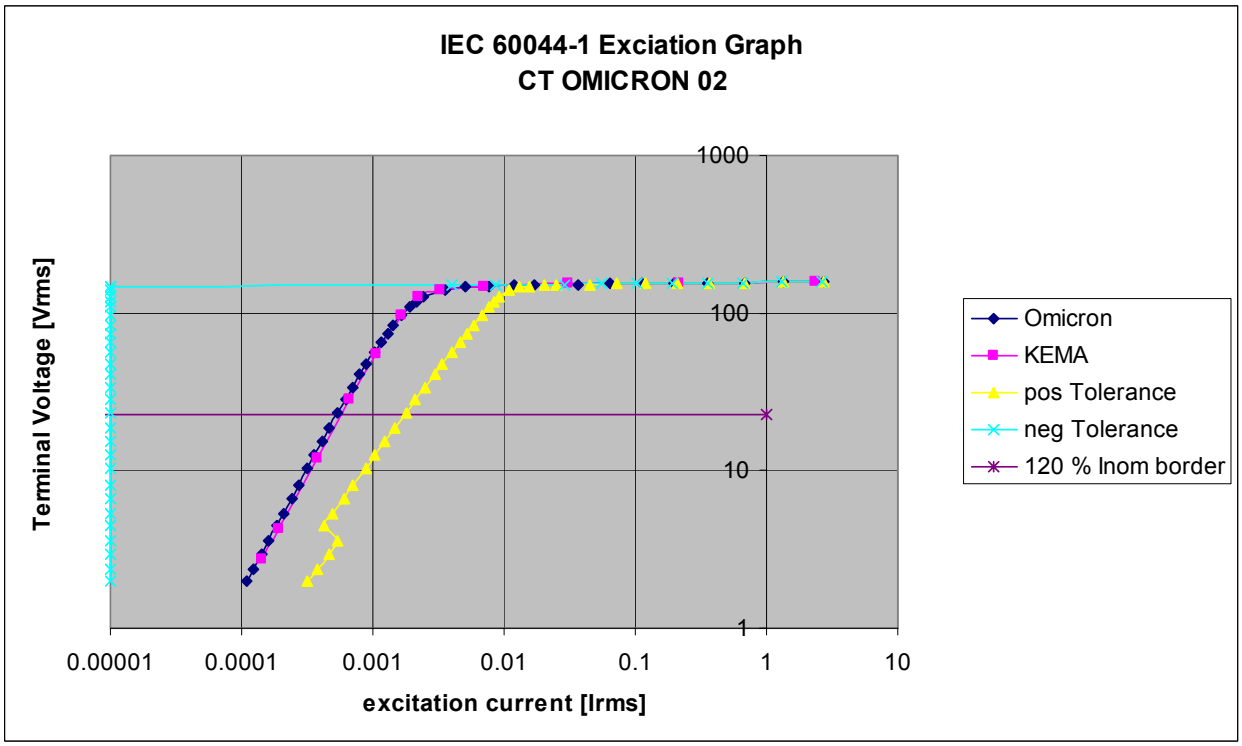
## Excitation Curves and Maximum Tolerance Curves

The graph below shows the positive tolerance border (yellow) and the negative tolerance border as defined in IEC 60044-1 for class 0.1 as well as the two measured excitation curves. The logarithmic scale does not allow the negative tolerance border to be shown properly, therefore the negative values were limited to 10µA. IEC60044-1 only defines the tolerances up to 120% of nominal current.
The 0.1% tolerance was used for all currents above 20% Inom with a burden of 15 Ohm.

The output current was calculated by $Is = \frac{U_{Terminal}}{R_{CT} + R_{Burden}}$

The error border was calculated as in the following example with 100% Inom.

$$I_{posTolerance} = I_s + I_s * 0.001$$



**APPENDIX C**

## FURTHER ASSESMENT INFORMATION AS PRESENTED BY THE MANUFACTURER

(5 pages)

