

# B6. AC / DC chokes - routine tests

## Standard Approach

The main reactor standard for AC/DC chokes should be IEC/EN 60076-6 - Reactors. IEC 60076-6 covers many reactor types, including shunt reactors, series reactors, filter reactors, motor starting reactors and smoothing reactors in HVDC / industrial applications. For small LV reactors, IEC/EN 61558-1 + IEC/EN 61558-2-20 may be used as auxiliary references for safety requirements; IEC 61558-2-20 covers the special safety requirements and tests for small reactors. If system verification will be performed together with a drive, rectifier or UPS, IEC 61800-5-1 is used as an auxiliary reference in terms of electrical, thermal, fire, mechanical and energy safety. For harmonic/ripple measurement, IEC 61000-4-7 may be used for the measuring instrument and method.

## 1. Routine Tests

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### Winding resistance

<b>Main standard</b>	IEC/EN 60076-6; IEC/EN 61558-1 / 61558-2-20 for small LV chokes
<b>Construction / method standard</b>	DC resistance measurement; manufacturer routine test procedure
<b>Description for AC/DC choke</b>	Winding resistance is measured. In multi-phase AC chokes, each phase is measured separately. In DC chokes, the DCR value is especially important because it creates continuous I <sup>2</sup> R loss and temperature rise under DC current.

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### Inductance measurement - AC choke

<b>Main standard</b>	IEC/EN 60076-6
<b>Construction / method standard</b>	Measurement at rated frequency with an LCR meter, AC test setup or power analyzer
<b>Description for AC/DC choke</b>	For AC chokes, inductance is usually measured at 50/60 Hz or at the application frequency. Reactor impedance depends on frequency according to $X_L = 2\pi fL$ ; therefore, the measurement frequency must be stated in the report. The OMSAN technical glossary also explains that reactor impedance increases with frequency.

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### Inductance measurement - DC choke

<b>Main standard</b>	IEC/EN 60076-6
<b>Construction / method standard</b>	Small-signal L measurement + L measurement under DC bias conditions; according to customer current profile
<b>Description for AC/DC choke</b>	For DC chokes, no-load/small-signal inductance alone is not sufficient. Since the core operating point changes under DC bias, the L value must also be verified at rated DC current or at defined bias currents.

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### Consideration of the DC bias condition

<b>Main standard</b>	IEC/EN 60076-6; IEC 61800-5-1 as auxiliary for system application
<b>Construction / method standard</b>	DC bias source + LCR/AC small-signal injection or equivalent test setup
<b>Description for AC/DC choke</b>	In DC link, rectifier and UPS applications, the reactor continuously carries a DC component. The OMSAN document specifically states that the DC bias effect in DC reactors must be evaluated in the design.

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**Rated current check**

<b>Main standard</b>	IEC/EN 60076-6
<b>Construction / method standard</b>	Nameplate current, winding cross-section, connection and thermal design check; measurement under current if necessary
<b>Description for AC/DC choke</b>	For AC chokes, RMS current; for DC chokes, DC current + ripple RMS component must be evaluated together. The OMSAN technical glossary states that rated current must be considered together with continuous operation, ambient temperature and ventilation conditions.

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**Loss measurement - copper loss**

<b>Main standard</b>	IEC/EN 60076-6
<b>Construction / method standard</b>	$I^2R$ calculation based on DC resistance and current
<b>Description for AC/DC choke</b>	Copper loss is the $I^2R$ loss caused by current flowing through the windings and is one of the main inputs for temperature rise. In the OMSAN glossary, copper loss and total loss are explained as key parameters for thermal design/efficiency calculations.

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**Loss measurement - total loss of AC choke**

<b>Main standard</b>	IEC/EN 60076-6
<b>Construction / method standard</b>	Power measurement or calculation under rated AC current/frequency conditions
<b>Description for AC/DC choke</b>	In iron-core AC chokes, core loss and stray losses must be taken into account in addition to copper loss.

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**Loss measurement - total loss of DC choke**

<b>Main standard</b>	IEC/EN 60076-6
<b>Construction / method standard</b>	Loss calculation/measurement under DC current + ripple current
<b>Description for AC/DC choke</b>	In a DC choke, the pure DC component creates copper loss, while the ripple component may increase additional AC losses and core losses. Therefore, if the customer ripple profile is known, the test/calculation should be made accordingly.

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**Insulation resistance**

<b>Main standard</b>	IEC/EN 60076-6; IEC/EN 61558-1 / 61558-2-20
<b>Construction / method standard</b>	Insulation resistance measurement; IEC 61557-2 as an auxiliary reference for practical measurement
<b>Description for AC/DC choke</b>	Winding-to-frame insulation is measured; in multi-winding or multi-phase designs, phase-to-phase/winding-to-winding insulation is also measured. Since the DC bus voltage may be high in DC link applications, insulation must be clearly shown in the report.

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**Dielectric withstand / hipot**

<b>Main standard</b>	IEC/EN 60076-6; IEC/EN 61558-1 / 61558-2-20
<b>Construction / method standard</b>	AC or DC withstand test; the test level is selected according to product voltage, insulation class and customer specification
<b>Description for AC/DC choke</b>	Winding-to-frame and, where required, phase-to-phase/winding-to-winding main insulation are verified. If used together with a drive/UPS system, the safety approach of IEC 61800-5-1 may be used as an auxiliary reference.

