Industry brochure

ABB drives in chemical, oil and gas
Medium voltage drives for greater profitability and performance

Power and productivity
for a better world™


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ABB – the world's leading supplier of variable speed drives in the chemical, oil and gas industries

Most of the processes in the chemical, oil and gas industries are complex and are exposed to the harshest environmental conditions. These conditions put a high demand on the process equipment. Achieving high levels of efficiency and availability will translate directly in an increased production output and an improved product quality.

A pioneer in AC drive technology, ABB started research in the 1960s and industrial production in the 1970s. Today, ABB is the world's leading supplier of variable speed drive systems. To date ABB has installed medium voltage drives with a total rated power of approximately 35'000 MVA.

Leading-edge drive technology in chemical, oil and gas industries

All processes in the chemical, oil and gas industries can benefit from variable speed drives.

Upstream	Applications
Oil & gas production and gathering	Pumps
Gas treatment	Compressors
Gas export	
Subsea	
Midstream	
Oil & gas transportation and distribution	Pumps
Oil & gas storage	Compressors
Gas liquefaction (LNG/CNG)	
Gas to liquid (GTL)	
Liquefied petroleum gas (LPG)	
Downstream	
Petroleum refining	Pumps
Petrochemical plants	Compressors
Air separation plants	Extruders
Chemical industry	Mixers
	Blowers

Variable speed drives in chemical, oil and gas

The investment in high efficiency, largely maintenance-free, variable speed drives helps to keep costs under control.

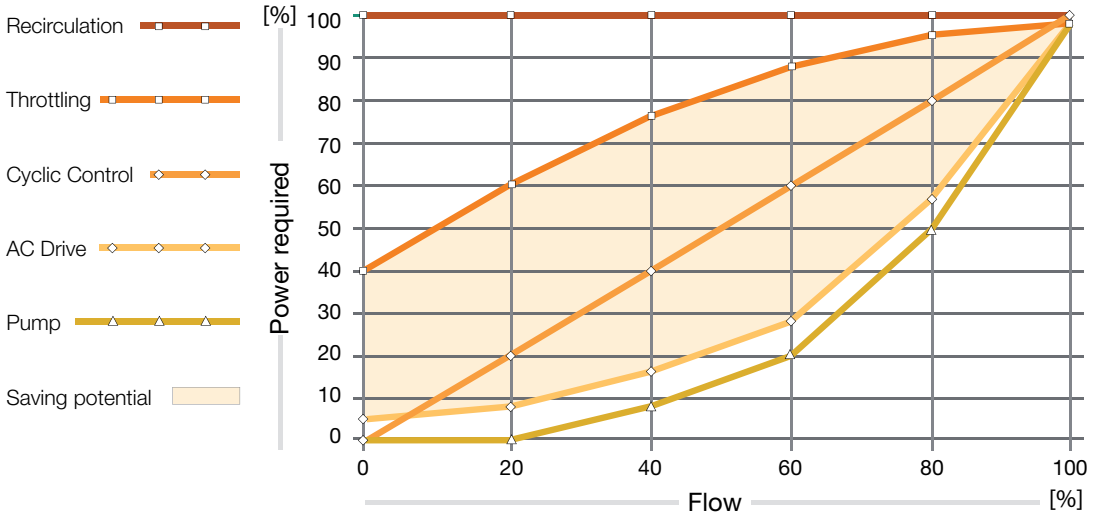
Higher efficiency and less emissions

Energy saving has never been higher on the agenda than today. People have become increasingly aware of the correlation between wasting energy and environmental damage and acknowledge the benefits of conserving energy by technical means. By employing variable speed drives instead of throttling or using by-pass vanes, the energy bill can be reduced by as much as 60%. ABB electric drives reduce NOx and CO_2 emissions on site that could delay granting of a permit and cause penalties.

The power required to run a pump or a compressor is roughly proportional to the cube of the speed. In other words, a pump or compressor running at half speed can consume as little as one eighth of the energy compared to one running at full speed. A small reduction in speed can make a big difference in the energy consumption. As many pump and compressor systems often run at partial load, the use of a variable speed drive can produce huge savings.