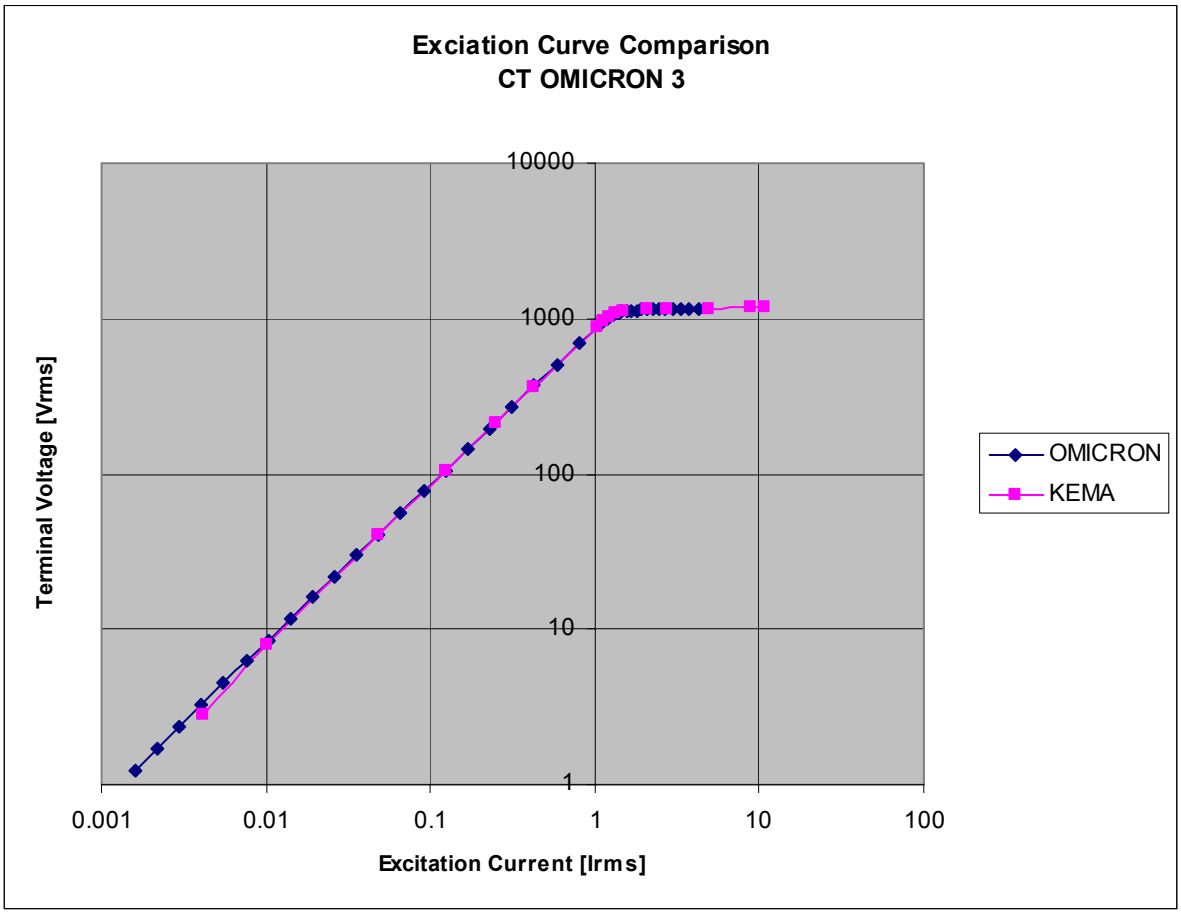
Tested CT (Current Transformer): **CT OMICRON 3** (see Material Data)

## Excitation Curve - Comparison between Measurement by Omicron and KEMA

Tested CT (Current Transformer):

| | |
|---|---|
| Name: | CT OMICRON 3 (see Material Data) |
| Type: | Protection core with gapped ring core |
| Class: | TPY |
| Burden: | 14.75VA/CosPhi 0.8 |

Comment: The OMICRON CT-Analyzer does only guarantee high accuracy for non gapped cores but the measurement results below show that also on gapped protection cores reasonable results can be reached.



