Coil Products
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Customer partnership around the globe

More than 250,000 coil products delivered to more than 170 countries. More than 60 years of operational experience.

Continuous innovation since 1900

- **1900** – Beginnings
  - Open Style Windings
  - Cast in concrete, large cables, air between turns
  - Technology limited to small coils and distribution voltages

- **1960** – State of the Art
  - 1954 Foundation Spezielektra (Trench Austria today)
  - 1962 Foundation Trench Electric (Trench Canada today)
  - Winding design encapsulated in epoxy resin and filament fiberglass
  - Small diameter conductors
  - Windings film insulated
  - Parallel winding design

- **35,000 in Europe**
- **161,000 in America**
- **13,000 in Middle East**
- **8,000 in Africa**
- **40,000 in Asia**
Proven reliability

- Trench developed the technology that is Air Core Reactors today
- Trench is the largest reactor manufacturer in the world
- Over 250,000 units in service worldwide
- Product lifetime of 30 years and more
- All units custom designed based on:
  - More than 60 years of experience
  - Continuous R&D and product improvement
  - Four competence centers around the world

70’s to 90’s Development

- Development of specialty cables and insulation systems
- Higher short circuit ratings
- New applications: SVC, Filters, HVDC, low loss shunt reactors

Transmission focus

- Large series reactors: EHV, Current Limiting & Power Flow Control
- Acoustic design
- Seismic designs for very large coils
- Higher voltage shunt reactors

2000’s
Introduction

With 60 years of successful field experience, Trench is the recognized world leader in the design and manufacture of air-core dry-type power reactors for all utility and industrial applications. The unique custom design approach, along with fully integrated engineering and manufacturing facilities in North America, Brazil, Europe and China have enabled Trench to become the technical leader for high-voltage inductors worldwide.

A deep commitment to the power industry, along with extensive investment in engineering, manufacturing and test capability, give Trench customers the utmost in high-quality, reliable products that are individually designed for each application. Trench reactor applications have grown from small-distribution class, current-limiting reactors to complex EHV-applied reactors surpassing 300 MVA per phase.

Trench Management System is certified to ISO 9001, ISO 14001 and OHSAS 18001. Trench’s highly developed research and development program constantly addresses new technologies and their potential application in reactor products. Trench welcomes challenges for new applications for power reactors.

Design features

Design features of air-core dry-type reactors are:
- Epoxy impregnated, fiberglass-encapsulated construction
- Aluminum construction throughout with all current-carrying connections welded
- Highest mechanical and short-circuit strength
- Essentially zero radial-voltage stress, with uniformly graded axial-voltage distribution between terminals
- Low noise levels are maintained throughout the life of the reactor
- Weatherproof construction, with minimum maintenance requirements
- Design service life in excess of 30 years
- Designs available in compliance with ANSI/IEEE, IEC and other major standards.

Construction

A Trench air-core dry-type reactor consists of a number of parallel-connected, individually insulated, aluminum (copper on request) conductors (fig. 1). These conductors can be small wire or proprietary cables which are custom-designed and custom-manufactured. The size and type of conductor used in each reactor is dependent on the reactor specification. The various styles and sizes of conductors available ensure optimum performance at the most economical cost.
The windings are mechanically reinforced with epoxy resin-impregnated fiberglass, which after a carefully defined oven-cure cycle produces an encapsulated coil. A network of horizontal and vertical fiberglass ties coupled with the encapsulation minimizes vibration in the reactor and achieves the highest available mechanical strength. The windings are terminated at each end to a set of aluminum bars called a spider. This construction results in a very rigid unit capable of withstanding the stresses developed under the most severe short-circuit conditions.

Exceptionally high levels of terminal pull, tensile strength, wind loading and seismic withstand can be accommodated with the reactor. This unique design can be installed in all types of climates and environments and still offer optimum performance.

Trench air-core dry-type reactors are installed in polluted and corrosive areas and supply trouble-free operation. In addition to the standard fixed reactance type of coil, units can be supplied with taps for variable inductance. A number of methods are available to vary inductance for fine-tuning or to provide a range of larger inductance steps.

In addition, Trench utilizes various other designs for reactors, e.g., iron-core and water-cooled.

Line traps
Line traps (fig. 2) are connected in series with HV transmission lines. The main function of the line trap is to provide a high impedance at power-line-carrier frequencies (30-500 kHz) while introducing negligible impedance at the power frequency (50 or 60 Hz). The high impedance limits the attenuation of the carrier signal within the power system by preventing the carrier signal from being:
- Dissipated in the substation
- Grounded in the event of a fault outside the carrier transmission path
- Dissipated in a tap line or a branch of the main transmission path.

Series reactors
Reactors are connected in series with the line or feeder. Typical uses are fault-current reduction, load balancing in parallel circuits, limiting inrush currents of capacitor banks, etc.

Current-limiting reactors
Current-limiting reactors reduce the short-circuit current to levels within the rating of the equipment on the load side of the reactor (fig. 3). Applications range from the simple distribution feeder reactor to large bus-tie and load-balancing reactors on systems rated up to 765 kV/2100 kV BIL.
Capacitor reactors
Capacitor reactors are designed to be installed in series with a shunt-connected capacitor bank to limit inrush currents due to switching, to limit outrush currents due to close-in faults, and to control the resonant frequency of the system due to the addition of the capacitor banks. Reactors can be installed on system voltages through 765 kV/2100 kV BIL. When specifying capacitor reactors, the requested continuous current rating should account for harmonic current content, tolerance on capacitors and allowable system overvoltage.

