SHUNT REACTORS
AIR-CORE | DRY-TYPE

TRENCH
MAIN ADVANTAGES OF AIR-CORE, DRY-TYPE SHUNT REACTORS VERSUS OIL IMMERSED TYPES

- No environmental concern, no oil collection system required
- No fire hazard, no fire deluge system
- Minimal efforts and maintenance costs
- Less civil work, lower weight
- Easy to handle and transport
- Simplicity of insulation to ground (self-healing)
- Simple protection scheme
- No risk of bushing failures
- No excessive magnetizing inrush current, no iron core
- Lower investment cost
- Affordable cost for spare units (single phase unit only)
- Shorter lead time
- Cold start capability (no need to pre-heat oil prior to energization during low ambient temperatures)
**General**

Trench is a supplier of specialized electrical products and a recognized world leader in the design and manufacture of dry-type, air-core reactors for all utility and industrial applications. Trench air-core reactors range from small kVAR units (for applications such as capacitor bank inrush limiting or distribution system short circuit current reduction), to large power reactors for a number of applications (such as shunt reactors that may be over 100 MVAR per coil).

**Application**

As the name implies, shunt reactors are connected in parallel to compensate for the capacitive reactive power of transmission and distribution line systems to keep the operating voltages within admissible levels. Depending on the application, shunt reactors may be permanently connected to the system or switched on (only under light load conditions).

The main technical advantages of shunt reactors can be summarized as:
- Reactive power compensation in long transmission lines and cable systems
- Minimizing line losses
- Increasing lines power transfer capability
- Increasing voltage stability margin
- Controlled voltage profile of the line

Depending on several factors, shunt reactors may be connected (1) to the tertiary winding of a power transformer, (2) directly to the station busbar, or (3) to transmission lines terminations, as shown in Fig. 1.

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**Connection**

**TERTIARY CONNECTED SHUNT REACTORS**

Depending on the application, the reactive power rating of tertiary connected shunt reactors may vary from a few MVAR up to approximately 100 MVAR per phase. The voltage rating of these reactors is typically 34.5 kV and below. A tertiary connected shunt reactor is usually a short single coil per phase with several windings. These reactors are normally Star connected with ungrounded neutral. It is common to use elevated structures, such as fiberglass pedestals and steel poles, to mount these reactors sufficiently above the ground grid.

**SHUNT REACTORS DIRECTLY CONNECTED TO HIGH VOLTAGE**

In high voltage transmission lines, such as connection to wind farms, the amount of stray capacitance from the line or cable to ground is significantly high. Therefore, the excessive capacitive reactive power in the line can cause serious over-voltages at the end of the line during light load conditions. Air-core dry-type reactors are a favorable solution to compensate for this excess reactive power. Typical ratings of these types of shunt reactors are 69 kV to 345 kV and a few tens to 100 MVAR per phase. Shunt reactors are typically comprised of a few stacked coils in series per phase with minimum number of windings per coil. These shunt reactors are Star connected with solidly or impedance grounding.

**SWITCHING OF SHUNT REACTORS**

Switching shunt reactors is one of the most significant duties for a circuit breaker. Whenever applying shunt reactors, whether dry-type, oil immersed, tertiary type or direct connected, it is extremely important to pay particular attention to the switching device selected. Guidance can be found in the IEEE Std. C37.015-2009: IEEE Guide for the Application of Shunt Reactor Switching.

**WYE CONNECTED SHUNT REACTORS WITH THE NEUTRAL GROUNDING THROUGH A NEUTRAL REACTOR**

The majority of faults on transmission lines are single-phase-to-ground faults caused by flashovers of the air insulation. The auto reclosing function of circuit breakers is activated when faults occur to temporarily isolate the transmission line from the grid in both ends as attempt to extinguish the fault arc. Secondary arc can happen due to capacitive and inductive coupling between the healthy phases and the isolated line. In order to achieve a successful reclosing attempt, the secondary arc needs to be extinguished during the deadtime of the recloser. An addition of an air-core dry-type neutral grounding reactor between the neutral point of shunt reactor banks and ground is a well proven practice to increase the zero sequence impedance of the shunt reactor bank. Thus, it will mitigate the secondary arc.

A dry-type air-core reactor consists of a cylindrical winding (1) made of one or several concentric layers of film/glass tape insulated aluminum conductors (2). All layers are electrically connected in parallel by welding their top and bottom ends to metallic cross arms, commonly referred to as spiders (3). Each spider carries a terminal (4) for electrical connection of the reactor. The individual layers are configured so the radial voltage stress is virtually nil and the remaining axial voltage stress results in surface stress values that are less than those on porcelain insulators.

The turn-to-turn steady state operating voltages are well below the required level resulting in partial discharges can occur. All layers are radially spaced by several glass fiber sticks (5) which form air ducts that are necessary for the cooling of the winding. Cooling is provided by natural convection of ambient air which enters at the bottom end of the winding and exits out the top end. The winding is impregnated by epoxy resin resulting in a mechanically strong and compact unit. The reactors are mounted on several base insulators (6) and associated mounting brackets (7).
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DESIGN EXAMPLES

132 kV, 120 MVar

345 kV, 20 MVar

420 kV, 120 MVar