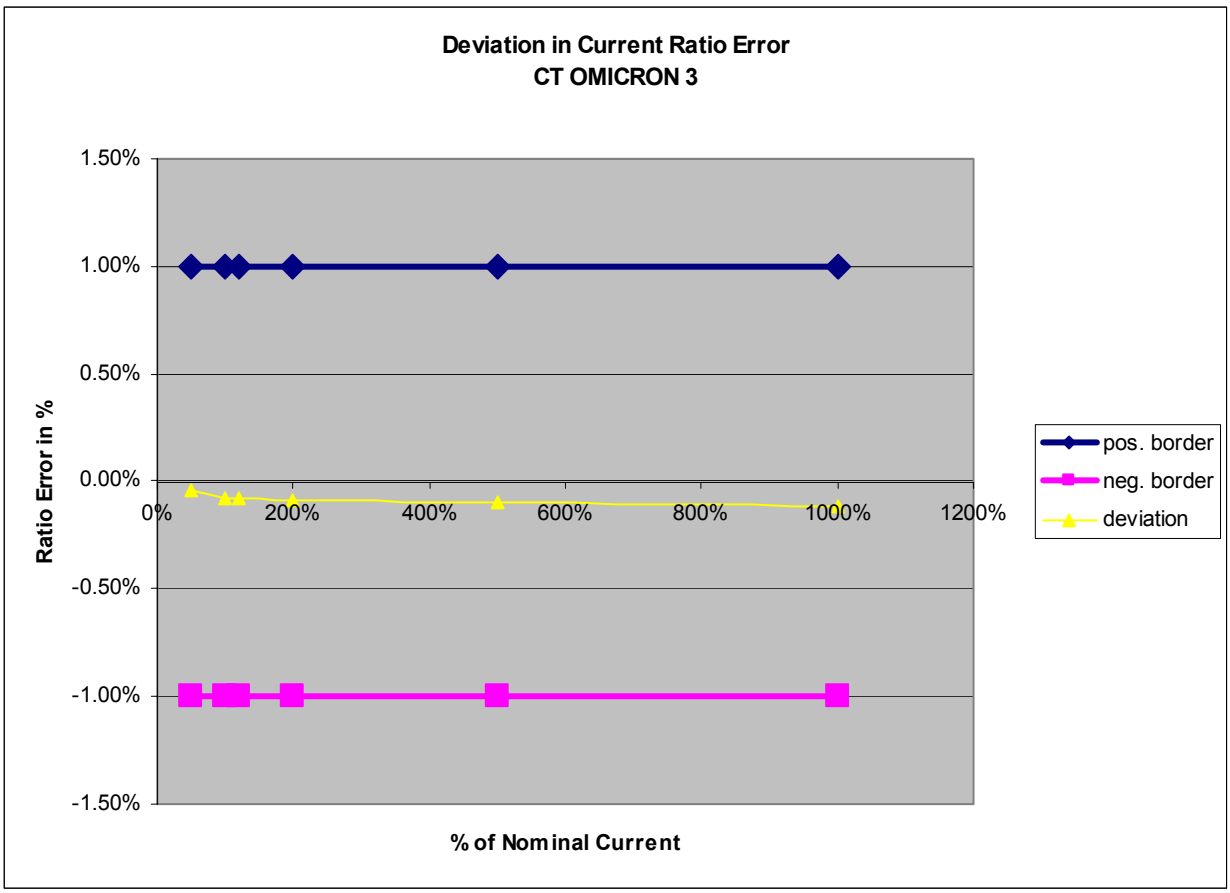

Blue line: Measurement with Omicron CT-Analyzer.
Pink line: Measurement with KEMA equipment.

## Comparison of Current Errors within 1% Tolerance Borders

The graph below shows the current error within 1 % tolerance. It shows the relative current error calculated from the excitation graph measured with the OMICRON *CT Analyzer* and the KEMA test equipment. The calculation was done under the assumption that only the difference of the two excitation curves would influence the deviation, therefore, no difference of the two excitation curves would result in a deviation of zero.

The ratio error measured by KEMA was -0,97% the ratio error measured from CT-Analyzer was -1,076% (difference 0.106%). The used burden was 14,75VA, Inom = 1 A.

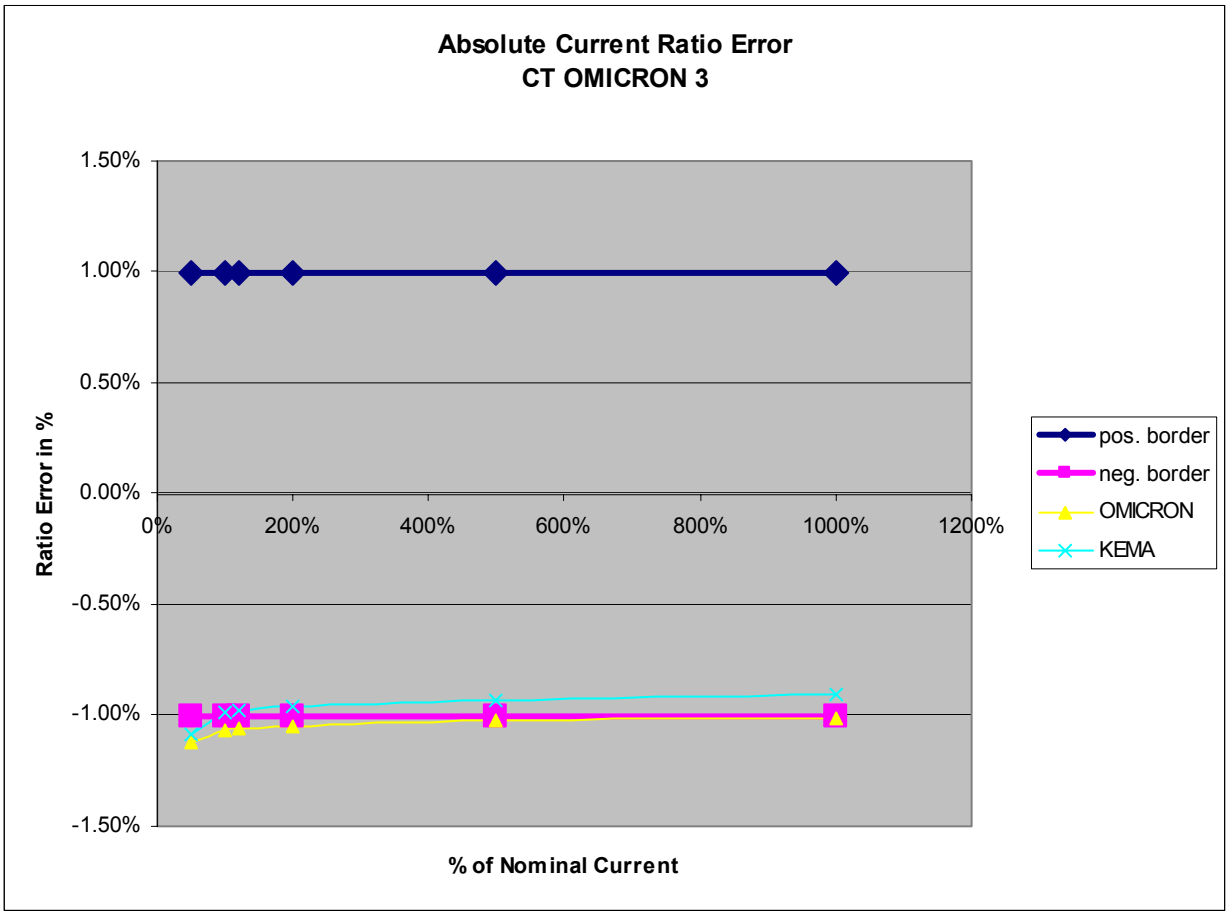
The graph is supposed to show the influence of the measurement error of the excitation measurement and not the absolute ratio error.




Dark blue line: +1% error border
Pink line: -1% error border
Yellow line: Deviation between the measurement from KEMA and the measurement with OMICRON CT-Analyzer.