Improved control and flexibility of processes

Outputs of oil and gas fields can vary greatly in their compounds, density, volume flow rates and pressure levels. This imposes varying operating conditions on process equipment, which means that compressors and pumps, which must exhibit a high degree of flexibility, cannot always be operated at their optimum design point. The employment of variable speed drives offers the possibility to control the process simply and effectively by speed control and to run equipment at its optimum operating points.



Power consumption for various pump control methods

Improved product quality

The product quality optimization of some plastic materials requires operating flexibility over a distinct speed range. Variable speed drives adjust the speed precisely to optimize the operation of process machinery.

Power conversion

Some processes have an energy excess, which can be converted into rotating power. With variable speed drives this rotating power can easily be converted into electrical energy, synchronized to grid frequency and fed back into the supply network.

Reduced starting impact on network and machinery

Starting machinery with heavy load torque and/or high mass moment of inertia impose large stresses on the supply network and the mechanical parts of the shaft string of the installed equipment. A direct-on-line started electric motor can cause starting currents of up to five to six times of nominal current. This will, in weak supply networks, cause massive voltage drops on the supply bus as is often seen in remote areas or offshore facilities.

Soft-starting machinery with variable speed drives results in the following benefits:

- No voltage drops upsetting the process, no trips on other electrical devices on the same bus
- No excessive thermal and mechanical stress on the motor leading to a longer lifetime
- No mechanical stress on the shaft system leading to a longer lifetime
- Immediate start-up without warming up delay (e.g. turbines)
- Gentle process start-up, controlled in all respects from zero speed

Benefits of variable speed drives
High performance and reliability increases plant availability and decreases maintenance costs
Smooth torque over the entire speed range reduces noise and vibration levels, which minimizes mechanical stress
Better efficiency, particularly at partial load results in lower energy costs
No inrush currents and voltage drops during starting
Regeneration of rotating power and braking capability
Improved speed control and process optimization
Enhanced operating flexibility to suit the process needs
Lower impact on piping/valve system results in longer equipment life and less maintenance
Better dynamic performance during starting and during supply grid turbulences
No on-site emissions

High reliability and maximum availability of process equipment

Apart from a smoother process and energy savings, electronic speed control also results in less maintenance because there is less mechanical stress on the machines, bearings and shafts. This prolongs operational life and keeps downtime to a minimum.

The low starting current also reduces the mechanical and thermal stress on the machine and the adverse influence of starting surges on the power system. All these factors contribute to high reliability and maximum availability of a plant.

