A COMPLETE RANGE OF SOLUTIONS

As a critical component of networks, the power transformer is essential to high voltage electrical power transmission as it adapts and transfers electrical energy from one circuit to another and optimises energy efficiency.

Combining the expertise of a global manufacturer with local service centres, Alstom Grid offers high voltage asset management throughout the power transformer’s lifecycle. With more than 100 years of experience on transformers worldwide, we provide customers with a full range of services for any transformer.

Based on our manufacturing expertise and time-proven refurbishment experience, Alstom Grid offers the most cost-effective and efficient solutions to increase the lifetime of your power transformer.

From onsite assessments, mid-life overhauls, periodic inspections and diagnosis to complete upgrading, we provide customised services according to your power transformer’s age and type.

Our technical experts take care of your assets and we make sure that all quality and safety regulations are respected.

Our services include:
• Erection, commissioning and supervision
• Fault diagnosis, testing, partial discharge measurement, condition monitoring and oil analysis
• Long-term operations and maintenance
• Renovation, modernisation and extension
• Maintenance, repair, emergency support
• Spare parts and strategic spare parts management
• Technical training and competence development programmes

Make your equipment smarter and more sustainable based on field-proven techniques

At Alstom Grid, our mission is to ensure that your energy supply is reliable, efficient and environmentally-friendly. We leverage the technical know-how of our equipment design and manufacturing into customised services.

An efficient, proactive monitoring system combined with Alstom Grid’s expert services is the best way to prolong equipment life. Our condition monitoring service solutions can drastically reduce the risk of failure. Alstom Grid brings you innovative technological solutions to keep your high voltage equipment up-to-date, safe, reliable and efficient. Asset management optimises your infrastructure performance while keeping your operating costs under control.

Alstom Grid local service units around the world are managed by strict quality management systems - including our own methodology - and fulfil the requirements of ISO 9001, environmental, health and safety standards, ISO 14001 and OHSAS 18001.

" Take advantage of our manufacturing experience and decades of expert knowledge "

Investing in quality, innovative equipment that optimises your electrical infrastructure and heightens your return-on-investment is essential.

Once the equipment is purchased, you need to ensure that it continues to function optimally throughout its lifetime.

\[ \text{PRODUCT LIFECYCLE MANAGEMENT - p. 4 } \]
\[ \text{Condition assessment} \quad \text{Oil analysis} \]
\[ \text{Maintenance and repair} \quad \text{Condition monitoring and asset management} \]
\[ \text{Strategic spare parts} \quad \text{Technical training and competence development} \]

\[ \text{LONG TERM MAINTENANCE - p. 12} \]
\[ \text{Lifecycle maintenance recommendations} \]

\[ \text{RENOVATION, MODERNISATION, EXTENSION - p. 14} \]
\[ \text{Transformer modernisation and upgrade examples} \]
Transformer models

Alstom Grid stands by its products throughout their lifetimes. Our experts provide services on all types of high voltage transformers - both Alstom legacy products and third party.

Alstom Grid offers complete, innovative and high quality services to optimise your electrical infrastructure, improve your return-on-investment and extend the lifetime of your assets. Our local technical experts provide comprehensive solutions to get the most out of your assets during their lifetime and can support you in your asset fleet management.
PRODUCT LIFECYCLE MANAGEMENT

Taking care of your equipment components is essential to keeping your assets safe and reliable. Alstom Grid offers comprehensive services to support you in getting the most out of your assets.

Customer challenge
Power transformers are designed to optimise performance and efficiency. Operators require cost-effective solutions to avoid unscheduled downtimes, major failures and the subsequent penalties.

Alstom Grid solution
Alstom Grid offers complete services to cover all operations and maintenance needs so that their customers to get the most out of their assets and investments. Based on our manufacturing and service experience, Alstom Grid proposes efficient and customised solutions to increase the life of power transformers according to their type, age and ratings.

- From network consulting and planning to operational implementation
- From asset diagnostics to condition-based maintenance
- From emergency support to full operations and maintenance
- From training your engineers and technicians to customised competence development programmes.

Erection and commissioning
Our local teams ensure that the transformer is erected, tested and commissioned according to the latest standards. Our certification process, based on “on-the-job coaching” ensures the same high level of quality everytime, everywhere.

Our experts and technicians plan and execute all erection and commissioning services concerning:
- Assembly, disassembly, transportation and removal
- Oil processing, filling and treatment
- Commissioning, electrical and chemical testing (windings and bushings for power factor, insulation resistance test, ratio measurement, doble test, tapchanger tests, insulating oil analysis, auxiliary circuits control tests...)