## Comparison of Absolute Current Errors in 1% Tolerance Borders

The graph below shows the absolute current ratio error calculated from the excitation graph and the ratio measurement with both the equipment from KEMA and the OMICRON CT-Analyzer.
The used burden was 14,75VA, Inom = 1A.



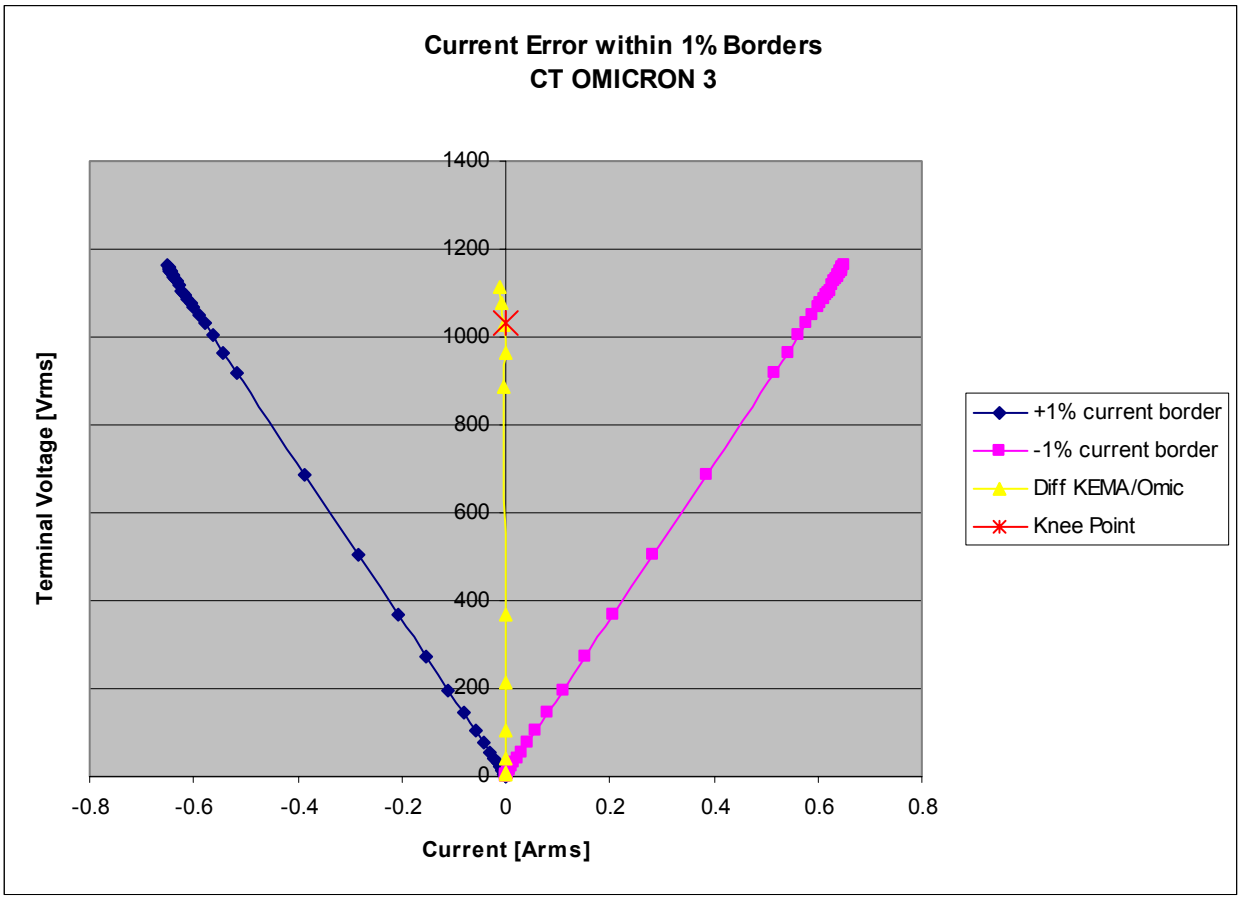

Dark blue line: +1% error border
Pink line: -1% error border
Yellow: ratio error with OMICRON CT-Analyzer
Light blue: ratio error measured with KEMA equipment

## Comparison of Current Deviation up to the Knee Point:

The graph below shows the maximum current tolerance to keep the current error within 1 %. It furthermore shows the deviation (not the absolute values) of current between the measurement with the KEMA equipment and the OMICRON *CT Analyzer* (measurements from KEMA would be 0 $A_{rms}$.

The graph is shown up to the knee point only. Above the knee point, the deviation between the two curves cannot be calculated properly anymore because of the steep current rise. In this area, a small deviation in voltage would result in a large deviation in current.

Only the 1% tolerance borders were used.




