EN

LIQUID IMMERSED INDUSTRIAL TRANSFORMERS

For metallurgical, steel, chemical, glass plants and VSD

TRANSFORMING THE FUTURE

SEA has been designing and manufacturing transformers for very high current applications and transformers for harmonic levels, positioning itself among the industry leaders since 1959.

IQTRAFOTEC®

Innovative construction solutions, modern and technologically advanced processes, detailed checks throughout the entire design and construction chain asssure the total quality of the product.
SEA has established procedures to assure the TOTAL QUALITY of its products availing itself on its own know-how and adapting it to innovative manufacturing processes and strict control procedures.
This type of technology has been identified by SEA with the name IQTRAFOTEC®, a brand guaranteeing a continual commitment to improve the product and its manufacture, considering 4 main areas such as:

- Safety of the working environment
- Quality of the product
- Saving of materials and reduction of waste
- Lowest environmental impact during manufacture, maintenance and after use

HIGH QUALITY STANDARDS

MANAGEMENT SYSTEM

The Quality of our products is achieved by processes that are continuously refined, combining experience in the electromechanical sector since 1959 with the most modern technologies, and approved in accordance with the most important Standards concerning the Quality (EN ISO 9001) and Environmental (EN ISO 14001), Safety (OHSAS 18001) Management Systems.
Moreover, OTN/OTR/OTF transformers comply with the IEC and DIN standards, with the possibility of correspondence with other International Standards or Customer Specifications (BS, ANSI, IEEE, GOST, etc.).

PRODUCTION QUALITY

The high reliability of the products results from a continuous perseverance in achieving high quality standards during all “supply chain” phases. Especially during the production cycles there is a strict compliance with the implemented control parameters, which assure both the suitability of the assembled components and the performance of the finished product, all this even through tests carried out at our internal laboratories equipped with the most modern instruments available for type-testing or special testing, if the customer requests it.

ENVIRONMENTAL ASPECTS

The constant research aimed at improving efficiency merges with the commitment to minimize environmental impacts. This is another essential issue on which SEA focuses its corporate policy. All this has an impact on both the construction process and the realization proposals for our OTN/OTR/OT transformers. The use of a transformer, as we all know, can produce, in case of failure, severe environmental impacts, such as, for example, various oil leaks or fire. Right with a view to reducing these serious risks, SEA focused on the most effective security systems assembled on the transformers themselves and on the type of insulating liquids used for filling them, which can be also biodegradable, upon request.

Aluminium, copper, chemical, alloy, glass and all other melting and heavy metallurgical plants needs high reliable transformers to withstand to the high stress due to the critical conditions that are affected.
SEA is able to produce both single-phase and three-phase transformers for AC electric arc furnaces (EAF), ladle furnaces (LF), reduction furnaces (metallurgical industry) or for special applications, as well as for DC furnaces usually installed in combination with a rectifier.
Other transformers manufactured for industrial purposes are converter transformers (6-12-18-24-36-48 up to 72 pulse app.). These transformer types as well as converter transformers for large drive applications are defined as Industry Transformers, whose design is customized to enable significant savings in such processes.

AC FURNACE TRANSFORMERS

EAF AND LF TRANSFORMERS

The transformer used for Electric Arc Furnace (EAF) and Ladle Furnace (LF) are somewhat different from the other power transformers and their design has to take in consideration specific solutions suitable for the critical conditions that are affected:

- Very high secondary currents
- Low secondary voltages
- Heavy current fluctuations
- Switching transients
- Short circuits
- Unbalanced and overloading conditions
- Dielectric, thermal and mechanical stresses
- Pollution and dust
- Vibrations

Electric Arc Furnace transformers are used for many different furnace processes:

- Steel furnace, for long arc applications (EAF)
- Ladle Furnaces (LF), normally in combination with an arc furnace
- Reduction furnaces for ferroalloy and similar (ferro-sylicon, silicon metal, ferro-manganese, ferro-nickel, ferro-chrome) with short and submerged arc
- Reduction furnaces for non-ferrous metals
- Other furnaces for special purposes for the production of electrode material, Submerged Arc Furnaces (SAF), Electroslag Refining (ESR) and smelter furnaces for the production of special iron alloy

Steel arc furnace transformers operates under severe conditions due to the overcurrents and overvoltages generated by short circuits in the furnace and by the HV circuit breaker.
The loads are cyclic compared to other applications where they are more continuous at high utilization.

DESIGN

SEA EAF transformers are designed to withstand repeat short circuit conditions, high thermal stresses and operational overvoltages.