Customer benefits

- Complete range of services to ensure equipment continuity and full availability
- Reliable asset management
- Project design recommendations
- Condition assessment and proactive detection of potential dysfunctions
- Proximity to local service experts and remote operations support
- Improved return on investment
- Prompt response time with 24/7 emergency support
- Equipment life extension and increased reliability and performance
- Environmentally-friendly solutions
- Increased safety for employees
- Alstom Grid’s vast and trusted experience and know-how based on worldwide installations and support
Maintaining your assets is essential to optimise equipment uptime, guarantee the safety of your infrastructure and ensure effective return-on investment.

Alstom Grid offers maintenance operations and our local teams can cover all your needs:
• From a single inspection to a long term operations and maintenance partnership
• From emergency support to predictive maintenance
• From risk assessment to spare parts recommendations

Maintenance and repair plans must be carried out by a qualified field service supervisor with the required technical level. Our local teams support customers in emergency repairs and in time-based, predictive and corrective maintenance.

When replacement of a transformer is the best available solution, our specialists can propose either new or uprated equipment. Service experts can also provide equipment-upgrading solutions to keep assets up-to-date with the latest protection, cooling and moisture management systems.
**Asset Information Management (AIM)**

You need to adjust your transformer assessment and maintenance strategy according to the criticality of the substation. Alstom Grid has developed a specific approach to meet your needs: Asset Information Management.

<table>
<thead>
<tr>
<th>LEVEL 1</th>
<th>LEVEL 2</th>
<th>LEVEL 3</th>
<th>LEVEL 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Oil sampling &amp; testing</td>
<td>- External condition</td>
<td>- Oil analysis</td>
<td>Based on the information collected from</td>
</tr>
<tr>
<td>- External condition</td>
<td>- Historical data for oil</td>
<td>- External inspections</td>
<td>assessment levels 1 to 3, Alstom Grid</td>
</tr>
<tr>
<td>- Historical data</td>
<td>history, electrical test</td>
<td>- Historical data</td>
<td>experts recommend specific equipment for</td>
</tr>
<tr>
<td>- Results and services</td>
<td></td>
<td>- Internal inspections</td>
<td>online monitoring of critical parameters.</td>
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<tr>
<td>history</td>
<td></td>
<td>- Condition analysis</td>
<td>The continuous watch over transformers</td>
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<tr>
<td>This assessment provides</td>
<td></td>
<td>- Life assessment</td>
<td>allows experts to develop a predictive</td>
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<tr>
<td>some basic indications of</td>
<td></td>
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<td>maintenance strategy for the asset.</td>
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<td>the transformer’s current</td>
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<td>In addition, the estimation of remaining</td>
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<td>condition, including</td>
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<td>asset lifetime provides information to</td>
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<td>indicative internal</td>
<td></td>
<td></td>
<td>plan a replacement efficiently.</td>
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<td>conditions. Based on a</td>
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<td>If necessary, the transformers can use a</td>
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<tr>
<td>qualified engineering</td>
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<td>specific online monitoring system (MS3000)</td>
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<td>analysis of historical</td>
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<td>device to control some parameters remotely.</td>
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<td>data, the report will</td>
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<td>assessments and urgent</td>
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<td>maintenance needed. It</td>
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<td>also defines the</td>
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<td>maintenance scope for</td>
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<td>outages. It is ideal</td>
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<td>for non-critical</td>
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<td>transformers.</td>
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<td>In addition to level 1, our</td>
<td>In addition to level 2, our experts</td>
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<td>experts undertake routine</td>
<td>undertake an internal examination.</td>
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<td>electrical tests during a</td>
<td>This solution provides current</td>
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<td>short outage. It provides an</td>
<td>conditions with good insight into</td>
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<td>assessment of the transformer’s</td>
<td>the electrical &amp; physical state of</td>
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<td>condition, including electrical</td>
<td>bushings and windings. The</td>
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<td>state of bushings and</td>
<td>monitoring of strategic assets</td>
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<td>windings. Internal</td>
<td>identifies early warning signs which may</td>
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<td>conditions i.e. clamping,</td>
<td>jeopardise transformer operating</td>
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<td>sludge, etc., are not</td>
<td>conditions. It is the best method to</td>
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<td>indicated. This information</td>
<td>determine remaining transformer lifetime and</td>
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<td>allows experts to judge the</td>
<td>any necessary rectification work.</td>
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<td>transformer’s remaining</td>
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<td>lifetime, but not conclusively</td>
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<td>expected electrical parameters</td>
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<td>investigations are required.</td>
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<td>&gt; Condition analysis report</td>
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<td>&gt; Deviation analysis report</td>
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<td>&gt; Life assessment report</td>
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<td></td>
<td>&gt; Strategic operational</td>
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<td>report</td>
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</table>
Oil analysis

A poorly maintained transformer is a high risk transformer. Alstom Grid provides complete oil analysis and asset management studies so you can be confident about your transformer’s condition and make effective decisions on transformer maintenance.