Yellow line: Deviation of the output current measured with KEMA equipment and OMICRON CT-Analyzer. No ratio error is considered.
Dark blue line: +1% error border
Pink line: -1% error border

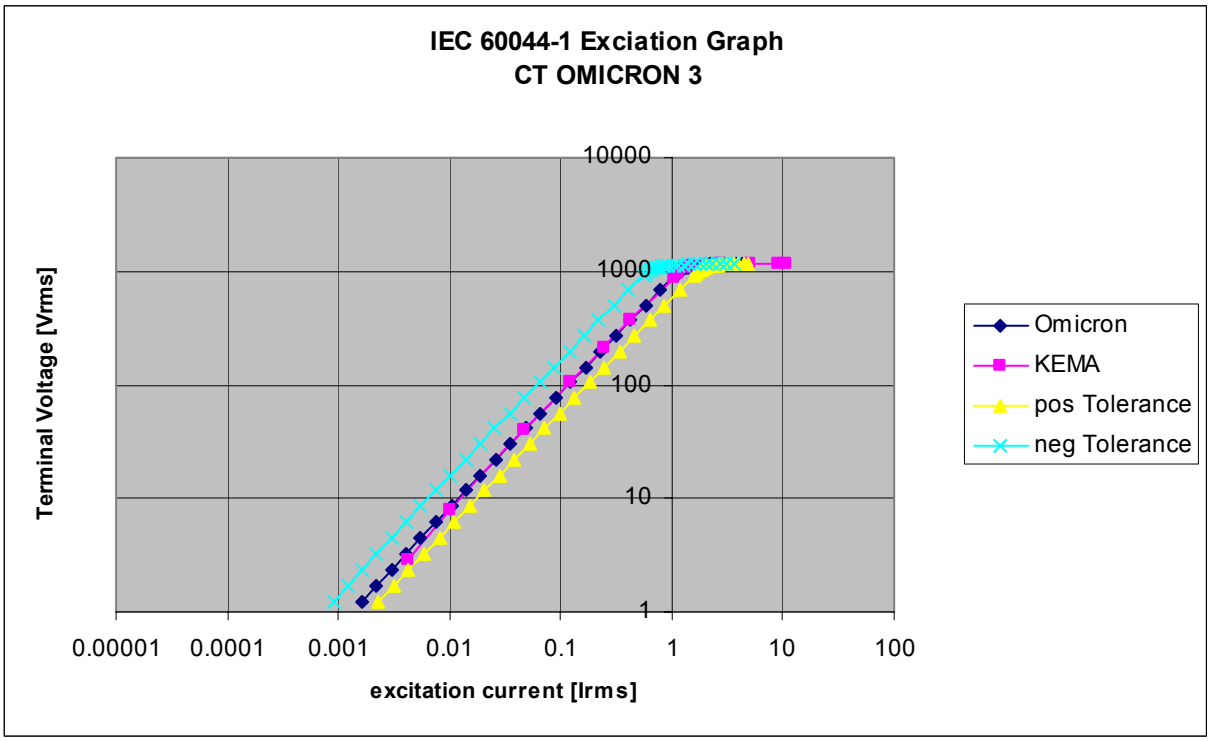
## Excitation Curves in 1% Tolerance Borders

The graph below shows the positive tolerance border (yellow) and the negative tolerance border that would represent a ratio error of 1% as well as the two measured excitation curves.
The burden to calculate the 1% tolerance borders was 15 Ohm.

The output current was calculated by $Is = \frac{U_{emf}}{R_{CT} + R_{Burden}}$

The error border was calculated as in the following example with 100% Inom.

$I_{posTolerance} = I_s + I_s * 0.01$



**APPENDIX D**

## FURTHER ASSESMENT INFORMATION AS PRESENTED BY THE MANUFACTURER

(5 pages)

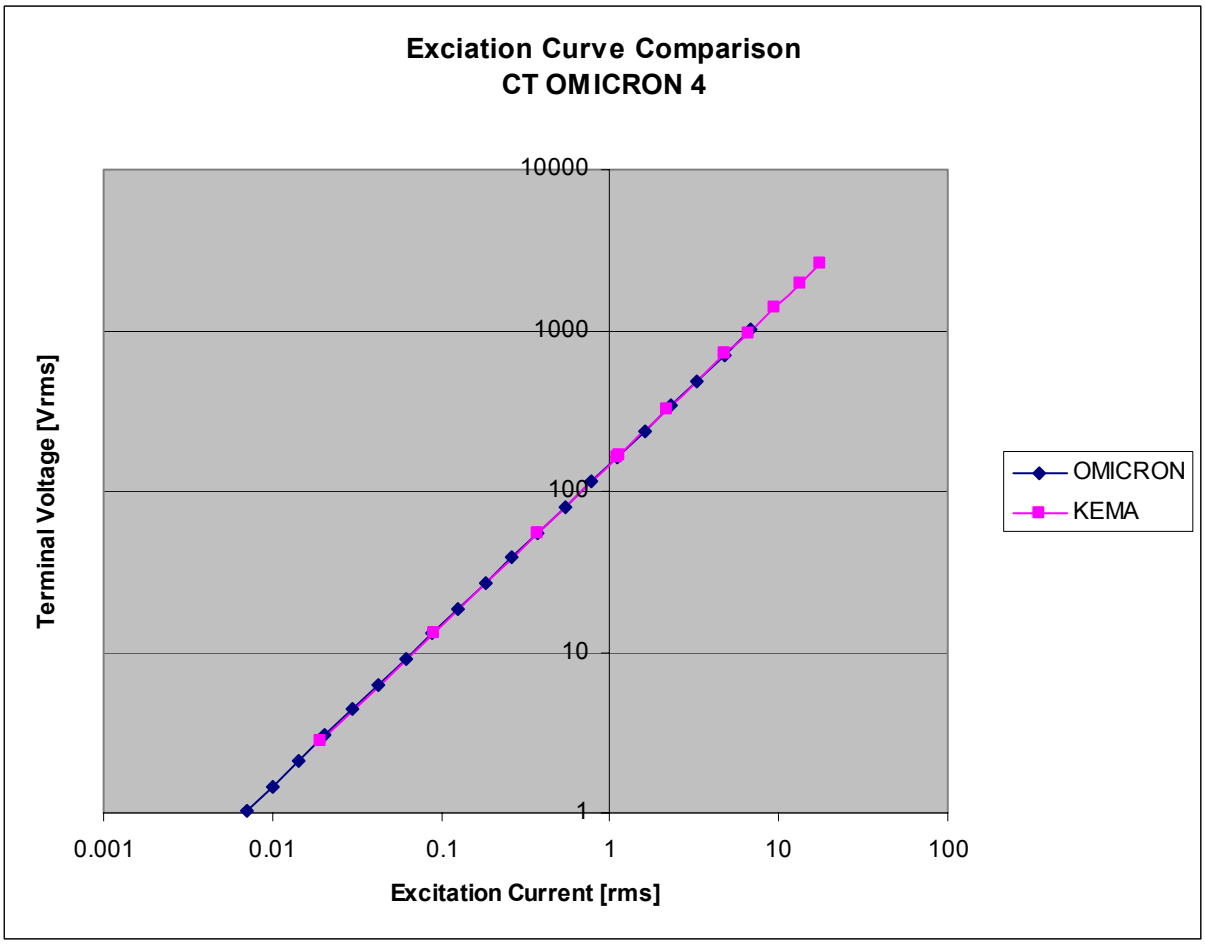
Tested CT (Current Transformer): **CT OMICRON 4** (see Material Data)