The following options are available:

- Direct or indirect regulation
- On-load (OLTC) or No-load/Off-circuit (NLTC / OCTC) tap changer located at HV side
  (Secondary Voltage is normally regulated by OLTC located in HV windings or in an intermediate circuit of a two core-design (booster regulation) with the transformer tank)
- Air or water cooling system
- Single phase or three-phase type
- Different secondary bushing arrangement (copper bars or water cooling pipes system)
- LV secondary phase Delta closure either inside or outside the tank
- LV exits either lateral on the tank or top on the cover

ELECTRICAL DATA

Rated Power: up to 120 MVA
Rated Secondary Current: up to 100 kA

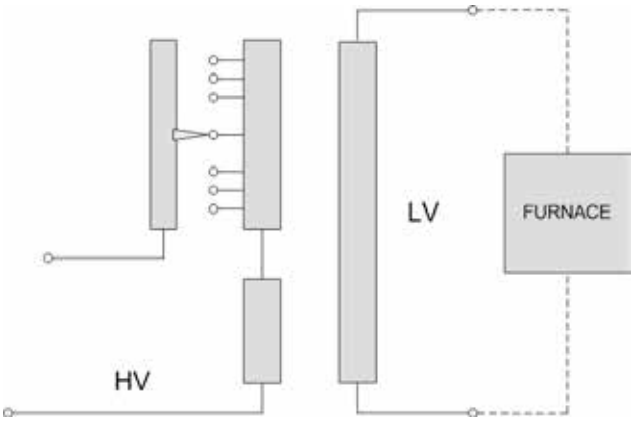
VOLTAGE REGULATION OPTIONS

DIRECT REGULATION (VARIABLE FLUX VOLTAGE REGULATION)

It is made by taps on the high voltage winding. This configuration is the most advantageous because it allows to use just one single magnetic core that means reduction of weight and losses. The taps are usually placed on the neutral end of the primary winding.

The disadvantage is related to the step voltages that are not constant through the range of voltage regulation.

The transformers can be equipped with an additional star-delta reconnection switch (by this way a wide range for the secondary voltage is obtained).

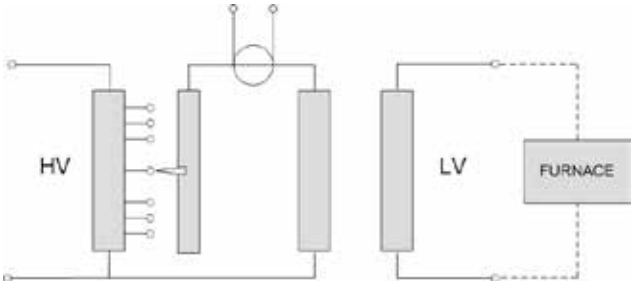


REGULATION BY AUTOTRANSFOMER

By this configuration is easy to get a system with small values and equal steps. It is used for larger furnace applications.

The autotransformer reduces the voltage down to the primary winding level of the furnace transformer.

The cores are two, placed in the same or separate tanks. The advantage of manufacturer is related to the maximum flexibility in the choice of the most suitable tap changer.



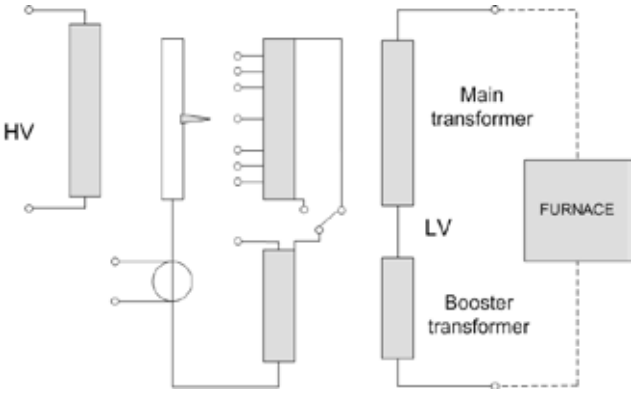
REGULATION BY AN AUXILIARY TRANSFORMER (BOOSTER REGULATION)

This is a special circuit with two cores design in the same tank used with medium and large furnace applications.

The booster transformer increases the output of the fixed secondary voltage of the main transformer.

The tap changer is installed on the tertiary winding. The voltage and current values of the tertiary are selected by the transformer manufacturer: such way offers an optimization of tapping operating condition using the most suitable tap changer.

With this solution multiple voltages can be also obtained. One option could be to use a series reactor with one OLTC.



