SOLUTIONS FOR IMPROVING MAINTENANCE OPERATIONS ON POWER TRANSFORMERS IN PRIMARY SUBSTATIONS

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ABSTRACT

The maintenance of apparatus operating on the electrical networks can be improved following the total cost evaluation approach.

Power transformers to be installed in primary substations - typical ratings: 40 MVA, 150 kV/20 kV - have been implemented taking into account the maintenance operations to be performed in all their expected life.

This paper describes the main improvements that have been adopted or that are going to be adopted on transformers and relevant accessories in Enel Distribuzione. Moreover economical evaluations, quality of energy supply implications as well as safety and environmental considerations are reported.

INTRODUCTION

The Enel Distribuzione network has about 1800 Primary Substations, high voltage (HV) 150 or 132 kV and medium voltage (MV) 20 or 15 kV, with an amount of about 3800 power transformers of 16, 25, 40, 63 MVA rated power.

Such transformers are standardised with specific requirements about ratings, design and test procedures. They usually operate at maximum 70-80 % of rated load and they are therefore not so thermally stressed, except if emergency load condition occurs but such situation rarely happens and for short period (just few days).

Dielectric stresses are also limited as usual in European networks, by proper surge arresters on both HV and MV sides.

Limited stresses also concern the short circuit strengths on the windings, because of the following reasons: Yyn connection with AT not accessible neutral; absence of delta connected tertiary; high short-circuit impedance to limit the MV short circuit current at 12.5 kA; neutral of MV system insulated or earthed by Petersen coil.

With the above mentioned parameters the fault ratio is quite low (even if a certain increase has been recently recorded) and the main problems as oil leakages, oxidation of metallic parts and porcelains damages (sometime also bushing faults) are usually not so relevant.

It is therefore self-evident how maintenance operations connected to such large numbers of transformers are of strategic importance.

Technological modifications on power transformers have been for many years developed slowly and continuously, mainly in the direction to improve electromagnetic performances and design solutions.

On the other hand, transformer components and accessories based on new material and technologies developed have not been subjected to the same adoption and diffusion. Probably due to the tendency of power transformer experts not to support strongly new electronic technologies and because buyer targets are often focused on saving purchase cost.

Present wide availability on the market of low maintenance components for primary substations has addressed utilities towards new ways to manage installing and maintenance operations.

In order to avoid any decreasing in good standard level of energy quality, simplification of the maintenance operations must be evaluated properly taking into account all related aspects.

SOLUTIONS ADOPTED

The more important solutions recently adopted and in progress for improving maintenance operation on transformers are reported in the following.

Vacuum type on load tap changers

Traditionally power transformers have been equipped with resistor type OLTCs with oil diverter switches for several years.

The OLTC oil technology has been proved reliable and is giving satisfactory operation results.

Prescribed maintenance for such components (necessary for diverter switch contacts substitution and for contained oil treatment or substitution too) represents a relevant cost and requires also to plane the transformer out of service for one day.

The period recommended for maintenance is approximately 8-10 years or 100,000 operations. Such operation can take place 2 or 3 times during transformer life.

From few years a new technology based on vacuum switching technology with diverter switch equipped with vacuum type breakers is available on the market and has became always more and more diffuse.

From the positive feed-back of papers and literature available on the matter, this new technology is considered to be reliable.
Moreover the reliability of the vacuum interruption technology has been well tested in Enel medium voltage network 20 kV where a large part of the circuit breakers is presently based on such technology. Despite the higher purchase cost compared to traditional ones, vacuum type OLTCs allow a large reduction of the maintenance operations usually required for traditional type. The vacuum type OLTCs should require maintenance of oil and contacts after about 300,000 operations, which should mean maintenance free for all transformers life. The operating current range of new OLTSs is wider than traditional ones and it allows to use the same OLTS size for all the mentioned transformer sizes (from 16 to 63 MVA). Moreover, it has also to be evidenced that for vacuum type OLTC the treatment of oil is no more necessary with consequent safety and environmental benefit.