## Excitation Curve - Comparison between Measurement by Omicron and KEMA

Tested CT (Current Transformer):

| | |
|---|---|
| Name: | CT OMICRON 4 (see Material Data) |
| Type: | Protection core with gapped ring core |
| Class: | TPZ |
| Burden: | 5.16VA/CosPhi 0.799 |

Comment: The ratio measurement of the TPZ core was done according IEC 60044-1 to get comparable results between the KEMA equipment and the CT-Analyzer. The OMICRON CT-Analyzer does only guarantee high accuracy for non gapped cores but the measurement results below show that also on gapped protection cores reasonable results can be reached.



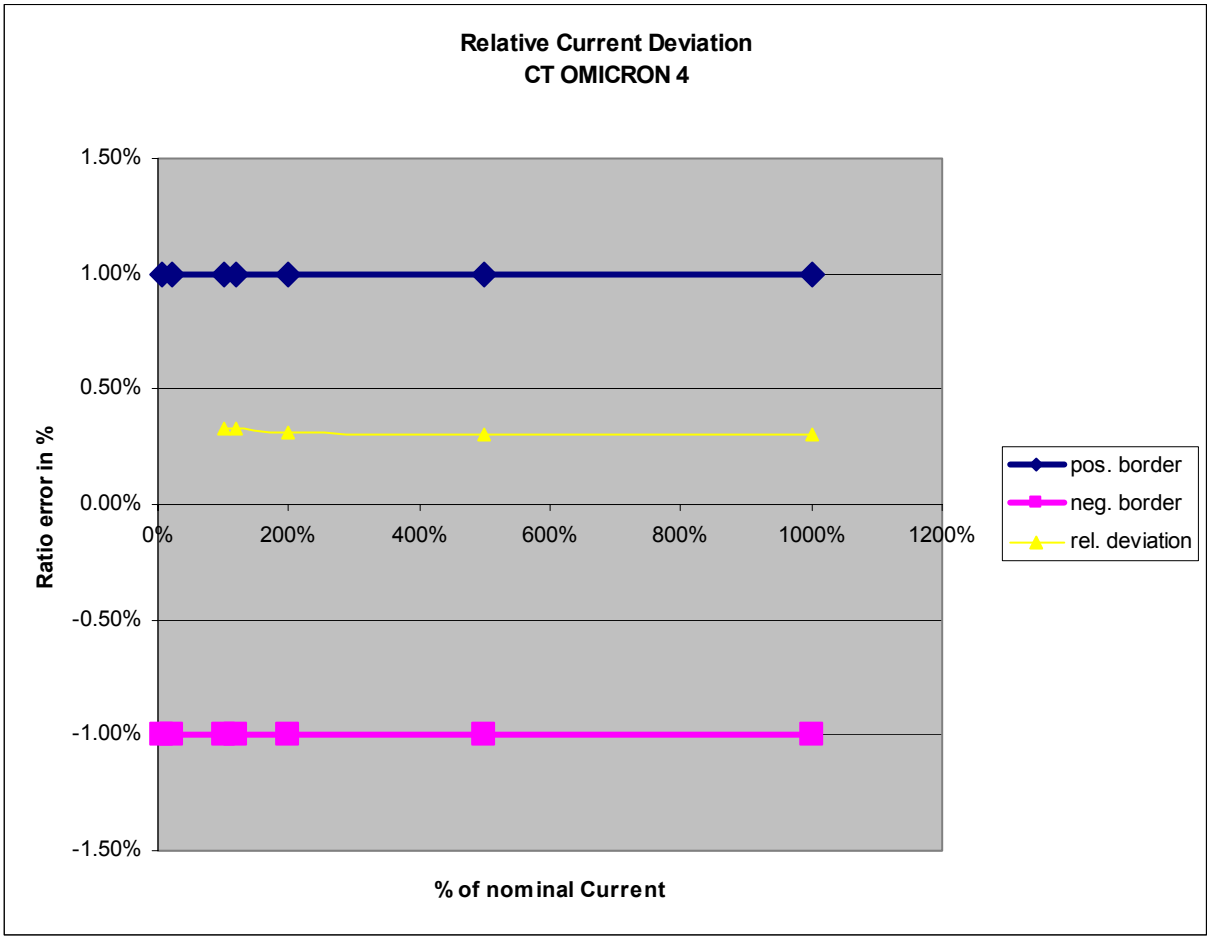

Blue line: Measurement with Omicron CT-Analyzer.
Pink line: Measurement with KEMA equipment.