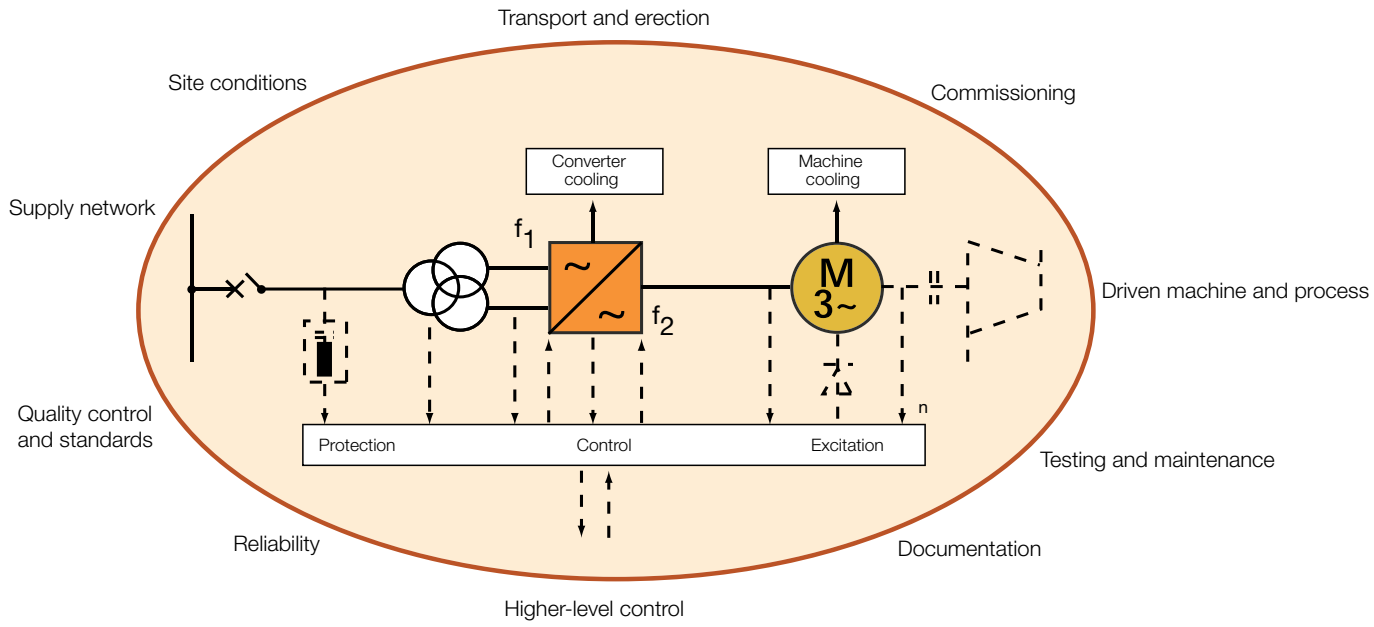
Minimized environmental impact

Variable speed control is the most eco-efficient way to optimize process performance. Variable speed drives reduce energy consumption and NOx and CO_2 emissions. Furthermore, ABB's electric drives are designed using state-of-the-art DFE (Design for Environment) guidelines covering the complete product life cycle. This entails a long-term commitment to waste reduction and to reuse and recycle components.

Full drive package responsibility

A single source offering consolidated and coordinated work from design to production, testing, delivery and commissioning gives the following advantages to ABB's customers:

- Minimized risk and reduced commissioning time
- Optimized system with all associated auxiliaries; no mix-and-match of single products
- System design supported by a professional engineering team and sophisticated IT tools
- Integrated manufacturing and delivery schedules of the complete drive system
- Verification of the functionality, as well as the load performance of the drive system
- Fully integrated documentation



Main components of a variable speed drive system

ABB has the ability to offer the entire drive system, consisting of transformer, frequency converter, motor and auxiliaries.

The components are selected and engineered to ensure optimum operation, meeting the requirements of the application and complying with international standards for electrical equipment.

Power supply, mechanical interface, control interface, cooling, enclosure protection class, building constraints, cable terminations, transport lots and ambient conditions are site dependent and are taken into consideration by project engineering.

All system components are routine tested according to international standards. When required, acceptance tests can be performed in ABB's well equipped testing facilities.

Reliability and availability is a must

ABB ensures the highest reliability by implementing standards and procedures of quality in design and production conforming to ISO 9001. Tests are performed at various stages during the manufacturing process in addition to the final tests before delivery. Redundancy of wearing components (e.g. cooling pumps) can be provided to increase availability while enabling maintenance intervals to be extended.

ABB medium voltage drive systems

– State-of-the-art technology and proven design in harsh environments and demanding applications
– Pre-engineered modular build-up, easy to customize
– Single source responsibility
– Optimization of the complete drive system
– Comprehensive performance test capabilities
– Easy to adapt & implement (process automation environment, network)
– Compliance with global standards
– Sophisticated tools for remote monitoring and diagnostics
– Worldwide service network

Medium voltage drives

The heart of the variable speed drive system is the frequency converter. ABB offers the entire range of frequency converters for medium voltage applications in the power range from 315 kW to more than 100 MW.

ABB medium voltage drives have been designed to ensure a long lifetime in harshest environments as can be found in chemical, oil and gas applications. ABB offers air- and water-cooled converters for different power and voltage requirements.

ACS 1000

The ACS 1000 is suitable for both retrofit applications and new standard induction motors. Due to its unique output sine filter common mode voltages and voltage reflections are eliminated. It is available with air and water cooling. The air-cooled ACS 1000i, is a fully integrated standard drive that includes input isolation transformer and input contactor.

ACS 2000

The ACS 2000 is suitable for retrofit applications and new standard induction motors up to 6.9 kV. It can be used without an input isolation transformer, thereby allowing a direct connection to the line supply (direct-to-line), or it can be connected to an input isolation transformer. The general purpose drive provides simple and reliable motor control for applications such as fans, pumps and compressors.

