1 Air-core dry-type reactors in general

Air-core dry-type reactors are mainly **employed in electric power transmission and distribution systems** as well as **in electric power systems of plants**. They are installed to protect these systems and/or to increase their efficiency. As a special application air-core dry-type reactors will also be used **in electrical test laboratories and research institutions**.

Dry-type reactor technology has been employed since the early 1900's. In the beginning the technology was based on "open style" construction concepts consisting of windings with insulating air between turns. The turns were hold in place by several supports made from concrete or from ceramic material. The application of such reactors was restricted to low power and system voltage rating and the reactors were mostly installed indoors.

In the 1960ies a technology based on the use of solid insulation between turns and complete impregnation and encapsulation of the windings was introduced. The utilization of new weatherproof insulation materials, in particular the use of synthetic resins, and advanced manufacturing technologies have facilitated the use of **air-core dry-type reactors up to the highest voltage and power levels**. It became general practice to install **dry-type reactors outdoors as well as indoors, even in adverse environments**.

With the ongoing development of electrical power technology, especially through the increased use of semiconductors in electric power systems, the requirements of power inductors have changed during the last decades. The application spectrum for air-core dry-type reactors has been extended, caused by **economic advantages of the air-core reactor technology** and by a **number of other benefits in comparison with iron-core reactors** (see item 2 below). For more and more applications in modern power systems the dry-type technology has become the **technology of choice**.

2 Features of air-core dry-type versus oil-immersed iron-cored reactors

2.1 Linear inductance-current characteristics

As there is no iron core magnetic saturation effect, the impedance of a dry-type air-core reactor is constant from minimum current levels to maximum fault current. This linear characteristics makes air-core dry-type technology ideal for the use in current limiting applications as the **full reactor impedance is also maintained during system fault conditions**. Such reactors are in widespread use in transmission and distribution systems in a number of locations, including main buses, feeders or transformer neutrals.

Current limiting reactors are series connected to the transmission/distribution line or to the feeder in order **to limit the short-circuit power** on the load side of the reactor. The reactor limits the short-circuit current to a level which can be handled by the components installed in the electrical system, such as breakers, switches or fuses. Other special applications of current limiting reactors are **load balancing reactors** for load sharing in parallel circuits, **bus tie reactors** installed between two different bus systems, **load flow reactors** to control the transmission path impedance and **capacitor inrush current limiting** or **damping reactors.**

Another type of current limiting reactor is the **neutral grounding reactor**, used for low-impedance grounding of the neutral point of three-phase networks in order to limit the fault current in the event of a phase-to-ground short-circuit.

The absence of any saturation effects is, however, also an important feature of air-core reactors for many other applications. For instance, an iron core reactor in a filter circuit may become saturated during switching, resulting in a considerable reduction of inductance so that the filter circuit may become fully detuned and may absorb currents to an extent which prevents the return from saturated to unsaturated state.

2.2 Absence of insulating oil

Air-core dry-type reactors do not utilize an oil insulation system. They are **environmentally-friendly** and there are **no fire hazard** concerns. Furthermore no oil collecting system must be provided since there is no oil that can leak into the ground and no auxiliary equipment for oil supervision is needed.

2.3 Insulation to ground

The major insulation to ground is **simply provided by support insulators**, whereas in oil-immersed iron-cored reactors complex oil-paper insulation systems are employed. This is in particular true for higher system voltages. With regard to the insulation to ground there is more or less no restriction to apply the air-core dry-type reactor technology. Up to now air-core reactors are employed in **AC transmission systems up to 400 kV** and in **HVDC schemes up to 800 kV** system voltages.

2.4 Insulation across the winding

In order to keep the physical dimensions within reasonable limits applicable to production, transportation and handling of air-core dry-type reactors, **the maximum steady state voltage across one single coil unit is in the order of 72,5 kV** (voltage between terminals). Assuming that no more than two coil units will be stacked the **maximum voltage across an air-core reactor may be as high as 145 kV**. These limits correspond to the maximum specific surface voltage across the reactor winding applicable for outdoor installations.

2.5 External magnetic field

Due to the absence of a magnetic core or magnetic shield a dry-type **air-core reactor produces an external magnetic field.** However, **magnetic field strength drops off very quickly** with the third power of the distance from the reactor. Coil Innovation can provide guidelines about magnetic clearances as well as recommendations for the design of foundations and nearby metallic structures.

2.6 Transport and Handling

Even though sizes of air-core reactors are usually larger than those of iron-core reactors, **transportation and handling is simpler** because of much lower weight. This is especially the case for reactors with high power ratings.

2.7 Maintenance

Air-core dry-type reactors are **essentially maintenance-free**. As also mentioned under 2.2 they do need auxiliary equipment.

3 Range of technical data of Coil Innovation air-core dry-type reactors

The table below shows the range of technical data, which can be designed and manufactured at Coil Innovation.

A major parameter describing the physical size of an air-core dry-type reactor is the reactive power. To use this parameter for AC and DC application the table below refers to the 50 Hz-equivalent reactive power $S_{50\,Hz}$, which may be calculated as follows:

$$\boxed{S_{50Hz} = I^2 \cdot 2\pi \cdot 50 \cdot L}$$

$S_{50\,Hz}$ 50 Hz-equivalent reactive power $S_{50\,Hz}$ in [VAr]
I Rated continuous DC current or rated continuous AC current (r.m.s.) in [A]
L Rated inductance in H

Reactor parameter	Range of technical data
Max. system voltages: • DC systems • AC systems	 Low voltage up to 800 kV Low voltage up to 500 kV
Max. continuous voltage across the reactor	145 kV, r.m.s.
Rated continuous current	100 A up to 10 kA
Rated inductance	10 µH up to 1,5 H
Power ratings (50 Hz-equivalent reactive power $S_{50\,Hz}$*): • for DC reactors • for AC reactors	 50 kVAr bis 300 MVAr 50 kVAr bis 100 MVAr
Max. physical winding dimensions: • winding outside diameter • winding height/length (excl. supports and insulators)	 up to 4 m up to 4 m
Max. winding mass (excl. supports and insulators)	up to 30 to
Ambient temperatures	-45°C up to +50°C