

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



# ABB – one of the world’s leading suppliers 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 one of the world’s leading suppliers of variable speed drive systems. To date ABB has installed medium voltage drives with a total rated power of more than 40,000 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 (VSDs).

Upstream	Applications
Oil and gas production and gathering	Pumps
Gas treatment	Compressors
Gas export	
Subsea	
Midstream	
Oil and gas transportation and distribution	Pumps
Oil and 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 percent. ABB electric drives reduce NO<sub>x</sub> and CO<sub>2</sub> emissions on site that could delay granting of a permit and cause penalties.

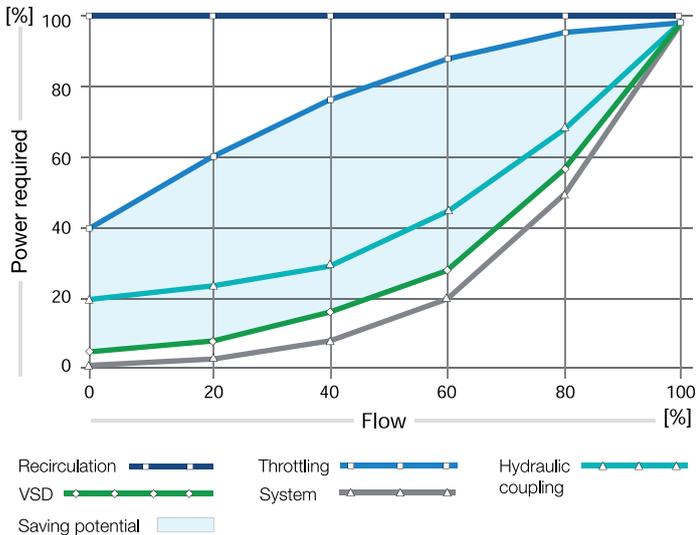
The power required to run a pump or a compressor is roughly proportional to the cube of the speed. In other words, a pump or compressor running at half speed can consume as little as one eighth of the energy compared to one running at full speed. A small reduction in speed can make a big difference in 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.

## Minimized environmental impact

Variable speed control is the most eco-efficient way to optimize process performance. Variable speed drives reduce energy consumption and NO<sub>x</sub> and CO<sub>2</sub> 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.



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 imposes 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 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.

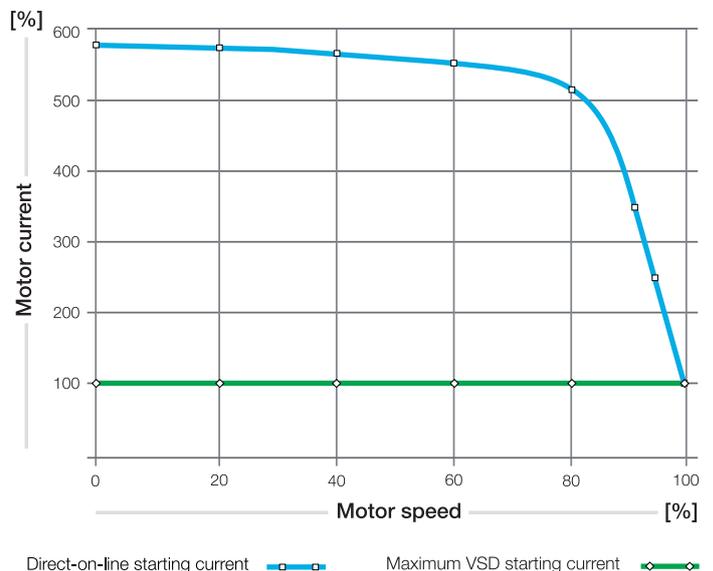
Soft-starting machinery with variable speed drives results in the following benefits:

- 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 (eg turbines)
- Gentle process start-up, controlled in all respects from zero speed

All these factors contribute to high reliability and maximum availability of a plant.

### 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



Motor current for various starting methods

# 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 variable speed drive system 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.