DC FURNACE TRANSFORMERS

The most larges DC arc furnaces are built also for the steel production to melt scrap metal.
The use of a thyristor rectifier reduces the requirement of OLTC and a NLTC can be mostly adequate because the steps voltages are larger than an AC furnace transformer.
These EAF transformers for DC furnace application have to withstand the:

- Stresses related to furnace operation
- Stresses related to rectifier operation, including generated currents harmonics
- HV side needs to be protected from frequent switching overvoltages

DESIGN

Normally these transformers have a structure with:

- 2 LV windings displaced axially, one connected in delta and one in wye
- 6 or 12 pulse system (in this double tier-design the transformer is connected to a 12-pulse system or two parallel 6-pulse systems)
- Air or water cooling system
- Intermediate yoke for double stacked coil structure
- Regulation by an NLTC or OLTC in the HV winding
- Secondary bushing different arrangements
- Bushing outlet in the cover or in the side of the tank

An important factor to be taken into account in these kind of transformers is the localized overheating.
The voltage range in these kind of transformer is high from zero to several hundred volts.

RECTIFIER TRANSFORMERS

for DC Applications and Aluminium Electrolysis

They are used to supply rectifier bridges for DC applications and various electrolysis application (metals like aluminium, magnesium, copper and zinc or chemicals like chlorine).
Electrolysis normally is considered to be continuous and stable processes, but with a constant high loading and current harmonics.
In conjunction with thyristor or diode rectifiers, these transformers form the link between the AC and the DC systems of the industrial plant.
Their development and construction requires extensive experience as well as deep know-how because these transformers face high operating currents and a considerable amount of harmonic content.
The distorted current waveform is due to the convertor causing higher losses and temperatures in the transformer.

DESIGN

In this type of transformers there are several factors to be considered:

- In case of thyristor rectifier, NLTC tap changer regulation
- In case of diode rectifier with a long range and high numbers of voltage steps in the transformer, OLTC tap changer regulation
- LV windings arrangements adapted to minimize the hotspots and harmonics
- LV bushings arrangements adapted to the rectifier design
- Various configurations available in a single unit: single bridge, double bridge, etc.
- Multi-pulse types options from 6 - 12 pulse unit to 72-pulse
- Different vector groups
- Phase shifting windings design option
- Regulating autotransformer available in the same tank or an OLTC operating on taps on primary windings to get a coarse on load voltage regulation
- Saturable reactors available in the same tank to get a fine on load voltage regulation
- Particular attention to the cooling system in order to avoid high eddy current losses caused by the rectifier harmonics

ELECTRICAL DATA

Rated Power: up to 80 MVA
Rated Secondary Current: up to 50 kA

CONVERTER TRANSFORMERS
for Variable Speed Drives (VSD)

The main differences between these type of transformers and the other types is that the load currents have an higher content of harmonics due to the distorted waveform.
Combined with a frequency converter they supply the input for variable-speed drives (VSD).
Variable speed drives are used to control the speed of rotation of electric motors in many industrial applications like pumps, ventilators, compressors, belt conveyors, rolling mills, paper machines and an innumerable amount of different machines used in manufacturing and industrial sectors.
Mostly built as double-tier models with two secondary windings they allow 12 / 24 pulse operation.
In small oil immersed units natural cooling (ONAN) is normally utilized. In larger units cooling is mostly obtained by forced circulation of either oil and water (OFWF) or oil and air (OFAF) in a cooler connected by oil pipes to the transformer tank.
In the case of OFWF cooling, one redundant system is usually provided.
Each of them is rated for the full transformer losses, so that the transformer can be kept running at its full load in the event of a failure of either a cooler itself or its auxiliary equipment.

DESIGN

In this type of transformers there are several factors to be considered and several design options:

- Double tier or multiple tier design
- Phase shifts design
- OLTC or NLTC tap changer option
- Additional winding is used as filter for harmonics
- Electrostatic shield design between primary and secondary windings
- Air or water cooled bushing design.