**High voltage polymeric insulators**

As for OLTCs polymeric insulator technology is available on the market from several years. A typical problem related to the organic material consumption has been solved. Mainly for the lower diffusion, compared with traditional porcelain insulators, the polymeric insulators are available with higher purchase cost. The present experience in Enel-Distribuzione, even if limited to GIS, is satisfactory. Traditional porcelain insulators require specific maintenance for cleaning operations in order to avoid electrical discharge on the external surface. Even if a general criteria is not scheduled because strictly related to the pollution level of the installing area, such operation has to be performed in off-voltage condition and therefore they have to be planed carefully. Polymeric insulators due to their characteristics do not need the same number of maintenance operations for cleaning. By adopting them, maintenance operation should be avoided in light polluted area and also strongly reduced in area with high pollution level. Moreover the problems related to the porcelain rupture, during transport, handing operation have also been taken into account as well as the risk of explosion. With the new solution such problems are expected to be avoided or at least consistently reduced.

**Plug-in medium voltage terminals**

Despite their expensive cost, the plug-in medium voltage terminals allow direct connection of the MV cables on the transformer. The present traditional solution requires a heavy permanent support frame to sustain the bus bar connection system between transformer terminals and cable terminals at the prescribed minimum safety height. With the new solution the assembling operation for the connecting cables are simplified, support for the cable can be lighter and the insulating system for the copper bus bar is not necessary. Moreover, the present fault risk caused by contacts of animals or large birds with bus bars is avoided and the specific protections used for not insulated busbar no more necessary because from this point of view the fully protection is reached. Therefore the solution is estimate also important for a quality of the energy supply, even if a reliable statistical evaluation is not available yet. Moreover, in case of necessity to measure transformer parameters or in case of fault on one of cables per phase, the inlet cable can be managed (connect, disconnect and moved) easily if adaptors are provided. New manufacturer in this field are expected, because the market is increasing but the price is deemed overestimate.
Maintenance free dehydrating breathers
Each of the transformers under consideration is equipped with two silica gel, one for transformer oil and a second smaller for the OLTC diverter switch oil.
The maintenance operation for traditional dehydrating breather in Enel-Distribuzione is about every 3 months for a visual check and about every year for the silica gel material substitution.
It is expected that the new component are maintenance free and the above mentioned maintenance operations no more necessary.
Therefore, with the use of the new type of dehydrating breather it is expected a pay-back of the larger purchase cost after few years.
Moreover, some benefits are also expected taking into account that regeneration of used silica gel and the conservation of the regenerated or new gel in a dry site will be no more necessary.
At last, from the environmental point of view, the no need of the dismissing of exhausted gel is considered a benefit.

Future developments
With the same aim to simplify maintenance operations other improvements are going to be introduced.
The radiators will be optionally prescribed of galvanized type, in order to avoid oxidation, oil leakages and the consequent necessity of re-painting or substitution just after few years of operation in polluted areas.
Oil dissolved gases analysis (DGA) are going to be implemented in order to monitor the transformers condition, their expected life and, if necessary, to adopt the appropriate corrective actions.
Another relevant optional modification concerns the reduction of the audible sound emitted by transformers. Typical prescribed noise level for 40 MVA of 70 dB (sound power level) has been reduced to 66 dB in order to avoid noise disturbances to privat houses close to the installation sites and to avoid works necessary to reduce noise levels within the prescribed law-limits.

CONCLUSION
Enel Distribuzione, following the positive result of the technical and economical evaluations of the above mentioned solutions, even if partially adopted, is intentioned to follow this way in order to reduce the maintenance operations of primary substations and, at the same time, to keep on with high level of energy supply quality.
The new solutions presently in field are constantly monitored and evaluated. New and more accurate comparison based on a larger number will be available in the future.