ACS 5000

The ACS 5000 is an unbeatable solution for various processes in the chemical, oil and gas industries. It can be applied to standard industrial motors (induction, synchronous and permanent magnet) up to 6.9 kV. It is available with air and water cooling. The air-cooled ACS 5000 can be delivered with integrated or separate input transformer. The ACS 5000 is ideal for applications such as pumps and compressors (including high speed compressors).

ACS 6000

ABB's water-cooled ACS 6000 is a modular drive designed for the most dynamic and powerful single or multi-motor applications for synchronous, induction and permanent magnet motors up to 3.3 kV. Inter-related motors can be connected to the same ACS 6000 via a common DC bus, enabling multi-machine operation with only one supply unit. It is the ideal solution for petrochemical applications such as extruders.

MEGADRIVE-LCI

ABB's MEGADRIVE-LCI is an optimal solution for high voltage and high power converter applications. It is also available as soft starter for applications with synchronous machines. Standard air- and water-cooled designs are available for ratings up to 72 MW, engineered designs for more than 100 MW.

ACS 1000
315 kW - 5 MW, up to 4.16 kV

ACS 2000
315 - 800 kW,
up to 6.9 kV

ACS 5000
2 - 22 MW, up to 6.9 kV
(higher power on request)

ACS 6000
3 - 27 MW, up to 3.3 kV

MEGADRIVE-LCI
2 - 72 MW, up to 10 kV
(higher power on request)

Technology highlights

Reliability is the main guiding principle of the research and development activities for medium voltage drives.

Control
The ACS drive control platform is based on ABB's award winning Direct Torque Control (DTC), resulting in the highest torque and speed performance ever achieved in medium voltage drives. Control of the drive is immediate and smooth under all conditions.

Low parts count
The fewer the parts the higher the reliability. ABB uses high power semiconductor switching devices and a topology that brings down the part count to a minimum.

Fuseless design
All ABB medium voltage drives are designed to operate safely without fuses. This results in less spare parts and fast re-starting after an overcurrent trip.

Encoderless
Encoders are known to cause failures. They have an exposed position on the motor. ABB's medium voltage drives can operate without encoder.

Remote monitoring and diagnostics
DriveMonitor™ allows secure real-time access to the drive. It supports monitoring and diagnostics of ABB drives independent of the implemented control method, thus also enabling the connection of existent installations.

The optional tool consists of a hardware module inside the drive, as well as a software layer that automatically collects and analyzes selected drive signals and parameters.

Long-term monitoring functions deliver important information on equipment status, tasks needed and possible performance improvements. Diagnostic procedures and trending can cover not only the converter itself but other parts of the shaft train as well.

High speed direct drive for gas compressors
ABB supplies high-speed variable speed drives for compressor applications. Combined with a high-speed motor (above 200 Hz), the motor can be coupled to the compressor without using a gearbox. This compact solution requires less space and maintenance, has a lower noise level and a considerably higher availability compared to a solution utilizing a step-up gearbox.

Components of variable speed drive systems

ABB offers motors, transformers, filters, recooling equipment, switchgear and outdoor control houses.

Synchronous or induction motors

ABB's medium voltage motors have earned an excellent reputation for performance and reliability. ABB's product range includes induction as well as synchronous motors.

Induction motors

Squirrel cage induction motors are the workhorses of the industry due to their versatility, reliability and simplicity. In the power range up to 12 MW a squirrel cage induction motor is usually the first choice. ABB's broad range of medium voltage AC induction motors includes ribbed cast iron fan cooled motors and modular type welded frame motors. The power range runs up to 23 MW. All types of motor cooling methods and enclosures are available, e.g. air or water designed for installations in harsh environmental conditions as well as for installations in hazardous areas. Different mounting designs - horizontal or vertical - are available.

Synchronous motors

Synchronous motors are typically considered for higher power ratings (above 8 MW). In addition to their high power capabilities, synchronous motors offer the benefits of high efficiency and high performance through the utilization of different rotor designs. New developments in permanent magnet rotor designs have in some cases even eliminated the need for the excitation circuit. As with modular induction motors, synchronous motors are available air or water cooled, self or forced ventilated. Designs for harsh environmental conditions or hazardous areas are available as standard options.