Expert diagnosis

Alstom Grid’s laboratories can keep you constantly up-to-date on the overall condition of your transformers.

Our teams of technicians and engineers perform reliable fluid analysis tests in order to provide you with an expert assessment of the overall condition of your transformers.

In order to detect thermal and/or electrical faults that lead to the production of certain gases, an analysis of up to 13 gases can be carried out according to IEC60567 standard satisfying IEC60599 and IEEE C57.104 DGA guidelines. By measuring the concentration, respective proportions and rate at which these gases are produced, we can interpret the phenomenon or fault causing these gases.

In order to determine the condition of the dielectric fluid, we perform dielectric strength, water content and acidity tests to check the fluid’s insulating and cooling properties.

For information on pollution levels, the laboratory can carry out tests to measure possible PCB pollution in the oil and ensure compliance with regulations.

Tests are carried out to check for furan derivatives in order to obtain information on the condition of cellulose insulation.

Other assessments can also be performed on a case-by-case basis depending on the device’s age, brand, power, load, strategic position, etc.

Stage-by-stage procedure

Customer

Transformer

Laboratory

A - Evolution of test results
B - Recommendations
C - Annual report on equipment
D - Recommendation and estimate
E - Receipt of order
F - Send sampling kit
G - Sampling
H - Identification of samples
I - Performance of tests
J - Comparison with previous results
K - Send report

Customer benefits

Expertise, skills and resources
- Specialist for close to 30 years
- In-house R&D, state-of-the-art materials
- Participation in international working groups (CIGRE)

A team that listens to you - available and proactive for diagnosis and emergency analysis

Our know-how at your service
- Onsite training in sampling and in interpreting physicochemical tests
- Technical reports and expertise

Reliability: recognised certifications
- Professional ethics charter based on confidentiality, impartiality and independence
- ISO 9001, ISO 14001, OHSAS 18001, COFRAC based on ISO 17025

Price commitment
- Sampling kits, justified emergency, annual report
- Analysis alert services
- Diagnosis with a monitoring policy
- Test volume based rates
Transmission equipment is an important capital investment and critical to network stability. To prolong asset lifetimes and ensure their reliability, Alstom Grid offers condition-based maintenance on critical transformers or on the full fleet.

Condition monitoring and asset management

Transmission systems and their equipment are designed for reliability. Energy managers require cost-effective applications and solutions to avoid unscheduled power transformer downtimes, major failures and the subsequent penalties.

Some substations, such as oil and gas platforms, offshore rigs and nuclear power plants require particular attention because they are located in dangerous or restricted areas, far from populated or centrally controlled sites.

Alstom Grid solution

The most effective solution to avoid potential failure is through condition-based asset management with advanced detection. This is why Alstom Grid developed the MS3000 monitoring system for transformers. The system is cost-effective, reliable and easy to adapt to any transformer type.

Alstom Grid has designed monitoring products to keep a constant watch over assets. Continuous condition monitoring allows a shift from time-based maintenance to a condition-based maintenance strategy, providing a more cost-effective service while doubling capability to predict and prevent failures. Online technology enables remote technical assistance and diagnosis for better customer support in the decision-making process of operations and maintenance. Condition monitoring devices embed capabilities of generating alarms, on settable thresholds, in absolute value and time trends. The monitoring tool records conditions of the main components for several transformers, allowing predictive analysis for preventive maintenance.

Data analysis expertise

Armed with the proper information received from our installed monitoring tools, we can provide a full assessment to evaluate the equipment in real time, define the scope of maintenance operations and plan actions for future execution (planning, operation, repair, replacement). This enables a better match of intervention teams, spare parts replacement and special tools management, saving on downtime and costs, avoiding unexpected situations and maximising your electrical system’s availability. Alstom Grid can also provide 24/7 asset management.