ELECTRICAL DATA

Rated Power: up to 120 MVA
Pulse operation: up to 72

THREE-PHASE LIQUID IMMERSED TRANSFORMER
WITH VARIABLE FLUX REGULATION FOR AC EAF FURNACE

ELECTRICAL DATA		
Rating power:	25000	kVA
N° of phases:	3	
N° of windings per phase:	2	
Cooling:	OFWF	
Fn:	50	Hz
No load primary voltage:	33	kV
N° of secondary windings:	2	
No-load secondary voltage:	120 ÷ 220	V
Vector Group:	Star + N / Open Phase	
Insulating Level at I°:	36 / 70 / 170	kV
Insulating Level at II°:	1,1 / 3 / --	kV
Primary bushing protection degree:	IP00	
Secondary bushing protection degree:	IP00 (4+4 hollow copper tubes suitable for water cooling circulation inside, located on long side of the tank)	
LV output current:	91000	A

SPECIAL TECHNICAL REMARKS

The regulation is obtained by variable flux on HV windings by OLTC, complete with with motor drive unit and oil flow relay.
The range of regulation is obtained by 22 steps and 23 voltage positions at LV side.

THREE-PHASE LIQUID IMMERSED TRANSFORMER
FOR METAL PLANT (2500 M.A.S.L.)

ELECTRICAL DATA		
Rating power:	80000 / 100000	kVA
N° of phases:	3	
N° of windings per phase:	2	
Cooling:	ONAN / ONAF	
Fn:	60	Hz
No load primary voltage:	230	kV
N° of secondary windings:	1	
No-load secondary voltage:	34500	V
Vector Group:	YNd11	
Insulating Level at I°:	3245/460/1050 - 850	kV
Insulating Level at neutral:	123/230/550	kV
Insulating Level at II°:	38 / 70 / 170	kV
Primary bushing protection degree:	IP00 (N° 3+1 bushings oil/air)	
Secondary bushing protection degree:	IP55 (N° 3 bushings oil/air)	

THREE-PHASE LIQUID IMMERSED TRANSFORMER FOR DC FURNACE (COPPER REFINING) APPLICATION

ELECTRICAL DATA		
Rating power:	8570	kVA
N° of phases:	3	
N° of windings per phase:	2	
Cooling:	OFWF	
Fn:	50	Hz
No load primary voltage:	25	kV
Type of tap changer on primary:	OLTC	
No-load secondary voltage:	(189 - 171 - 151 - 132 - 112 - 91) adjustable by OLTC	V
Vector Group:	Yy0	
Insulating Level at I°:	36 / 70 / 170	kV
Insulating Level at II°:	1,1 / 10	kV
Primary bushing protection degree:	IP00 (3 plug-in connex on the short side of the tank)	
Secondary bushing protection degree:	IP00 (flat and drilled copper busbars on the side of the tank)	
LV output current:	20500	A

THREE-PHASE LIQUID IMMERSED TWO SEPARATED CONVERTER UNIT WITH REGULATING AUTOTRANSFORMER

ELECTRICAL DATA		
Rating power:	8055	kVA
Secondary 21/22 rating power:	4027 / 4027	
N° of phases:	3	
N° of windings per phase:	3	
Cooling:	OFWF	
Fn:	50	Hz
No load primary voltage:	20	kV
N° of secondary windings:	2	
No-load secondary voltage:	(35 ÷ 76 - 35 ÷ 76)	V
Vector Group	Dd0 - Yd1	
Insulating Level at I°:	24 / 50 / 145	kV
Insulating Level at II°:	1,1 / 3 / -- / 1,1 / 3 / --	kV
Primary bushing protection degree:	IP00	
Secondary bushing protection degree:	IP00 (6 + 6 phase bars, on the long side of the tank)	
LV output current:	2 x 31000	A

SPECIAL TECHNICAL REMARKS

This transformer unit for converter operation is composed by one anodic transformer double tier type (Dd0 - Yd1) and one regulating autotransformer in the same tank.
The regulation is obtained by autotransformer and OLTC, complete with Motor drive unit and oil flow relay.
The range of regulation is obtained by 16 steps equally spaced and 17 positions

THREE-PHASE LIQUID IMMERSED RECTIFIER TRANSFORMER FOR INDUCTION FURNACE

ELECTRICAL DATA		
Rating power:	5300	kVA
Secondary 21/22 rating power:	2650 / 2650	
N° of phases:	3	
N° of windings per phase:	3	
Cooling:	OFWF	
Fn:	50	Hz
No load primary voltage:	11	kV
N° of secondary windings:	2	
No-load secondary voltage:	600 - 600	V
Vector Group:	Dy11d0	
Insulating Level at I°:	17,5 / 38 / 95	kV
Insulating Level at II°:	1,1 / 3 / --/ 1,1 / 3 / --	kV
Primary bushing protection degree:	IP00	
Secondary bushing protection degree:	IP00	