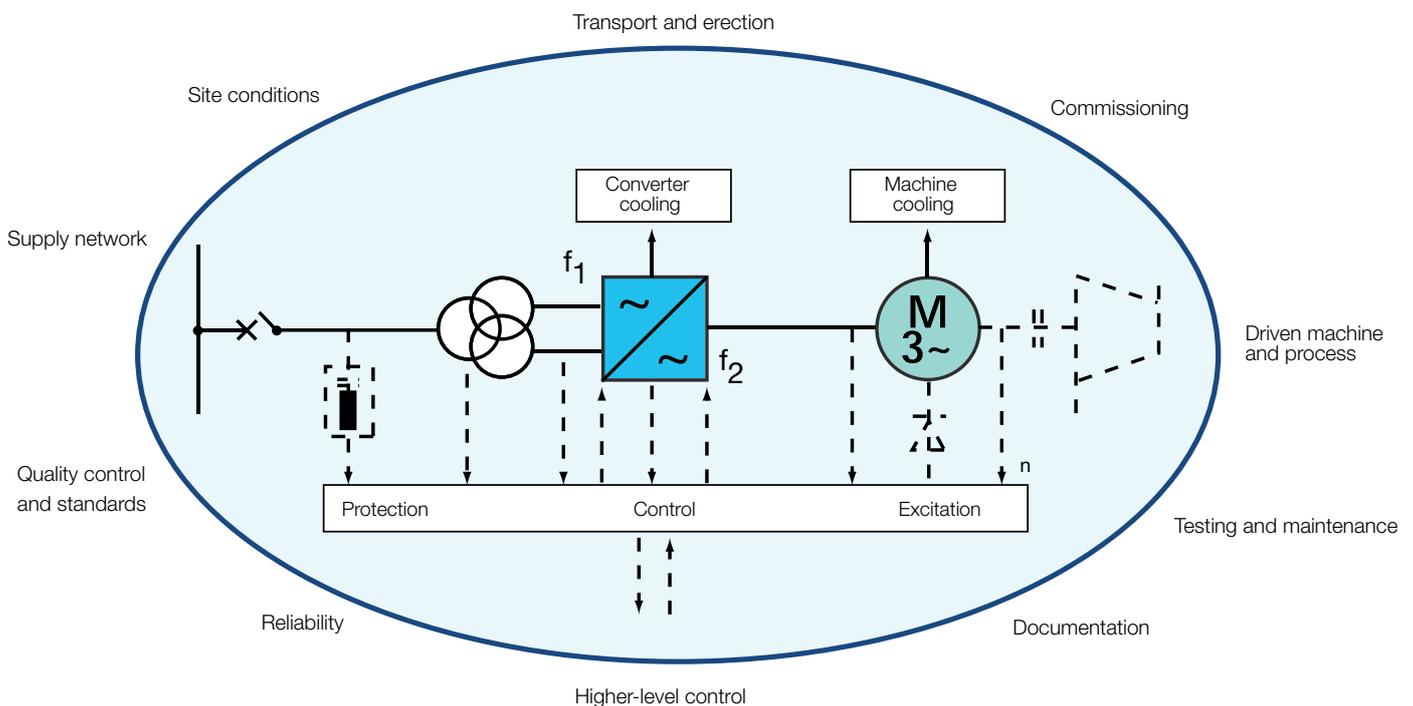
## Reliability and availability is a must

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 (eg cooling pumps) can be provided to increase availability while enabling maintenance intervals to be extended.

## 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
- Optimization of the complete drive system with all associated auxiliaries
- 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



## 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 250 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-cooled and water-cooled converters for different power and voltage requirements.

### **ACS 1000 (315 kW – 5 MW, up to 4.16 kV)**

The ACS 1000 is suitable for both retrofit applications and new standard induction motors. Due to its unique output sine filter bearing currents and voltage reflections are eliminated. It is available with air and water cooling. The ACS 1000i is a fully integrated drive including input transformer and input contactor.

### **ACS 2000 (250 – 1,600 kW, 4.0 – 6.9 kV)**

The ACS 2000 is suitable for retrofit applications and new standard induction motors. It can be used without an input isolation transformer, thereby allowing a direct connection to the line supply (direct-to-line), with an integrated transformer, or for connection to an external input isolation transformer. The ACS 2000 is available with an Active Front End (AFE) to minimize harmonics. It is also available for four-quadrant operation for energy regeneration and reactive power compensation.

