Air-Core Dry-Type Shunt Reactors from distribution class applications up to 110kV voltage level have been widely used for decades. Due to recent developments made by Trench, the application of Air-Core Dry-Type Shunt Reactors is now possible up to voltage levels as high as 550kV. The use of Dry-Type Reactors provides utilities with a wide range of advantages which will be outlined in this paper.

ADVANTAGES OF DRY-TYPE REACTORS
Shunt Reactors can basically be split into two groups:
• Direct advantages related to the equipment
• Indirect advantages

DIRECT ADVANTAGES
• Modular Construction
• Reduced Maintenance
• Reduced delivery times
• Absence of Bushings
• Absence of Oil
• Reduced costs for spare units
• More robust against system harmonics
• Homogeneous insulation along the whole winding

INDIRECT ADVANTAGES
• Reduced costs for civil work
• No secondary equipment (oil-level meter, Buchholz Relay, PT100, …)
• Easier handling and transportation
• Environmentally friendly > Easier to receive environmental permits when planning new or upgrading existing substations
• Faster re-energization in case of failures

Trench has done different total cost of ownership calculations. Dependent on the requirements from different utilities and countries the total cost advantage can be as high as 40% compared to commonly used technology.

AVAILABLE VOLTAGE AND POWER RATINGS

<table>
<thead>
<tr>
<th>VOLTAGE LEVEL</th>
<th>AVAILABLE RATED POWER</th>
</tr>
</thead>
<tbody>
<tr>
<td>550 kV</td>
<td>20 MVA</td>
</tr>
<tr>
<td>420 kV</td>
<td>40 MVA</td>
</tr>
<tr>
<td>362 kV</td>
<td>60 MVA</td>
</tr>
<tr>
<td>245 kV</td>
<td>80 MVA</td>
</tr>
<tr>
<td>170 kV</td>
<td>100 MVA</td>
</tr>
<tr>
<td>145 kV and below</td>
<td>120 MVA</td>
</tr>
<tr>
<td></td>
<td>140 MVA</td>
</tr>
<tr>
<td></td>
<td>160 MVA</td>
</tr>
<tr>
<td></td>
<td>180 MVA</td>
</tr>
<tr>
<td></td>
<td>200 MVA</td>
</tr>
<tr>
<td></td>
<td>220 MVA</td>
</tr>
<tr>
<td></td>
<td>240 MVA</td>
</tr>
</tbody>
</table>

345kV SHUNT REACTOR
MODULAR DESIGN OF DRY-TYPE HV SHUNT REACTORS

Generally, Air-Core Dry-Type Reactors are constructed as single-phase units.

EXAMPLE 345 OR 420KV SHUNT REACTOR

A 420kV Shunt will typically be constructed by Trench in two reactor columns connected in series, each composed of two windings. At 345kV this arrangement is also common however single column per phase units have also been supplied.

To have full availability even following a failure, Trench recommends purchasing one complete phase, which means 4 windings or two columns, as a spare. In case of a shunt reactor failure, normally only a single column or part column will fail. This means that for two column per phase designs only one column needs to be replaced. If a complete phase (two columns) has been purchased as a spare, one column is still available as a spare after a failure has occurred.

Traditional oil filled iron core units are manufactured either as 3 phase units in a single tank or as three separate single phase units. In the case of 3-phase units a complete 3-phase shunt reactor must be used as a spare. If the shunt reactor is constructed as three separate single phase units, a complete phase must be replaced in the event of a failure. The major drawbacks in both these cases is a higher overall cost for spares and the unavailability of a spare following a failure until a new reactor can be delivered. The modular construction of Dry-Type Air-Core HV Shunt Reactors overcomes this problem and furthermore opens the opportunity to distribute the spares over more than one substation.

EXAMPLE 4 SUBSTATIONS EACH HAVING TWO 420KV SHUNT REACTOR BANKS

For this example, the spare strategy could be as follows:

To have two complete phases as spares. This can be translated into a total of 8 windings. The 8 spare windings could be distributed to have two windings per substation. The example outlined will provide the user with much more security, better logistics, faster re-energization time and all of this at significantly reduced spare costs.

DID YOU KNOW THAT 20 TO 40% OF ALL REACTOR AND TRANSFORMER FAILURES ARE CAUSED BY BUSHINGS?

SIMPLE AND SECURE INSULATION SYSTEM

For HV Dry-Type Shunt Reactors Trench utilizes an insulation system which has been proven over decades in combination with innovative measures in material, construction and manufacturing.

To also allow the modular design Trench HV Dry-Type Shunt Reactors are designed with a homogenous insulation along all windings.

No graded insulation!

One very special advantage of Dry-Type HV Shunt Reactors is the absence of bushings. The bushings are one of the most stressed elements in traditional Shunt Reactors.

Different surveys are showing that dependent on the region 20 to 40% of all Shunt Reactor and Transformer failures are caused by failing bushings.