Control all main components for several transformers at the same time

Main module
- Operating voltage (1 phase)
- Load current (1 phase)
- Apparent power and load factor
- Oil temperature
- Hot-spot temperature
- Gas-in-oil content
- Moisture-in-oil content
- Ageing rate
- On-load tapchanger position
- Number of switching operations
- Sum of switched load current
- Operating condition of pumps and fans
- Operating time of pumps and fans
- Cooling efficiency (Rth)
- Ambient temperature
- Auxiliary digital inputs

Insulation module
- Gas-in-oil Gradient
- Moisture of Paper
- Bubbling Temperature and Safety Margin
- Lifetime Consumption
- Predicted top oil temperature
- Predicted hot spot temperature
- Breakdown voltage

Bushings Module
- Operating voltages (3 phases)
- Overvoltages, number of overvoltages
- Change of capacitance, online capacitance

Tapchanger Module
- Power consumption of the motor drive
- OLTC oil temperature
- Assessment of mechanical quality
- Contact wear model
- Oil temperature difference OLTC / tank

Overload Module
- Load currents (3 phases)
- Overcurrents and short circuit currents
- Number of overcurrents
- Overload capacity
- Emergency overloading time
- Thermal model
- Actual losses

Protocol Module
- IEC 60870-5-101/104
- DNP3 0
- Modbus
- IEC 61850

Customer benefits

- Improved power transformer performance and reduced failure rate
- Optimised and preventive maintenance: better scheduling, reduction of costs, planned outages...
- Continuous watch over asset conditions with condition monitoring tools
- Efficient control of asset operations
- Equipment life extension
- Environmentally-friendly
- Increased safety and reliability of equipment
Asset management

Maintenance and repair

Transformers are vital to large power networks and industries. When they function incorrectly or fail, you need diagnostic assistance fast, followed by timely repairs.

Customer challenge
When large transformers or transformer fleets need repairs, you need engineering expertise and manufacturer capabilities. If transportation to a workshop is not possible, you need onsite repair options.

Alstom Grid solution
On a case-by-case analysis, Alstom Grid service experts propose the most efficient solution based on your asset management strategy and transformer conditions. Alstom Grid experts handle all transformer repairs:
- Repair defective parts, including active parts
- Repair oil leaks
- Repair bushings: replacement of small and main components, restoring the correct oil level or pressure, replacement of insulating oil

Whether they are onsite or workshop repairs, all procedures performed are in accordance with quality, safety and environmental standards and practices (ISO9001 / ISO14001 / OSHAS18001).

Alstom Grid also conducts transformer tests to guarantee their performance.

Our century of experience in transformers gives service technicians access to original technology, calculations, designs, and quality documents. This knowledge enables us to anticipate the supply of critical materials and reduces lead times.

Customer benefits
- Improved power transformer performance and reduced failure rates
- Shorter lead time than installing a new transformer
- Cost efficiency
- Equipment life extension: up to +30% when repairing or upgrading insulation material
- Environmentally-friendly
- Increased safety and reliability of equipment

Make the most of your assets

Onsite repair
Avoiding transportation back to a workshop saves you time and money. Alstom Grid mobile workshop facilities have been designed to handle onsite repairs.

Alstom Grid expertise reaches out to you with experts, engineers and technical teams. They can assemble a repair area with all equipment necessary to repair or do maintenance work on the active parts and windings: Alstom Grid brings in mobile cranes and lifting equipment, drying processes - our active part drying process achieves a very low moisture level (<1%) - and testing equipment.

Workshop: repair, refurbishment, redesign
When returning the transformer to a workshop is unavoidable, service experts will design the most optimised repairs possible, often with the possibility of upgrading or uprating to better suit your current or future network requirements.

Alstom workshops uses the latest manufacturing processes and tools, at the same standards as manufacturing new transformers. As moisture is one of the main variables which accelerate the cellulose and insulation aging process, ovens and vapor phase equipment allow an improved drying process, offering very low moisture rates and ensuring increased life spans.
Strategic spare parts management

Although some parts play mainly a supporting role, they are vital for optimal operation. Any problem associated with any piece of equipment can result in damage or failure of the equipment. Alstom Grid proposes strategic spare parts to mitigate risks.

Customer challenge

Most power transformers are still active after more than 40 years of operation. The delivery time for phased-out product parts (no longer in our current range) can reach several months (up to 12 months depending on the part), causing penalties or loss of revenue. Strategic spare parts supplies are one way to reduce downtime, transportation and overall spare parts costs. A strategic spare parts stock focuses on main and critical components.

Alstom Grid solution

Power transformer availability is conditional to its capability of rapidly re-energising after a failure. This is why Alstom Grid recommends maintaining a stock of strategic spare parts, allowing fast repairs of any major failure within a short time.

Alstom Grid’s product range has been continuously evolving to better match our customers’ needs and to fully comply with the latest electrical and environmental standards. As part of comprehensive customer support throughout the equipment lifespan, we can supply any part or equivalent component for all our products, even for older Alstom legacy products. Service engineers define a strategic spare parts stock adapted to the customer’s substation specifications.