## Comparison of Current Errors within 1% Tolerance Borders

The graph below shows the current error within 1 % tolerance. It shows the relative current error calculated from the excitation graph measured with the OMICRON *CT Analyzer* and the KEMA test equipment. The calculation was done under the assumption that only the difference of the two excitation curves would influence the deviation, therefore, no difference of the two excitation curves would result in a deviation of zero.

The ratio error measured by KEMA was -1,94% the ratio error measured from CT-Analyzer was -1,658% (difference 0.28%). The used burden was 5,16VA, Inom = 1A.

The graph is supposed to show the influence of the measurement error of the excitation measurement and not the absolute ratio error.

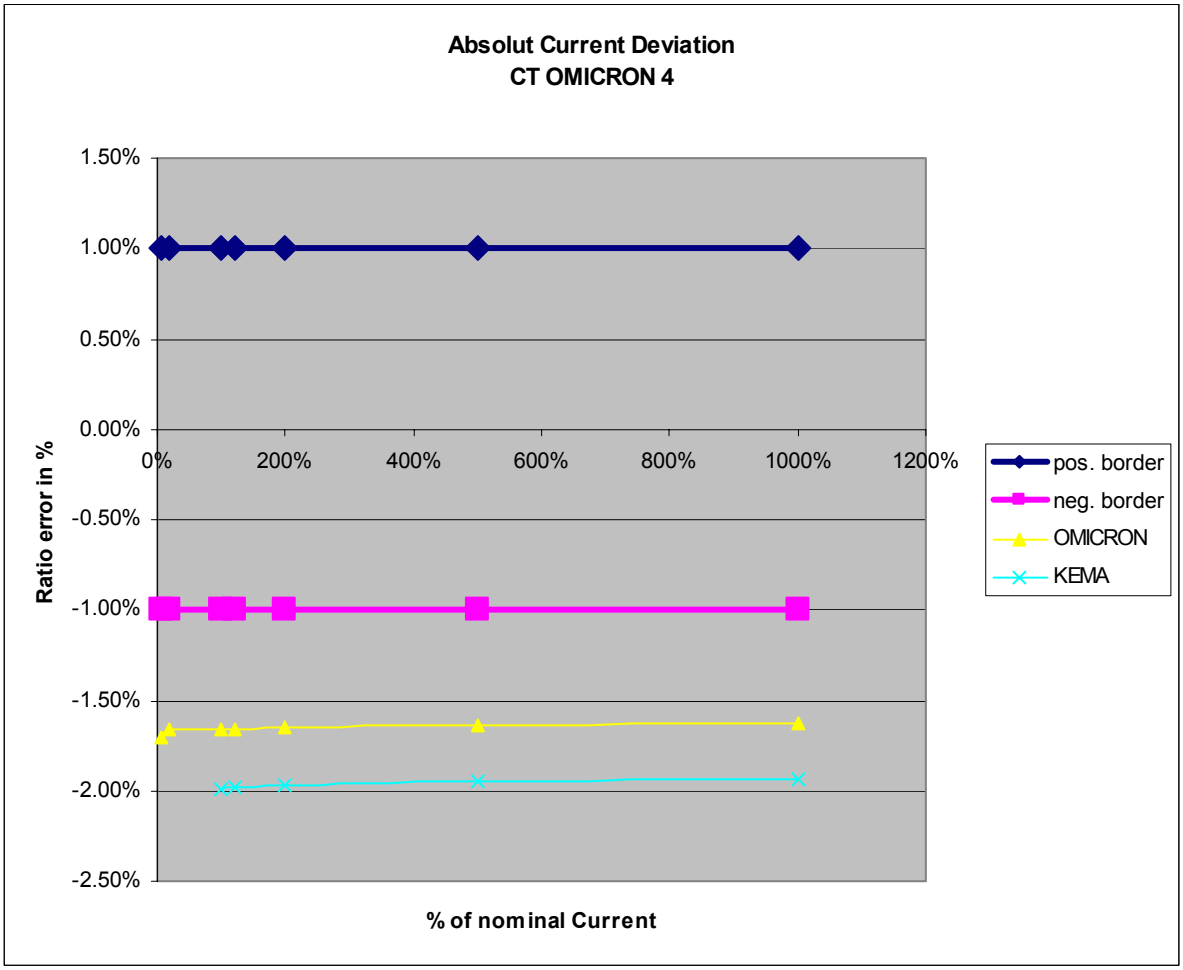



Dark blue line: +1% error border
Pink line: -1% error border
Yellow line: Deviation between the measurement from KEMA and the measurement with OMICRON CT-Analyzer.