THREE-PHASE LIQUID IMMERSED RECTIFIER TRANSFORMER UNIT WITH REGULATING AUTOTRANSFORMER

ELECTRICAL DATA		
Rating power:	15235	kVA
Secondary 21/22 rating power:	7886 / 7886	kVA
N° of phases:	3	
N° of windings per phase:	3	
Cooling:	OFWF	
Fn:	60	Hz
No load primary voltage:	13,2	kV
N° of secondary windings:	2	
No-load secondary voltage:	(557 ÷ 222 - 557 ÷ 222)	V
Vector Group:	Dd0,y11	
Insulating Level at I°:	17,5 / 38 / 95	kV
Insulating Level at II°:	1,1 / 3 / -- / 1,1 / 3 / --	kV
Primary bushing protection degree:	IP54	
Secondary bushing protection degree:	IP00 (3 + 3 phase bars, located on the long side of the tank)	

SPECIAL TECHNICAL REMARKS

This transformer unit for converter operation is composed by one anodic transformer double tier type (Dd0, Yd11) and one regulating autotransformer in the same tank. The regulation is obtained by autotransformer and OLTC, complete with motor drive unit and oil flow relay.
The range of regulation is obtained by 16 steps equally spaced and 17 positions.

THREE-PHASE LIQUID IMMERSED RECTIFIER TRANSFORMER WITH TERTIARY WINDING

ELECTRICAL DATA		
Rating power:	4300 / 2x2150 / 4300	kVA
Secondary 21/22 rating power:	2150 / 2150 + tertiary	kVA
N° of phases:	3	
N° of windings per phase:	4	
Cooling:	ONAN	
Fn:	50	Hz
No load primary voltage:	6	kV
Type of tap changer on primary:	NLTC	
No-load secondary voltage:	531 - 2x185	V
Vector Group:	Dd0, y11-Dd0	
Insulating Level at I°:	12 / 28 / 75	kV
Insulating Level at II° and III°:	1,1 / 3 / --	kV
Primary bushing protection degree:	IP00	
Secondary bushing protection degree:	IP00 (3x3 phase bars, located on top of the tank)	

THREE-PHASE LIQUID IMMERSED RECTIFIER TRANSFORMER WITH REGULATING AUTOTRANSFORMER

ELECTRICAL DATA		
Rating power:	7720	kVA
Secondary 21/22 rating power:	3860 / 3860	kVA
N° of phases:	3	
N° of windings per phase:	3	
Cooling:	OFWF	
Fn:	50	Hz
No load primary voltage:	30	kV
Type of tap changer on primary:	OLTC vacuum type	
No-load secondary voltage:	303 ÷ 180	V
Vector Group:	ATR + Dd0,y11	
Insulating Level at I°:	36 / 70 / 170	kV
Insulating Level at II°:	1,1 / 3 / --	kV
Primary bushing protection degree:	IP00	
Secondary bushing protection degree:	IP00 (2x3 phase bars, located on long side of the tank)	

SPECIAL TECHNICAL REMARKS

This transformer unit for converter operation is composed by one rectifier transformer double tier type and one regulating autotransformer in the same tank. The regulation is obtained by autotransformer and 16 positions OLTC Vacutap complete with motor drive and oil flow relay.

THREE-PHASE LIQUID IMMERSED TRANSFORMER DOUBLE TIER TRANSFORMER FOR CYCLOCONVERTER APPLICATION (12 PULSE APP.)

ELECTRICAL DATA		
Rating power:	16150	kVA
Secondary 21/22 rating power:	8075 / 8075	kVA
N° of phases:	3	
N° of windings per phase:	2	
Cooling:	ONAN / ONAF	
Fn:	60	Hz
No load primary voltage:	33	kV
N° of secondary windings:	2	
No-load secondary voltage:	2485 - 2485	V
Vector Group:	Dd0y5	
Insulating Level at I°:	38,5 / 95 / 250	kV
Insulating Level at II°:	7,2 / 20 / 60	kV
Primary bushing protection degree:	IP55	
Secondary bushing protection degree:	IP55	

THREE-PHASE LIQUID IMMERSED CONVERTER UNIT MADE BY TWO TRANSFORMERS IN ONE TANK

ELECTRICAL DATA		
Rating power:	27136	kVA
Secondary 21/22 rating power:	13568 / 13568	kVA
N° of phases:	3	
N° of windings per phase:	3	
Cooling:	ONAN	
Fn:	54,2 ÷ 77,6	Hz
No load primary voltage:	18	kV
N° of secondary windings:	2	
No-load secondary voltage:	960 - 960	V
Vector Group:	Dd0,y11	
Insulating Level at I°:	24 / 50 / 125	kV
Insulating Level at II°:	7,2 / 20 / 60 / 7,2 / 20 / 60	kV
Primary bushing protection degree:	IP55 (connection on the long side of the tank)	
Secondary bushing protection degree:	IP55 (connection on cover)	

SPECIAL TECHNICAL REMARKS

Two transformers (two indipendent cores) in the same tank to avoid any magnetic coupling between secondaries.
Suitable for operation at 77,6 Hz and lower to 54,2 Hz, with the same feeding voltage.
Short circuit withstand test performed in external laboratory passed.