Strategic spare parts stock focuses on main and critical components:
- Tapchanger
- Bushings
- Buchholz relays
- Radiators
- Pumps
- Fan motors
- Temperature sensors
- Oil alarm and indicators
- Drier elements
- Gaskets

These recommended parts are relatively inexpensive when compared to the main equipment. Having these parts or accessories in-house and keeping your transformer up-to-date can drastically contribute to system outage time reductions, with all the associated cost savings.

Depending on the level of availability needed, you have several options:
- The customer stores all necessary parts recommended by Alstom Grid. This option provides the best guarantee level of parts availability and minimises transportation time to the site.
- The customer signs a service contract which includes Alstom Grid’s commitment to supply any part within a specified time. (Spares are manufactured by Alstom Grid and kept available at localised Alstom Grid storage areas.)
- The customer signs a “Spare Parts Club” agreement with other owners of similar transformers and stores the specific parts which remain available to several users. Stored parts are replenished as required.

Customer benefits

- Transformer life extension and failure risk reduction
- Increased transformer availability and reliability
- Reduced manufacturing and unplanned transportation costs
- Spare parts available when needed
- Quality of spare parts supplied by a transformer leader, so you know you are getting the best for your network
- Increased operational and environmental safety
Well-trained employees are mandatory to get the best performances from your substation and to maintain it efficiently. Training has the best and fastest return on investment rate when it comes to enhancing your current electrical installation performance. Alstom Grid offers over 200 training courses in its 16 Technical Institute centres located around the world. Discover our training offer on www.alstom.com/grid/technicaltraining/

Customer challenge
Because power continuity is your concern, the acquisition of technical expertise in transformer operations and oil sampling is crucial to developing efficiency and safety at work.

Alstom Grid solution
Alstom Grid Technical Institutes offer a full range of training in electrical grid safety, operations, maintenance, protection, control and network management. These high value-added courses encompass all aspects of electricity fundamentals and in-depth equipment knowledge. Trainees benefit from trainers’ expertise and field experience, combined with effective pedagogy.

For equipment operations and maintenance, theoretical study is necessary but not sufficient to optimise site personnel reactivity. What makes a real difference is the experience site personnel can gain through practice. At our Technical Institutes, training combines theory with practice on real-sized equipment.

Standard training courses:
- Fundamentals of power transformers
- Transformer operations and maintenance
- Immersed transformers: fluid filtration, sampling for laboratory analysis
- On-load tapchanger operations and maintenance
- Bushings
- Protection for HV surges
- MS3000 monitoring system

Technical Institute Centres of Excellence for transformer training are located in Australia, India, France, Turkey and the United Kingdom. They all offer practical hands-on with real equipment for trainees.

Customer benefits
- Improved employee technical knowledge
- Increased efficiency and safety at work
- Adapted training for a wide audience (operators, managers, engineers, ...)
- Benefits from exchanges with field experienced trainers
- Choice of training methods: e-learning, classroom course, practical work, set curriculums, 3D modules, competence development
- Up-to-date contents according to local regulations and new technologies

Competence development: a turnkey approach to performance

ANALYSING
Needs analysis
Evaluation quiz
To evaluate trainee knowledge level

PREPARING
Course design
e-Learning Planning
To optimise the course

TEACHING
Teaching
Learning Application at site
To learn required skills

QUALIFYING
Evaluation quiz
Knowledge Validation
To check knowledge acquisition & deliver competence certificate

To know more: technical.institute@alstom.com
LONG TERM MAINTENANCE

Maintenance is critical for utilities and industries who need to ensure the reliability of their electricity supply and comply with current regulations. With the goals of getting the most out of your equipment over the long term and accelerating the decision-implementation process, we support you in your challenges by providing Long Term Maintenance plans: a set of tailored expert services executed over a multi-year partnership.

Customer challenge
Lack or absence of maintenance can generate deterioration or severe failures: electrical (hardware failure, coil, relay…); mechanical (loosening, parts breaking…); dielectrics (leaks, moisture, electric heating…).

Energy players need to make efficient decisions on equipment management to ensure their reliability and maximise their long term performance in a cost-effective way.

Alstom Grid solution
To support customers over the long term, Alstom Grid offers incremental tailored maintenance levels to answer customer needs for critical substations or on full fleet asset management.