### **ACS 5000 (2 – 32 MW, 6.0 – 6.9 kV)**

The ACS 5000 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 (3 – 27 MW, up to 3.3 kV)**

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. Inter-related motors can be connected to the same ACS 6000 via 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 (2 – 72 MW or higher on request)**

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 motors. Standard air-cooled and water-cooled designs are available for ratings up to 72 MW, engineered designs for more than 100 MW.

### **PCS 8000 (25 – 100 MW, up to 6.6 kV)**

The PCS 8000 is the right selection for high power compressor drives. It is a modular voltage source inverter with optional semiconductor redundancy.



# Medium voltage drives technology highlights

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



## Direct Torque Control (DTC)

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.

## Power loss ride through

Due to its power loss ride through function, the drive system is able to withstand disturbances of the power supply. The drive will continue to operate in an active but non-torque producing mode if the incoming supply voltage is cut off. The drive will be active as long as the motor rotates and generates energy to the drive. It will resume normal operation immediately upon return of power supply.

## 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

ABB medium voltage drives are designed to operate safely without fuses which are known to be unreliable, costly and subject to aging. The fuseless design 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, thereby reducing maintenance costs and ensuring high levels of availability.

## 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, 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.

# 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, eg 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

# Transformers and auxiliaries

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

## 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 types 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. Alternatively, ABB offers variable speed drives for direct-to-line connection or with integrated transformer.

## 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

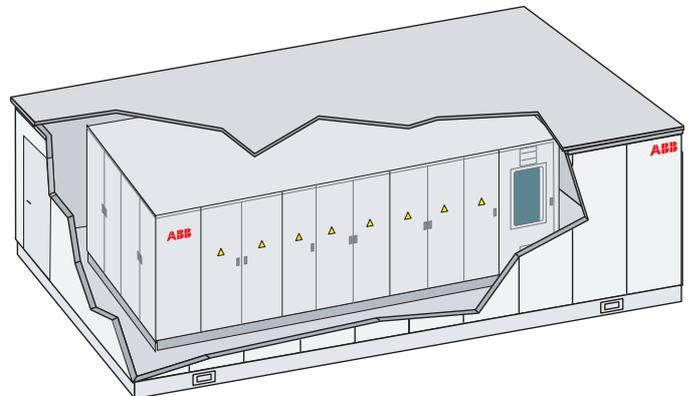
For sites where cooling water is not available ABB can offer fin-fan coolers or chillers for the cooling circuit of water-cooled frequency converters.

## 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

# Testing of variable speed drive systems

Thorough 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 (eg 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.

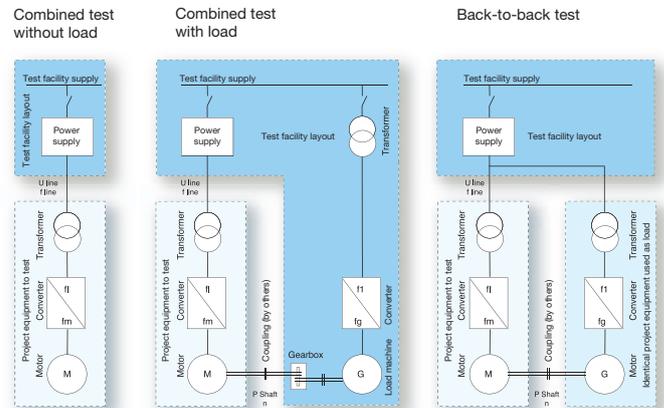


Illustration of extended test layouts

A full load test can, for example, be done with a back-to-back test setup. 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.