Induction motor

Synchronous motor

Converter transformers

Application-specific dimensioning

Converter transformers are especially designed for operation with variable speed drives. They are built to match the required pulse number and the windings are capable to withstand harmonic currents and any mechanical stress caused by steep current peaks.

Wide range of options

Converter transformers are available for nearly all ratings and primary voltages of more than 100 kV. Secondary voltages are optimized to match the converter and motor voltage. Oil or dry type for indoor or outdoor mounting are available. Transformers with a fourth winding for connecting harmonic filters are available. Busbar connections can also be provided.

Flexibility of location

A separate transformer allows flexible installation, which can be next to the drive or, when space is limited, in another location. Transformers are generally installed outdoors for safety, space savings and lower heat losses into the electrical room.

Filters

When designing a variable speed drive system, ABB pays special attention to minimizing the influence variable speed drive systems can have on the power factor and harmonic content of the supply system. In almost all cases ABB‘s standard design meets IEEE 519 requirements. ABB can offer network evaluation for harmonics.

For special customer needs and high power ratings in weak networks, filters and power factor correction equipment can be provided.

Recooling equipment

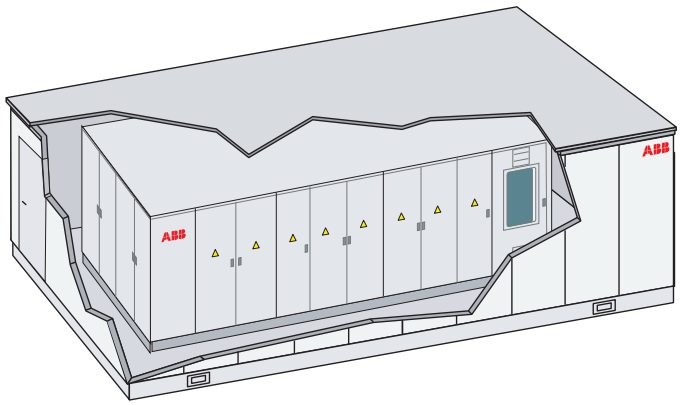
For sites where cooling water is not available ABB can offer fin-fan coolers or chillers for the cooling circuit of water-cooled frequency converters.

Switchgear

ABB offers medium voltage distribution switchgear for all drive sizes and other distribution tasks in the plant. The product range covers air and gas insulated panels with gas or vacuum circuit breakers.

Outdoor control houses

To reduce the time and cost of construction, installation and commissioning at site, outdoor control houses can be provided. The control houses for the converter and its auxiliaries are tailored to the specific needs and site conditions. Mezzanine floor for cabling and piping, air conditioning and fire detection are standard options.



Preinstalled and tested control house

Electric versus gas turbine drives

The question of the relative merits of electric and gas turbine drives is playing an increasingly important role in the decision-making process, especially at higher ratings. Frequently the discussion is initiated by environmental aspects.

When electric power is available, an electric drive offers significant advantages. This is the driving force behind the enormous increase in the number of electric drives being installed. The table below compares the most important features of the two solutions.

Comparison of ...	Gas turbine	Variable speed drive
Efficiency	low	very high
Investment cost	high	medium
Operating cost	to be evaluated	to be evaluated
Maintenance	high (important)	very low
Reliability	medium	high
Availability	medium	high
Mean time to repair	a factor to be considered	very low
Pollution, emissions	high	none
Speed control range	limited	wide
Speed control accuracy	medium	high
Design flexibility	low	high
Starting time	medium to high	short
Noise level	very high	medium
Influence on power supply	none	investigation required
Environmental permit	required	not required

Optimizing costs and processes in LNG plants with variable speed drives

Refrigeration compressors in LNG plants were traditionally driven by gas turbines. Gas turbines, however, must have starting aid and require constant maintenance. Moreover, their efficiency deteriorates during their lifetime for several reasons and at high ambient temperatures the rated output power of gas turbines decreases. By adding a variable speed drive to the compressor shaft string, the electric drive starts the gas turbine and can also compensate the declining driving power of the gas turbine at high ambient temperatures. These so-called starter/helper drives can also be operated as power generators when one of the gas turbines is running on excess of power to balance the power consumption between two refrigeration trains.