<table>
<thead>
<tr>
<th>Expertise</th>
<th>Performance</th>
<th>Serenity</th>
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<tbody>
<tr>
<td>To keep transformers operating efficiently and to ensure optimal performance, preventive maintenance is recommended for key components. Maintenance operations are regularly planned and range from visual inspections by trained specialists to the replacement of used parts. Preventive maintenance is the most effective way to avoid potential troubles before they occur. Through preventive maintenance, outages can be planned and executed within the shortest delays and with the least disruption.</td>
<td>Full management of transformer maintenance and operations guarantees the maximum output. Advanced data provided by condition monitoring, operating measures and oil analysis results are proficiently analysed to plan strategic maintenance and operations. In case of failure or disturbance, experts are sent onsite promptly to diagnose and repair. Alstom Grid manages a spare parts strategic inventory to ensure high availability of main components.</td>
<td>Full management of substation equipment is a valuable solution ensuring the optimised reliability and performance of the substation. All maintenance and operations are under the responsibility of Alstom Grid. Experts provide a complete record of all work carried out during emergency support or upgrade. Service solutions are completely tailored to customer needs and to the environment. Alstom Grid is fully responsible for the substation’s performance.</td>
</tr>
</tbody>
</table>

- Preventive maintenance
- Spare parts on request
- Planned operations
- Maintenance and operations
- Technical training on request

- Preventive and corrective maintenance on legacy transformers
- 24/7 condition monitoring
- Strategic spare parts
- Dedicated team with response time engagement
- Technical training

- Full maintenance and operations on substation equipment, including Third Party
- 24/7 condition monitoring
- Strategic spare parts management
- Dedicated team with response time engagement
- Technical training

> EFFICIENT SUPPORT  > CONTINUOUS PERFORMANCE  > OPTIMUM GUARANTEE
Transformer maintenance recommendations

Alstom Grid has the following maintenance recommendations for transformers. Substation condition assessment by service experts will determine the most appropriate maintenance plan.

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<tbody>
<tr>
<td>Minor examination: every 2 years.</td>
<td>Minor examination: every 2 years.</td>
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<tr>
<td>Major examination: every 4-6 years.</td>
<td>Major examination: every 4-6 years.</td>
</tr>
<tr>
<td>According to deviation in regular measurements</td>
<td>According to deviation in regular measurements</td>
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</tbody>
</table>

### Mechanical conditions

- **Tapchanger**: functional and technical check of taphangers and piping for oil leakages*, cleaning of motore drive*, switching interrupter drying*, functional check and cleaning of monitoring relays*, functional check and cleaning of resistor for braze points, mechanical fixing and isolation distances*, check and cleaning of diverter switch compartment*, inspection of motor drive*
- **Bushing**: overheating identification*, oil level and leakage checks*, connection checks*, cleaning of porcelain*, connection fittings*
- **Protection & Control devices**: oil indicators and thermal images*, pumps/fans/relays/connections/pressure/tightness checks*, protection and control cubicle checks*, porcelain insulators and grounding connections of surge arrestors*
- **Surge arrester tests**
- **Tank/Coolers/Piping**: oil level and leakage checks*, valves check*, earthing systems and connections*, air and gas removal*, shut off devices control*, cleaning of fans*
- **Corrosion protection**: corrosion check*, rusted surface repair*
- **Other technical conditions**: Visual control, hot spots, oil temperature, load current, line voltage checks, manual checks of earthing connections

### Chemical conditions

- **Dissolved gas analysis**
- **Routine analysis**: moisture, neutralisation value, breakdown voltage, dissipation factor tan delta, interfacial tension, electrical breaking index, viscosity of oil, specific gravity test of oil
- **Furan analysis**

### Electrical testing

- **Winding tests**
- **Bushing tests**
- **Insulation tests**
- **Measurement of single phase current, turn ratio and tangens delta**
- **Frequency Response Analysis (FRA)**

### Internal examination

- **Inspection of leads, windings, connection joints, clamping structure and mechanical core fixing**
- **Internal tank inspection**

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### Importance of Insulation Drying

**Reference**: CIGRE Brochure 445

The moisture in a transformer is generated by several sources: humid air, moisture ingress through gaskets, chemical decomposition of cellulose, moisture absorption due to exposure during maintenance and topping-up of oil level made with humid oil. Cigré underlined the lack of drying insulation can accelerate ageing of the transformer insulation. Moisture in the oil combined with particles reduces the breakdown voltage of the oil and increases the risk of static electrification, partial discharge activity and tracking. High water content in cellulose increases the risk of bubbling during sudden overload or thermal stress, and the risk of dielectric breakdown.
RENOVATION, MODERNISATION & EXTENSION

Alstom Grid provides condition assessments of substations and on all types of equipment. Based on the situation, service experts offer renovation, modernisation and extension solutions to improve performance or to resolve obsolescence issues.

Customer challenge
High voltage substations are key contributors to asset values and critical to grid reliability and availability. After decades of operations, grid operators may foresee risks of increasing failure rates due to electrical and environmental stresses. They may also need evolving power performance or compliance upgrades.

Alstom Grid solution
Alstom Grid service experts support the decision-making process by providing the most cost efficient solutions for substation and transformer renovation, modernisation or extension based on condition and life assessment.