## Comparison of Absolute Current Errors in 1% Tolerance Borders

The graph below shows the absolute current ratio error calculated from the excitation graph and the ratio measurement with both the equipment from KEMA and the OMICRON CT-Analyzer.
The used burden was 5,16VA, Inom = 1A.

The ratio error measured by KEMA was -1,94% the ratio error measured from CT-Analyzer was -1,658% (difference 0.28%). The used burden was 5,16VA, Inom = 1A.

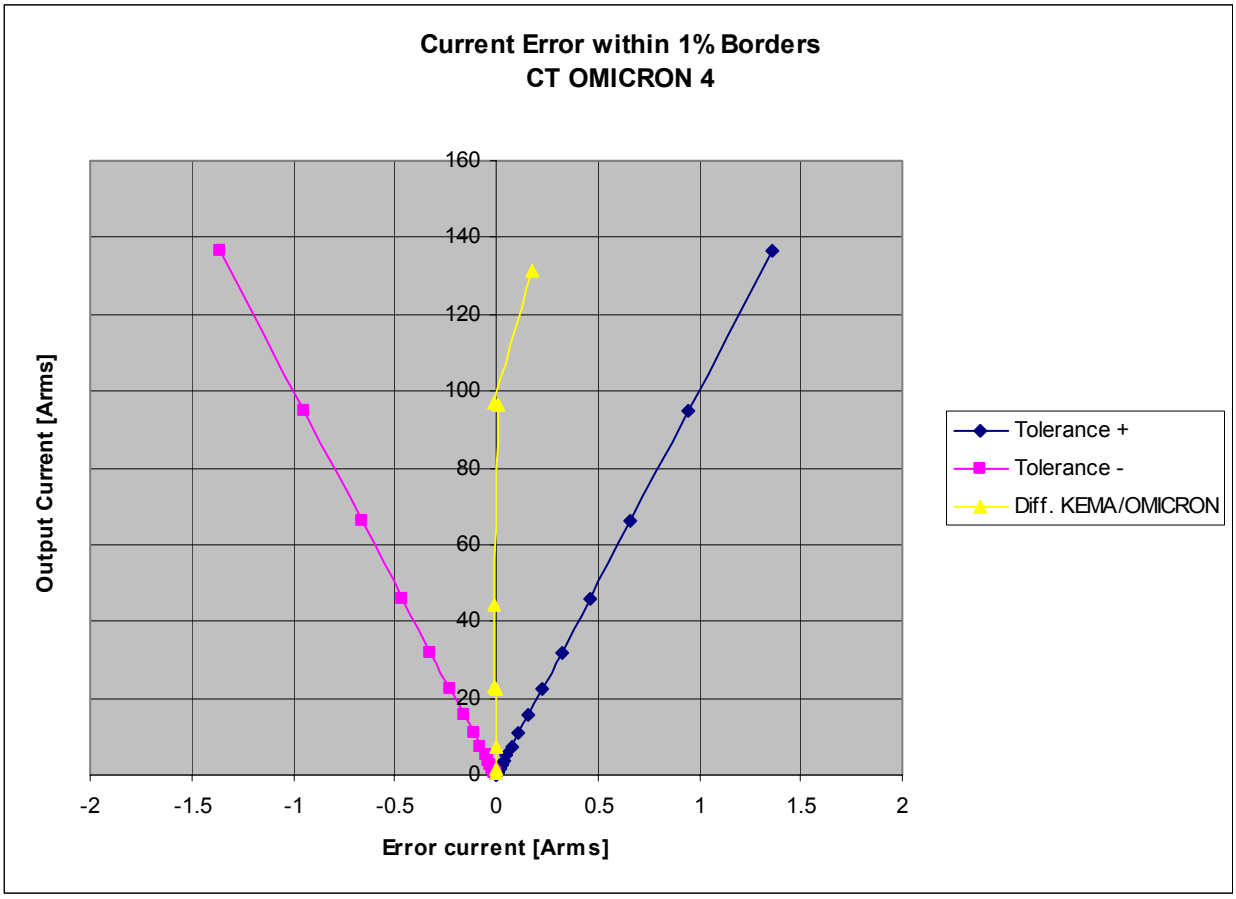



Dark blue line: +1% error border
Pink line: -1% error border
Yellow: ratio error with OMICRON CT-Analyzer
Light blue: ratio error measured with KEMA equipment

## Comparison of Current Deviation up to the Knee Point:

The graph below shows the maximum current tolerance to keep the current error within 1 %. It furthermore shows the deviation (not the absolute values) of current between the measurement with the KEMA equipment and the OMICRON *CT Analyzer* (measurements from KEMA would be 0 $A_{rms}$.

Only the 1% tolerance borders were used.




| | |
|---|---|
| Yellow line: | Deviation of the output current measured with KEMA equipment and OMICRON CT-Analyzer. No ratio error considered. |
| Dark blue line: | +1% error border |
| Pink line: | -1% error border |

## Excitation Curves in 1% Tolerance Borders

The graph below shows the positive tolerance border (yellow) and the negative tolerance border that would represent a ratio error of 1% as well as the two measured excitation curves.
The burden to calculate the 1% tolerance borders was 5,16 Ohm.

The output current was calculated by $Is = \frac{U_{emf}}{R_{CT} + R_{Burden}}$

The error border was calculated as in the following example with 100% Inom.

$I_{posTolerance} = I_s + I_s * 0.01$