If reliable electric power supply is available, the starter/helper drives can be upsized to fully rated variable speed drive systems to substitute the gas turbine. The entire liquefaction process can be optimized since variable speed drive systems are more efficient at part load and require less shut down periods for maintenance.

The following benefits, resulting from this change, will lead to increased profitability:
– Lower investment cost
– Higher up-time (increased production hours per year)
– Less maintenance
– Reduced operation/production costs

Variable speed motor versus fixed speed motor with hydraulic coupling

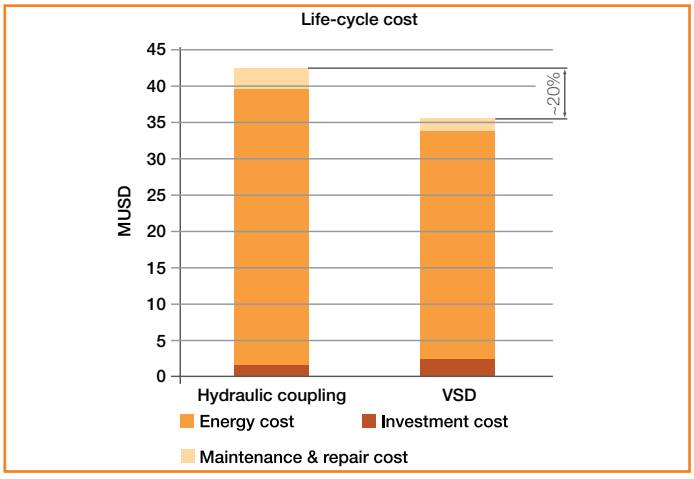
For decades hydraulic couplings have been used in many processes to control the speed of compressors and pumps. Although the principle is well established, development has reached a stage where, in view of the advantages of a variable speed drive, the situation warrants reappraisal.

The table below compares the most important characteristics of the two solutions.

Comparison of ...	Hydraulic coupling	Variable speed drive
Efficiency	low (varies with load)	high (over entire load range)
Cooling requirements	high	low
Initial investment cost	low	medium
Maintenance	high	low
Availability	medium to high	high
Total life-cycle cost	very high	very low
Influence on power supply	none	minimal with suitable topology
Inrush current from supply	up to 600% of rated current	less than rated current
Dynamic response	low	high
Environmental influence	high oil volume hazard	none
Space requirement at motor	extended shaft length	none
Weight	very high	medium
Speed control range	limited	wide and easy to adjust
Mean time to repair	several days	few hours

A variable speed drive has a much higher efficiency, which considerably reduces the overall life-cycle costs. The high inrush current of fixed speed motors can cause serious problems on weak power systems. The limited speed control range, the lack of supersynchronous speeds, the poor dynamic response and higher maintenance costs are other points which limit the application of the hydraulic coupling. The investment costs for both solutions are roughly comparable. The optimum drive system has to be selected on the basis of the specific plant data, i.e. speed control range, power rating, load characteristic, duty cycle, energy costs and return on investment.

Taking all these factors and the total life-cycle cost into consideration, an electric variable speed drive is the best solution.



VSD vs. hydraulic coupling	
Break-even point	**1.5 years**
Net return on investment	**900%**
Net present value of savings	**7 MUSD**
Life-cycle cost savings	**20%**

The calculation is based on the following data:
Power: 9 MW; service life: 15 years; cost per kWh: 0.07 USD; operating time per year: 8000 hours

Hazardous environments

ATEX directive

In the chemical, oil and gas industries, variable speed drive systems are operating mainly with compressors, pumps and all kinds of extruders, most of them under demanding ambient conditions (corrosive atmospheres and motors operating in hazardous areas). This requires that certain rules of safety are observed and standards complied with. Since July 2003, in Europe both electrical and non-electrical equipment installed in potentially explosive atmospheres containing gas or combustible dust have to comply with the directive ATEX 94/9/EC.

ABB was the first manufacturer to have its motors ATEX certified, with approval granted in December 1998.