Renovation
Alstom Grid offers solutions to extend the life of ageing equipment by replacing worn components. Service experts can conduct a transformer mid-life overhaul for example.

Modernisation
Modernisation of equipment is a way of getting the benefits of new design and technologies on equipment already in operation. It brings solutions to obsolescence challenges on old equipment, such as transformer upgrades or an add-on condition monitoring system allowing optimised asset management.

Extension
Increasing nominal power, changing voltage ratios and improving performances in existing substations are common demands addressed by the Alstom Grid Engineering team: service teams improve transformer performance and availability.

Customer benefits
- Optimisation of reliability and performance
- Adaptation of equipment to current needs and technologies
- Cost efficiency and short lead times (at least 50% savings compared to purchasing new equipment)
- Higher return on investment with life extension up to 40 years
- Improved safety for employees
Transformer modernisation and upgrade examples

**Life Extension Programme (LEP)**

Normal ageing can diminish with operating stress, which if not treated, can generate failures, financial losses (loss of revenue during outage and resulting penalties...) physical damage (windings, tank, peripheral equipment...) and can even result in complete asset loss.

LEP aims to evaluate existing problems, damage and defects that can reduce a power transformer’s remaining lifetime. LEP consists of a combination of different operations to extend power transformer lifetimes. LEP is generally conducted at transformer midlife and consists of the following operations:

- Evaluate actual condition (existing problems / damage / defects / deviations) which can reduce remaining lifetime
- Perform corrective actions
- Combine maintenance or modernisation tasks, such as: oil analysis, oil treatment, tapchanger review, drying of active part, re-gasketing, cooling system cleaning or upgrade (fans, radiators, pumps, pipes,...), corrosion treatment and painting, elimination of leakages, cubicle reviews or upgrades and accessories upgrades.

**Customer benefits**

- Increase equipment reliability and lifetime
- Reduce failure probability
- Reduce system outages and related costs
- Optimise asset performance and improve power quality

**Cooling power upgrade**

Every day, the worldwide demand for energy increases. As consumption rates are rapidly increasing, operators are pushing the rated limits of electrical systems. Transformers, the largest single pieces of equipment in power systems, are being asked to convert higher power ratings beyond their design specifications.

In many cases, it is possible to achieve better performances by improving transformer cooling systems. Cooling power upgrades can bring up to 30% power increase. Cooling power upgrade applications consist of upgrading cooler and protection systems, renewing control equipment and, in some cases, exchanging bushings and CTs in accordance with the new, higher current capacity.

These applications permit the use of self-controlled variable speed fans (electronically commuted fans with DC motors, internal speed control and motor protection), which provide a better performance range and optimise control cabinets. All fans can be controlled by just one temperature sensor. Alstom Grid can also add an external oil-air cooling system, with its own pumps and fans.

**Customer benefits**

- Low investment, high return
- Least invasive solution upgrade
- Short downtime with onsite upgrade
- Compatibility with monitoring systems
**Tap changer retrofit**

Alstom Grid conducts routine maintenance and even refurbishment of tap changers of all manufacturers, types, power and voltage ranges, onload and offload. Alstom Grid plans and supplies all resources (equipment, workforce, spare parts, ...) for this service which applies to all kinds of tap changers, regardless of power size or voltage range.

**Customer benefits**
- Know-how and expertise
- Reliability
- Skilled and trained personnel
- Compliance with international and local standards (electricity, quality, safety and environmental)

**Vegetable oil retrofit**

Environmentally-friendly, derived from seeds, biodegradable, non-toxic and harmless to humans, vegetable oils need no special contention structure or preventive action plans for eventual spills. They provide a better environment for insulating, slowing paper degradation and consequently extending equipment life. They also increase fire safety conditions due to higher flash and fire points.

**Main characteristics:**
- Residual mineral oil must be lower than 7.5%
- Deployment in sealed transformers or with membranes, not for free-breathing transformers
- Transformers oil-air contact must be upgraded to oil-rubber-air system
- Applicable for transformers up to 245 kV
- Applicable for transformers out of warranty

**Customer benefits:**
- Green image
- Reduced risk of environmental contamination
- Equipment lifetime extension
- Safety conditions increased by reduction of fire risks
- Financial savings: insurance, maintenance and contention structure costs reduced, replacement postponement.

**Conservator upgrade**

Oxygen and moisture are the main contributors to the transformer ageing process. Avoiding them is fundamental to extending transformer lifespans. This can be done by replacing air-oil systems or by including conservators with oil-rubber-air in free breathing transformers. Before implementing the conservator, our team conducts a feasibility study. An outage is requested to install the features (around 4 days). This service is applicable to any brand.