ELECTROMAGNETIC AND MECHANICAL CALCULATION

The Design is the first and the most critical step in the construction of a special power transformer: it requires a detailed study of the requirements to properly define the fundamental parameters of the transformer that has to be built.
The calculation of each transformer is performed keeping in consideration client's specification and relevant applicable standard (IEC, ANSI and / or others like DEFU, TR1-10E, etc..).
The first step is to identify the fundamental parameters such as power, transformer ratio, short circuit impedance, no-load and load losses, number of spires, section of the conductor, section of the core, the overall geometry of the active part (winding arrangement, physical size of each winding).
In parallel there is the analysis of electromagnetic behaviour including the study of magnetic circuit and distribution of magnetic flux in the transformer, the study of dielectric behaviour and the eddy losses on the windings and their distribution, the study of adding losses on metal parts, the study of hot spots on windings, the study of tank and the study of stresses of windings and internal components due to short circuit.
Once the electromagnetic design has been made, the following step is the thermal design including the calculation of temperature rise of the conductors above the temperature of the cooling liquid, the calculation of thermal distribution of the cooling liquid in the tank determining the average gradient above ambient temperature and the calculation of the cooling system.
In many cases, the industrial transformer is intended to replace an existing one, which has come to its end.
It is therefore necessary to comply with the electrical / mechanical constraints imposed by the existing LV connections and this fact imposes further constraints during design of windings.
In general, the electromagnetic calculation is carried out by optimizing the various input parameters (voltage, impedance, losses) and checking that temperatures and electro-dynamic forces remain well below the maximum permissible for each type of material.

The mechanical design of the transformer is carried out by our technicians using our CAD 3D (Creo). All the internal part, all the copper bars for the connections and external clamps, all the outside carpentry of the transformer are studied and designed inside our technical department.

SEA has several mechanical engineers who are mainly dedicated to the unification and testing of structural components.

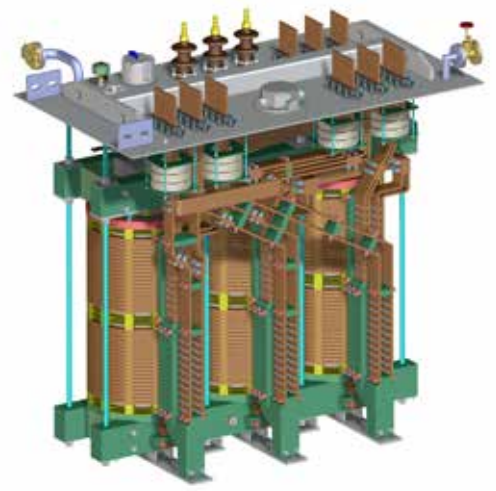
SEA can carry out FEM model verification:

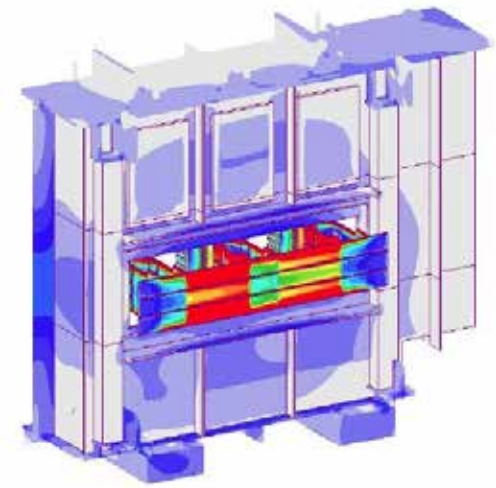
- For the tank, to evaluate mechanical stresses during transportation, lifting, vacuum
- For active part, to evaluate electric field, magnetic field, eddy losses with relevant effects, electrodynamics forces, etc.
- For evaluation of thermal fields
- To calculate losses in windings, connections and ferromagnetic structures, both in case of sinusoidal wave operation and in case of distorted loads
- To verify that the specific losses distribution is not generating hot spots that can damage the insulation system or cause aging of the sealing gaskets

Also some other calculations can be made in SEA R&D department:

- Seismic calculations
- Short circuit calculations
- Others, eventually required by clients in case of special applications

In case of more complicated cases SEA can also carry out further verifications by external consultants.