Back-to-back test 8 MW / 3,600 rpm



Back-to-back test 48 MW / 3,500 rpm

# 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 (more production hours per year)
- Less maintenance
- Reduced operation/production cost

# Variable speed motor versus fixed speed motor with hydraulic coupling

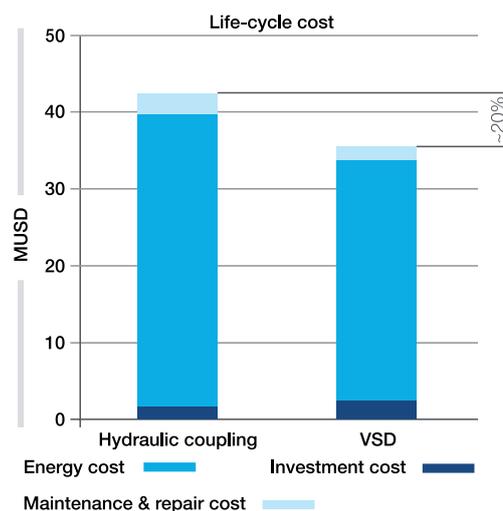
For decades hydraulic couplings have been used in many processes to control the speed of compressors and pumps. Although the principle is well established, development has reached a stage where, in view of the advantages of a variable speed drive, the situation warrants reappraisal.

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	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 cost. 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 cost are other points which limit the application of the hydraulic coupling. The investment cost for both solutions are roughly comparable. The optimum drive system has to be selected on the basis of the specific plant data, ie speed control range, power rating, load characteristic, duty cycle, energy cost 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	\$7,000,000
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;  
 operating time per year: 8,000 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			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.
... 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 1,000 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.	
<b>Zone 0</b>	<b>Zone 1</b>	<b>Zone 2</b>	

## Different protection markings available for motors in hazardous areas

According to EN/IEC standards:	According to North American rules (NEC and CEC):								
<p><b>For zone 1 and 2</b>                      Flameproof Ex d(e)                      Standards EN 60079-1, IEC 60079-1</p> <p>Increased safety Ex e                      Standards EN 60079-7, IEC 60079-7</p> <p>Pressurized Ex px or Ex px(e)                      Standards EN 60079-2, IEC 60079-2</p>	<p>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.</p> <p><b>Traditional system (NEC and CEC)</b>                      Class 1, Division 2</p>								
<p><b>For zone 2</b>                      Non sparking Ex nA                      Standards EN 60079-15, IEC 60079-15</p> <p>Pressurized Ex pz or Ex pz(e)                      Standards EN 60079-2, IEC 60079-2</p>	<table border="0"> <tr> <td><b>New system (NEC)</b></td> <td><b>New system (CEC)</b></td> </tr> <tr> <td>Class 1, Zone 2</td> <td>Ex nA</td> </tr> <tr> <td>Class 1, Zone 1</td> <td>Ex p(e)</td> </tr> <tr> <td></td> <td>Ex d(e)</td> </tr> </table>	<b>New system (NEC)</b>	<b>New system (CEC)</b>	Class 1, Zone 2	Ex nA	Class 1, Zone 1	Ex p(e)		Ex d(e)
<b>New system (NEC)</b>	<b>New system (CEC)</b>								
Class 1, Zone 2	Ex nA								
Class 1, Zone 1	Ex p(e)								
	Ex d(e)								

# Service and support

ABB drives are backed by comprehensive service and support, from the customer's initial inquiry throughout the entire life cycle of the drive system.

## Technical advice

As originators of AC drives technology in the late 1960s, ABB has over 40 years of application know-how in all industrial sectors, in virtually every country. ABB's specialists are located around the world to offer advice that ensures trouble-free operation of ABB drives.

## Installation and commissioning

Proper installation and commissioning of the equipment, done by qualified and certified commissioning engineers, reduces start-up time, increases safety and reliability and decreases life-cycle costs. In addition, operators can be given practical training by experienced specialists on site.

## Life-cycle management

ABB's drive life-cycle management model maximizes the value of the equipment and maintenance investment by maintaining high availability, eliminating unplanned repair costs and extending the lifetime of the drive.

Life-cycle management includes:

- providing spare parts and expertise throughout the life cycle
- providing efficient product support and maintenance for improved reliability
- adding functionality to the initial product
- providing a smooth transition to a new technology at the end of the life cycle

## Training

ABB provides extensive training for its medium voltage drives. A range of training programs is offered from basic tutorials to programs tailored to the customer's specific needs.

## Global network, local presence

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 services
- Customized service agreements
- Preventive maintenance
- Local support
- 24 x 365 technical support
- Spare parts and logistics network
- Worldwide service network



# Contact us

[www.abb.com/drives](http://www.abb.com/drives)