Compliance with the ATEX directive means new essential requirements, such as:

- Reinforced safety aspects
- Safer design, not only for normal operations, but also for starting conditions
- More demanding testing procedures
- Specific quality assurance for the design and manufacturing process
- Use of variable speed drive applications based on clear rules: second rating plate, certified loadability curves and bearing currents controlled against external sparking

Classification of hazardous atmospheres

Potentially explosive zones (areas), in which an explosive atmosphere containing gas or combustible dust

… is expected to exist continuously or for very long periods of time.	….is expected to exist for short periods of time but during a year the accumulation of such events is not in excess of 1000 hours.	…is not expected and should it occur it will only exist for a very short period of time and where the accumulation of events over a year does not exceed much in excess of 10 hours.	Explosive mixtures in temperature classes defining the maximum permissible temperatures of surfaces in electrical equipment, which do not exceed the ignition temperatures of the gas mixtures.
Zone 0	**Zone 1**	**Zone 2**	

Different protection markings available for motors in hazardous areas

According to EN/IEC standards:

For zone 1 and 2
Flameproof Ex d(e)
Standards EN 60079-1, IEC 60079-1

Increased safety Ex e
Standards EN 60079-7, IEC 60079-7

Pressurized Ex px or Ex px(e)
Standards EN 60079-2, IEC 60079-2

For zone 2
Non sparking Ex nA
Standards EN 60079-15, IEC 60079-15

Pressurized Ex pz or Ex pz(e)
Standards EN 60079-2, IEC 60079-2

According to North American rules (NEC and CEC):

NEC (National Electric Code) and CEC (Canadian Electric Code) nowadays have two systems for classifying hazardous areas. The traditional division system is still widely used. The new zone system, which refers to IEC standards, is becoming more widespread.

Traditional system (NEC and CEC)
Class 1, Division 2

New system (NEC)	**New system (CEC)**
Class 1, Zone 2	Ex nA
Class 1, Zone 1	Ex p(e)
	Ex d(e)

Testing of variable speed drive systems

Thourough testing ensures proven functionality and performance and reduces commissioning time.

To verify that quality standards and customer requirements are fully met every component of a drive is subjected to thorough testing in ABB's modern test facilities.

Routine tests

Routine tests and functional tests form an integral part of the scope of supply of ABB medium voltage drives. They are performed in accordance with international standards (e.g. IEC) and ABB quality assurance procedures (ISO 9001).

Combined tests

ABB offers the possibility to perform a combined test with the complete drive system, including transformer, converter and motor.

Depending on the project requirements, the drive system can be tested with or without load.

With such a test the functionality as well as the load performance of the drive system can be verified. This will confirm the design data and verify performance values as well as reduce installation and commissioning time on site.

Back-to-back tests

Back-to-back tests can be performed if two identical MEGADRIVE-LCI drives are ordered at the same time. One drive system works in motor mode and is loaded with a second drive system working in generator mode.

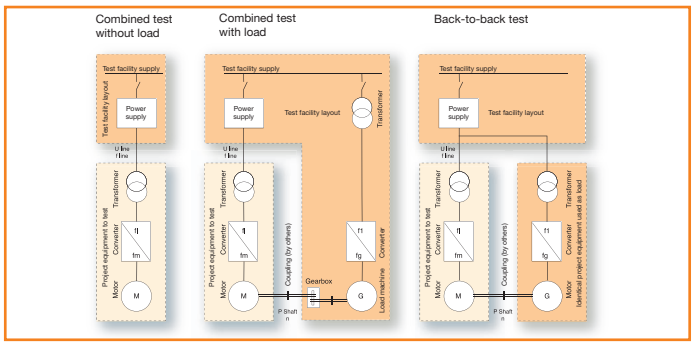


Illustration of extended test layouts

Back-to-back test 48 MW / 3500 rpm

Service - global network, local presence

Wherever you are, ABB is there for you.

After sales service is an integral part of providing the customer with a reliable and efficient drive system.

The ABB Group of companies operates in more than 100 countries and has a worldwide network of service operations.

Services for ABB's medium voltage drives

– Supervision of installation and commissioning
– Training
– Remote diagnostics
– Customized maintenance contracts
– Local support
– 24 x 365 support line
– Spare parts and logistics network
– Worldwide service network

Contact us

ABB Switzerland Ltd
Medium Voltage Drives
CH-5300 Turgi
Phone: +41 58 589 27 95
Fax: +41 58 589 29 84
E-Mail: mvdrives@ch.abb.com

www.abb.com/drives

Power and productivity
for a better world™