Buffer reactors for electric arc furnaces
The most effective performance of electric arc furnaces is achieved by operating the furnace at low electrode current and long arc length. This requires the use of a series reactor in the supply system of the arc furnace transformer for stabilizing the arc.

Duplex reactors
Duplex reactors are current-limiting reactors that consist of two half coils, magnetising against each other. These reactors provide a desirable low reactance under normal conditions and a high reactance under fault conditions.

Load-flow control reactors
Load-flow control reactors are series-connected on transmission lines of up to 800 kV. The reactors change the line impedance characteristic such that load flow can be controlled, thus ensuring maximum power transfer over adjacent transmission lines.

Filter reactors
Filter reactors are used in conjunction with capacitor banks to form tuned harmonic filter circuits, or in conjunction with capacitor banks and resistors to form broadband harmonic filter circuits. When specifying filter reactors, the magnitudes of fundamental and harmonic frequency current should be indicated. If inductance adjustment for fine-tuning is required, the required tapping range and tolerances must be specified. Many filter applications require a Q factor that is much lower than the natural Q of the reactor. This is often achieved by connecting a resistor in the circuit.

An economical alternative is the addition of a de-Q'ing ring structure on a reactor. This can reduce the Q factor of the reactor by as much as one tenth without the necessity of installing additional damping resistors. These rings, mounted on the reactor, are easily coupled to the mag-
netic field of the reactor. This eliminates the concern of space, connection and reliability of additional components such as resistors.

**Shunt reactors**

Shunt reactors are used to compensate for capacitive VARs generated by lightly loaded transmission lines or underground cables. They are normally connected to the transformer tertiary winding (fig. 4) but can also be directly connected on systems of up to 345 kV.

Thyristor-controlled shunt reactors (TCR) are extensively used in static VAR systems in which reactive VARs are adjusted by thyristor circuits. Static VAR compensator reactor applications normally include:
- Thyristor-controlled shunt reactors. The compensating power is changed by controlling the current through the reactor by means of the thyristor valves.
- Thyristor-switched capacitor reactors (TSC)
- Filter reactors (FR)

**HVDC reactors**

HVDC lines are used for long-distance bulk power transmission as well as back-to-back interconnections between different transmission networks. HVDC reactors normally include smoothing reactors, AC and DC harmonic filter reactors, as well as AC and DC PLC noise filter reactors. In addition, self-commutated HVDC schemes include converter reactors.

**Smoothing reactors**

Smoothing reactors (fig. 5) are used to reduce the magnitude of the ripple current in a DC system. They are required on HVDC transmission lines for system voltages of up to 800 kV. They are also used in power electronics applications such as variable-speed drives and UPS systems. Several design and construction techniques are offered by Trench.

**Test lab reactors**

Test lab reactors are installed in high-voltage and high-power test laboratories. Typical applications include current-limiting, synthetic testing of circuit-breakers, inductive energy storage and artificial lines.

**Neutral earthing reactors**

Neutral earthing reactors limit the line-to-earth fault current to specified levels. Specification should also include unbalanced condition continuous current and short-circuit current duration.
Arc-suppression coils
Single-phase neutral earthing (grounding) reactors (arc-suppression coils) are intended to compensate for the capacitive line-to-earth current during a 1-phase earth fault. The arc-suppression coil (ASC) represents the central element of the Trench earth-fault protection system (fig. 6).

Because the electric system is subject to changes, the inductance of the ASC used for neutral earthing must be variable. The earth-fault protection system developed by Trench utilizes the plunger core coil (moveable-core design). Based on extensive experience in design, construction and application of ASCs, Trench products can meet the most stringent requirements for earth-fault compensating techniques.

Variable shunt reactors (VSR)
Variable shunt reactors (fig. 7) are connected in parallel to the lines and supply the grid with inductive reactive power where fast control of reactive power is not necessary. VSRs utilize a plunger core technology to provide variation in reactive power.

Functions which can be achieved by a VSR are:
• Maintain steady-state voltage limit condition
• Keep reactive power flow within predefined limits
• Maintain a desired power factor

Typical network conditions which favor the application of variable shunt reactors can be:
• Networks with distributed power generation
• Strongly varying loads connected though long overhead lines or by cables
• Grid connection of remote renewables (e.g. wind power)
Capacitor filter protection relay (CPR)
CPRs (fig. 8) are specifically designed to provide comprehensive protection of medium and high voltage capacitor banks and filter installations.

The new CPR500 additionally features a capacitive touch user interface, graphical display and optional IEC61850 communication multi language support. Protection functions are:
- Peak repetitive overvoltage protection to the 50th harmonic
- Overcurrent, undercurrent and earth fault protection
- Neutral unbalance protection with residual compensation
- Line unbalance protection
- Thermal protection for capacitor, inductor & resistor elements
- Dual breaker fail protection with programmable logic
- Capacitor re-switching protection
The Trench Group is your partner of choice for electrical power transmission and distribution solutions today and for the development of your new technology solutions of tomorrow.

For more information check out our website at www.trench-group.com or send an e-mail to: sales@trench-group.com