**Customer benefits**
- Longer lifespan
- Failures less likely
- Lower future maintenance costs
- Financial savings (postponed investments/ asset replacement)
Oil processing

Insulating oil can absorb gases and moisture, factors along with normal operational temperatures which can accelerate the ageing process. With periodical oil analyses, Alstom Grid experts can detect the presence of acids, moisture, particles and dissolved gasses in the oil and carry out the following oil processing operations:

Dehydration
Eliminates excessive moisture found in the transformer to restore the dielectric strength of the fluid; inhibits the formation of aggressive acids and extends the life of the transformer.

Degasification
Eliminates dissolved gases in the transformer oil. These gases are generally a byproduct from the localised heating of the oil, or the decomposition of cellulose insulation. The removal of these gases helps to restore the unit to baseline conditions and eliminates combustible gases that could become an explosion hazard if vented. The process is the same as dehydration, using multiple passes of hot oil, vacuum and filtration treatments.

Reclaiming / Regeneration
Eliminates, by chemical and absorbent means, the acidic and polar colloidal oil contaminants and products of oil deterioration, to obtain an oil with characteristics similar to those of a new product. Removing acids, sludge and other degrading products reduces the ageing rate of the oil. This also has a beneficial effect on the ageing of the paper insulation. Conventional systems are commonly known as systems that use Fullers Earth within a filtration process, once the earth has maximised its absorbative quality.

Customer benefits
- Life extension
- Cost effective solution
- Increased reliability

Regenerative Oil Processing

Our state of the art regenerative clay systems allow us to remove acids and sludge from transformers without generating waste and while the transformer is still energised.

Main characteristics
- Benefit from a complete mobile solution: clay, generator, vacuum processor, office, laboratory all housed in one trailer
- Remove acids and sludge from transformers without generating waste
- Remove moisture from oil prior to vacuum process, unlike Fullers Earth
- Dehydration, re-inhibit, degasification
- Continuous 24-hour processing capabilities with 12-hour regenerative process
- Green solution with no make up oil shipped to site, no dumping Fullers Earth, no bags of clay shipped to site. It also eliminates the need to dispose of oil-soaked clay.

Customer benefits
- Green image
- Reduced risk of environmental contamination
- Equipment lifetime extension
- Safety conditions increased by reduction of fire risks
- Financial savings: insurance, maintenance and contention structure costs reduced, replacement postponement, reduced operations costs.
**Bushing renovation or replacement**

The regular measurement of main electrical parameters and oil conditions can drastically reduce the risk of catastrophic failures. The assessment of bushing conditions allows to define the appropriate service to conduct to ensure transformers are operating safely and efficiently.

Our experts conduct diagnostics on site for bushings of any brand and any type of technology: measurement of C and PFs in a range of frequency from 0 to 1 kHz, thermal scan, visual inspection. When necessary some analysis are done in our factory and laboratory: repetition of complete routine tests, Dissolved Gases Analysis of insulating oil, failure analysis.

According to the situation and customer’s expectations, our experts recommend either the renovation or the replacement of the bushing:

- **On site renovation**: replacement of small components (oil level indicators, test taps, top terminals, pressure gauges, etc.), restoration of correct oil level or pressure for pressurised bushings
- **Workshop renovation**: disassembling of the complete bushings for replacement of main components (porcelains, flanges, condenser cores, etc.) and replacement of insulating oil
- **Replacement**: supply of new bushings fully interchangeable with the old ones

**Drycol breather upgrade: dryness of transformer insulation**

A challenge in transformer operations is to maintain moisture-free insulating materials. Insulation damaging moisture can occur within the transformer via tank and cooler gaskets, normal insulation degradation and the oil/air interface in the conservator during load cycling.

The Drycol breather was designed as a simple device capable of removing moisture. It acts directly on the air in the conservator tank, operating continuously without any mechanical moving parts. The dryness of the air in the conservator tank causes moisture to migrate from the oil into the air for removal. The resulting dryness of the oil causes moisture to migrate from the insulation into the oil and hence into the air for removal. An additional benefit is the elimination of internal rusting of the conservator tank by the removal of corrosive acids.
A worldwide leader with a local presence
delivering continuous operational excellence

Our field expertise at your service!

Alstom Grid concentrates on the quality of their operations and the continuous professional development of their technicians and supervisors. Their competencies, qualification levels and certifications are checked regularly. As a result, Alstom Grid provides customers with the best field experts, ensuring satisfaction.

- More than 50 operational service centres in 30 countries
- 16 Technical Institutes located at our manufacturing sites
- 1,300 employees and experts
- More than 15,000 operations per year, onsite and in Alstom Grid workshops