MAGNETIC CORE

The continuous research of the best materials is focused on efficiency increase, as well as on reducing vibrations and noise levels.
The core consists of magnetic metal sheets plates with oriented grain, high-permeability and low specific losses, separated from each other by an inorganic insulated means.
The cut and the assembly of the core are made in such a way as to create junctions according to the “STEP- LAP” way.
Suitable core clamps (wooden or steel type) are designed avoiding bolts and holes in the laminations in order to reduce the losses, the noise and the vibrations.
Suitable cooling ducts, if necessary, are provided to keep the termal field uniform and free of hot points.

WINDINGS / ACTIVE PART

The type and the shape of the winding depends strictly on the current and voltages that are involved.
Paper-insulated flat conductors (disc type made by copper strips) are typically used for HV windings; continuously transposed conductors (CTC) are generally used for MV and LV windings with currents up to 2000 A for each conductor.
CTC can be either paper-insulated for MV applications or without paper for LV high-current applications.
For higher currents and for special design, a massive copper barr is used, allowing to obtain extremey robust windings from mechanical point of view, particulary suitable to repeat short circuit stresses. In transformers destinated to conversion sets, the secondary windings can be executed in 2 or more indipendent sections, axially or radially arranged.
In case the voltages involved are high, the disc windings represents the best choice: in such configuration, in each disc the turns are wound in axial direction towards the inside and towards the outside in the adiacent discs. Their use is preferred if the number of turns is high.
A long experience and a great care in the assembly of the active part are the secrets to guarantee our product reliability and robustness against the electric and electrodynamic stresses.
The windings carefully pressed and dried are keyed on the respective columns of the core. The assembling of the windings is carefully performed to avoid misallignement.
Windings are properly braced by wooden clamping rings, to assure uniform distribution of compression forces.
After the assembling of the yoke, the cover is fixed and the electrical connections are made. Before the positioning within the tank, the trasformers are checked to verify the correctness of the connections, turn ratio and vector group.
After a careful drying cicle with verification of residual humidity and a tightening torques, the complete active part is inserted inside the tank as quickly as possible (according to a specific time obtained by our R&D studies) in order to prevent the attack by the external humidity. Vacuum filling with oil is furtherly carried out.

TAPPING

Especially for industrial sector and mainly in the furnace applications, the variability of the load influences directly some key parameters of the transformer to be designed such as the choice of tap changer.
It is important to define the correct voltage range because improper design solutions can give expensive impacts (for instance in case of wrong choice of tap changer with wide range of voltage taps).
The not correct number of taps can increase the tap transition period through the secondary voltage range.
The NLTC type cannot operate when the transformer is energized (this is the most simple and economical execution).
The OLTC type is the most complete solution that allows to adjust the rated power supply voltage: it is composed by a tap selector immersed in the same oil of the transformer or, in case of request, in a separated tank.
The diverter switch selector of the OLTC is positioned in another separated section.
The tap changer can be equipped with motor drive unit, oil flow relay and other standard accessories.

TANK - COVER - COOLING SYSTEM

Minimizing the electrical losses during the operation, can ensure the increase and balance of energy input: this is an important topic also in terms of price reduction criteria.
The total losses should include the complete analysis of losses obtained by cooling system.
A focused solution design improves the energy efficiency of the entire industrial system, reducing costs and providing economic benefits together a better reliability of the furnace transformer.

The cooling system plays a key function for a long transformer life.
The industial transformers are mostly provided with OFWF (oil forced / water forced) cooling system, even if the the most used cooling system for power transformers is ONAN (oil natural / air natural) or ONAF (oil forced / air forced), by radiators mounted on the sides of the transformer tank or in separated banks with or without cooling fans.
The positioning of the coolers for OFWF cooling system can be vertical or horizontal, adopting specific customized solution for the connection to the water pipe.
The coolers are usually composed by a single-walled or a double one, in order to have a redundant system.
The accessories that can be included on the OFWF coolers are:

- Oil pump
- Interception valves oil side
- Water and oil flow indicators with alarm switch
- Water and oil thermometers
- Water and oil drain taps
- Other upon request

Also ODWF (oil direct / water forced) is an alternative if water is available.
In case the water cannot be available, other options are:

- OFAF (oil forced / air forced)
- ODAF (oil directed / air forced)

The tank is a conservator type, top bolted. Both tank and cover are made by welded steel sheets, reinforced by stiffeners.