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**Check of DC resistance and its effect on heating**

<b>Main standard</b>	IEC/EN 60076-6
<b>Construction / method standard</b>	DCR measurement + I <sup>2</sup> R loss calculation at rated DC current
<b>Description for AC/DC choke</b>	In DC chokes, DCR directly determines voltage drop, efficiency and temperature rise. This line should appear separately in the report.

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**Voltage drop check - in DC chokes**

<b>Main standard</b>	IEC/EN 60076-6; customer specification
<b>Construction / method standard</b>	Vdrop = I <sub>DC</sub> x R <sub>DC</sub> calculation; additional evaluation of ripple component if applicable
<b>Description for AC/DC choke</b>	Excessive voltage drop at the DC link or rectifier output may affect system performance. Therefore, voltage drop must be calculated using DCR and rated DC current.

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**Saturation check - especially in DC chokes**

<b>Main standard</b>	IEC/EN 60076-6
<b>Construction / method standard</b>	Inductance measurement at rated DC current and, if necessary, at higher current points
<b>Description for AC/DC choke</b>	This is a critical test for DC chokes. In the OMSAN glossary, saturation current is defined as the current level at which the core starts to deviate from linear behavior; exceeding this point causes inductance to decrease and the protective effect to weaken.

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**Linearity check in AC chokes**

<b>Main standard</b>	IEC/EN 60076-6
<b>Construction / method standard</b>	L measurement at different RMS current points
<b>Description for AC/DC choke</b>	If transient or overcurrent is expected in AC applications, the change of inductance with current is checked.

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**Mechanical tightness check**

<b>Main standard</b>	IEC/EN 60076-6
<b>Construction / method standard</b>	Visual inspection, core/winding tightness check, connection torque check
<b>Description for AC/DC choke</b>	Electromagnetic forces may create vibration and connection fatigue in choke windings. In the OMSAN glossary, mechanical vibration is defined as an important behavior in terms of noise, connection life and field comfort.

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**Air gap check**

<b>Main standard</b>	IEC/EN 60076-6
<b>Construction / method standard</b>	Production drawing, air gap measurement, mechanical inspection
<b>Description for AC/DC choke</b>	In iron-core AC/DC chokes, the air gap directly affects inductance, saturation current and acoustic behavior. The OMSAN document lists precise control of air gap tolerances as a point requiring attention in production.

<b>17</b>	<b>Nameplate check</b>	
	<b>Main standard</b>	IEC/EN 60076-6; IEC/EN 61558-1
	<b>Construction / method standard</b>	Cross-check of nameplate, technical datasheet and test report
	<b>Description for AC/DC choke</b>	Current, voltage, inductance, DCR, frequency/ripple information, insulation class, cooling, IP, connection and usage type are checked.

<b>18</b>	<b>Polarity / connection check</b>	
	<b>Main standard</b>	IEC/EN 60076-6; customer specification
	<b>Construction / method standard</b>	Terminal marking, continuity, connection diagram and polarity check
	<b>Description for AC/DC choke</b>	In a single-winding DC choke, polarity may often not be functionally critical; however, in DC link, multi-winding, screened or sensor-equipped designs, polarity and connection direction must be clearly verified in the report.

<b>19</b>	<b>Function test if thermal sensor is present</b>	
	<b>Main standard</b>	IEC/EN 60076-6; IEC/EN 61558-1 auxiliary
	<b>Construction / method standard</b>	PTC/PT100/thermostat continuity, resistance or contact test
	<b>Description for AC/DC choke</b>	Sensor leads, alarm/trip terminal and contact status are checked.

<b>20</b>	<b>Frame/PE continuity - for metal-enclosed products</b>	
	<b>Main standard</b>	IEC/EN 61558-1; IEC 60204-1 auxiliary inside panel/machine
	<b>Construction / method standard</b>	Low-resistance continuity measurement
	<b>Description for AC/DC choke</b>	Continuity is checked between the frame, mounting foot, cover, screen and PE terminal.

## 2. Optional / Special Tests

<b>1</b>	<b>Inductance test under DC bias</b>	
	<b>Main standard</b>	IEC/EN 60076-6; IEC 61800-5-1 auxiliary on the system side
	<b>Construction / method standard</b>	L measurement at rated DC current and at defined intermediate/high current points
	<b>When is it recommended?</b>	Highly recommended in DC link, rectifier, UPS, battery charging, inverter DC bus and energy storage applications. It is the strongest verification test for a DC choke.

<b>2</b>	<b>Temperature rise test</b>	
	<b>Main standard</b>	IEC/EN 60076-6; IEC/EN 61558-2-20 for small LV reactors
	<b>Construction / method standard</b>	Steady-state temperature measurement under rated DC current or AC RMS current
	<b>When is it recommended?</b>	Recommended when continuous operation, enclosed panel, high ambient temperature, high current density or customer specification exists. In the OMSAN quality approach, controlled temperature rise and heating-performance tests are defined as part of the general test process.