TERMINALS AND ACCESSORIES

Several possibilities are avilable for the bushings: oil/air type, oil/oil type, oil/SF6 connection to SF6 filled bus-ducts, flat plates.
The bushings on HV side can be also condenser type or with oil (or resin) impregnated paper.
The LV exits for rectifier/converter applications are made mainly by copper barrs with lateral exits on the tank or top on the cover.
Alternative solutions for higher power ratings (used for EAF furnaces for instance) are water cooled bushings instead of bars.
The key efficiency parameters of the transformer can be measured by the use of specific devices like:

- Temperature sensors (PT100), Oil temperature indicators (OTI) and Winding temperature indicators (WTI) that can give us important information related to the status of oil and the hotspots temperatures
- Flow meter that helps to monitor the energy/water consumption
- The monitoring of cooling system that can help to protect and extend the service life of the transformer
- Buchholz relay and on-line dissolved gas monitoring device for monitoring the gas/ moisture in the cooling liquid
- Self dehydrating breather for monitoring the moisture in the salt of the conservator or for the OLTC
- Pressure relief devices for the oil pressure control inside the tanks of the transformer
- Voltage meters to analyze the status of degradation of the insulation system
- Surge arresters for the protection of the transformer from external surges
- Impact recorder for the measuring of the acceleration and related transformer mechanical deformation during transport

Such accessories can increase the reliability, reducing also the maintenance costs of the transformer and guaranteeing calibrated control over time: lifecycle of the transformer will be increased.

QUALITY BEYOND THE TEST

In the new testing room routine, type and special tests can be performed according to the regulations required by customers. In the context of the revamping of the workshop, the power transformers testing room is completely new.
Some key facts:

- Overall height 20 meters, to allow the testing of power transformers up to 180 MVA and 245 kV
- Full shielding of walls, floor, roof by “faraday cage”
- Sound proof walls
- New automatic testing bench
- New electronic multifrequency and multivoltage power supply system
- New impulse generator 1200 kV (by Hivolt)
- New data acquisition system (by Hivolt)
- Analysis of hot points made by thermocamera
- Large control room with double floor, with a large sight to objects under tests, to accommodate our testing staff and clients’ staff

SEA has in adding has a large archive of type and special tests performed on many transformers delivered to customers all around the world.

TRANSPORT

SEA can deliver the transformer everywhere in the world.

Thanks to the experience gained over many years and to its qualified personnel SEA performs the shipping and reassembling on site, agreeing from time to time with the customer on the most appropriate approach.
For shipments carried out to particularly critical sites or if requested by the customer SEA can equip the transformers with a sophisticated “impact recorder” that allows to keep the quality of the transport monitored.

SERVICE

SEA is able to meet your needs with a modular and flexible intervention plan through which you can take care of your transformer, keeping it in perfect working order.

In addition you can count on a clear and defined price, including labor and spare parts, which shelters you from any surprise.
A qualified Technical Service is made available for any questions or needs that may arise during assembly or operation of all our products.

- Transport, unloading and positioning on site
  Thanks to its team of technicians SEA is able to deliver the transformer in a “turnkey” solution to the end customer.
- Assistance to commissioning
  One of our technicians will personally assist you during normal control operations prior to the first commissioning of the machine. The verification of the correct assembly of all accessories and some simple routine checks are essential for a reliable operation and the long life of the transformer.

- Hiring of transformers
- Diagnostics and Consultancy
  Using sophisticated portable equipment, SEA is capable of monitoring and recording the most relevant electrical quantities for the transformer and the system: voltage, currents, harmonics, impulsive overvoltages and noise, oil dielectric strength, temperature, noise, SFRA test.
  Data recording can be of great help in the diagnosis of a failure or to suggest to the customer changes and improvements to its system.
- Routine and extraordinary maintenance
  Many repairing and assistance works (replacement of accessories and seals, repairs of small leaks that require welding without the need to empty the oil tank, oil checking and processing, paint touch-up, oil top-ups) can be performed directly on site, thus saving time and avoiding the risks and inconveniences that may result from the movement of the transformer.
- Supply of spare parts
  Supply or supply and assembly on site of transformer accessories.
- Support Services
  Specifically designed to give the customer the possibility to get always the best performance from its transformer.

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