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**Test under ripple current**

<b>Main standard</b>	IEC/EN 60076-6; IEC 61000-4-7 auxiliary for harmonic/ripple measurement
<b>Construction / method standard</b>	Measurement of RMS current, L, loss and temperature by superimposing AC ripple on DC current
<b>When is it recommended?</b>	One of the tests closest to real operating conditions in rectifier, UPS and DC link applications. IEC 61000-4-7 can be used for harmonic and interharmonic measuring instruments/methods.

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**Noise test**

<b>Main standard</b>	IEC/EN 60076-10
<b>Construction / method standard</b>	Measurement by sound pressure or sound intensity method
<b>When is it recommended?</b>	Recommended for iron-core, high-ripple-current or indoor applications.

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**Vibration test**

<b>Main standard</b>	IEC 60068-2-6; customer specification in special applications
<b>Construction / method standard</b>	Sinusoidal vibration test or customer vibration profile
<b>When is it recommended?</b>	Recommended for machine-mounted, rail system, marine, mobile power electronics and high-vibration environments.

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**Thermal camera test**

<b>Main standard</b>	IEC/EN 60076-6 thermal performance approach
<b>Construction / method standard</b>	IR thermography at rated current or under ripple current
<b>When is it recommended?</b>	Hot spots are checked around terminals, busbars, winding exits, air gap areas, core clamping points and sensor areas.

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**Function test with customer rectifier/inverter system**

<b>Main standard</b>	IEC 61800-5-1; IEC 61000-4-7 auxiliary for EMC/power quality
<b>Construction / method standard</b>	Measurement of DC current, ripple, temperature, sound and voltage drop with actual rectifier/inverter/UPS
<b>When is it recommended?</b>	If the customer system is known, this is the most accurate verification. DC bus voltage, ripple frequency, switching frequency, duty cycle and cooling conditions should be included in the test plan.

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**Short-time overcurrent test**

<b>Main standard</b>	IEC/EN 60076-6; customer specification
<b>Construction / method standard</b>	Loading with the defined current/time profile
<b>When is it recommended?</b>	Recommended for rectifier start-up, DC link charging, inverter transients or fault transitions.

<b>9</b>	<b>Saturation curve / L-I characteristic</b>	
	<b>Main standard</b>	IEC/EN 60076-6
	<b>Construction / method standard</b>	Derivation of L-I curve according to DC bias or AC RMS current points
	<b>When is it recommended?</b>	Very useful for seeing behavior above rated current in DC chokes. The report can be arranged as "L @ 0 A, L @ 1n, L @ 1.2In, L @ 1.5In".

<b>10</b>	<b>Harmonic/ripple loss analysis</b>	
	<b>Main standard</b>	IEC/EN 60076-6; IEC 61000-4-7 for measurement
	<b>Construction / method standard</b>	Copper/core loss calculation according to ripple frequencies and RMS components
	<b>When is it recommended?</b>	Recommended in power electronics applications containing high-frequency ripple or high RMS current. The OMSAN renewable systems document lists loss calculation by harmonic frequencies among the topics to be considered in LV reactor design.

<b>11</b>	<b>IP test - for enclosed products</b>	
	<b>Main standard</b>	IEC/EN 60529
	<b>Construction / method standard</b>	Dust, water and access-to-hazardous-parts test according to IP code
	<b>When is it recommended?</b>	Applied if an enclosure declaration such as IP20, IP23, IP54 or IP55 exists.

<b>12</b>	<b>EMC effect / conducted disturbance evaluation</b>	
	<b>Main standard</b>	IEC 61000 series; IEC 61800-3 auxiliary for drive system
	<b>Construction / method standard</b>	Comparison of ripple, harmonics, conducted disturbance or system stability with/without choke
	<b>When is it recommended?</b>	A choke is not an EMI filter; however, it may contribute to system behavior by shaping current ripple and high-frequency components. The OMSAN glossary states that reactors may indirectly contribute to reducing EMI levels, but they do not replace an EMI filter on their own.

### 3. Lines Recommended to Be Added to the Test Report

Report line	Recommended content
Product type	AC choke / DC choke / DC link reactor / smoothing choke
Rated values	Voltage, AC RMS current or DC current, ripple current, frequency/ripple frequency
Inductance	L at rated frequency for AC choke; L at 0 A and under DC bias for DC choke
DCR	DC resistance, measurement temperature, temperature correction if applicable
Voltage drop	$I_{DC} \times R_{DC}$ in DC choke; voltage drop caused by reactance in AC choke
Loss	$I^2R$ copper loss; total loss in cored design
Saturation check	L-I curve or L value under rated DC bias
Ripple information	Ripple current, ripple frequency, RMS effect
Insulation / hipot	Winding-to-frame, phase-to-phase or winding-to-winding test results
Mechanical check	Air gap, core tightness, winding fixing, connection torque
Thermal protection	Function result if PTC/PT100/thermostat is present
Nameplate / connection	Current, voltage, L, DCR, connection/polarity, insulation class, cooling
System test	Ripple, temperature, sound and voltage drop result with rectifier/inverter/UPS if available