Low-cost FGD systems for emerging markets

Emerging markets have been calling for several years for new, lower-cost flue-gas desulfurization technologies as an alternative to the mature, proven FGD systems that are currently available. In response to this demand, ABB has developed new FGD technologies that perform as well or better than conventional systems at a much reduced cost. Three main technologies are used to control sulfur dioxide emissions: limestone-based wet, lime-based dry or seawater FGD. The optimum FGD solution for a particular installation depends on many site-specific factors, which can be technically and/or financially driven.

The combustion of fossil fuels generates a number of gaseous pollutants, including sulfur dioxide, which can be effectively controlled by air pollution control processes. Three main technologies are used to control sulfur dioxide emissions:

- Limestone-based wet FGD
- Lime-based dry FGD
- Seawater FGD

Since the introduction of FGD in the late 1960s, global market demand has been steady at between 5,000 to 10,000 MWe per year **1**.

In 1968 ABB introduced thr first commercial utility flue gas desulfurization system at Kansas Power & Light's Lawrence station. Currently, ABB's experience includes 30,000 MWe of limestone-based wet FGD systems, 15,000 MWe of dry FGD systems and 4,000 MWe of seawater FGD systems.

The *limestone-based wet FGD system* has been systematically improved over the years. For example, ABB pioneered forced oxidation for gypsum production, and in 1995 it introduced the LS-2 system, featuring advances such as a high-velocity, compact absorber, high-efficiency gas/liquid contact and a compact reaction tank.

Dry FGD technologies based on either rotary atomizers or dual fluid nozzles were introduced in the late 1970s as an alternative to limestone-based wet FGD. The installed base of dry FGD systems has provided considerable experience in areas such as two-phase fluid dynamics and materials, and ultimately led to the development of a new technology called Novel Integrated Desulfurization, or NID. The NID system uses simple but highly advanced moist dust recirculation, which eliminates the need for a spray dryer reactor and slurry handling equipment.

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The *seawater technology* was pioneered by ABB in the 1970s. This technology has matured slowly and gained increased market acceptance through in-depth, long-term environmental impact assessment. The process uses no reagent, produces no byproducts and is environmentally benign. ABB is the only company to have gained operating experience with this technology in power plants.

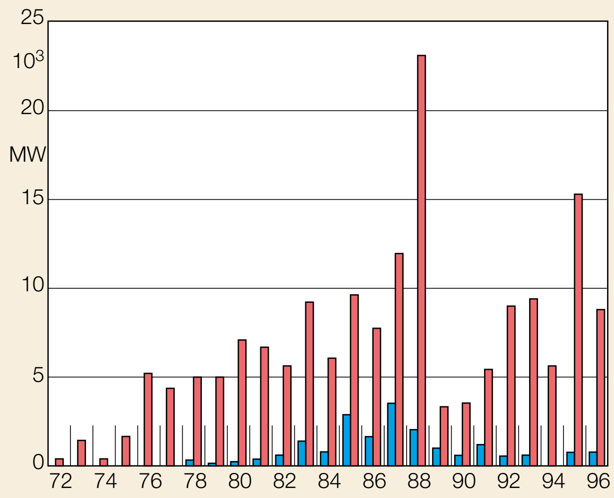
Novel Integrated Desulfurization

The key control factor in any dry FGD process is the relative humidity of the flue gas, which can be increased by injecting water into it. At a relative humidity of 40–50 %, the hydrated lime becomes activated and absorbs SO_2. In a conventional DFGD process, water and lime is supplied to the flue gas as a slurry (with or without recycled material) with a solids content of 35–50 %.

The amount of water injected into the flue gas in the NID process is the same as in conventional dry FGD. However, it is distributed on the surface of the dust particles to give a water content of only a few percent. Much more absorbent is therefore recycled than in a standard DFGD process, providing a much larger surface for the evaporation. The dust added to the flue gas thus dries in a very short time, allowing very small reactor vessels to be used. The increase in the relative humidity of the flue gas is sufficient to activate the lime for SO_2 absorption at typical DFGD/NID operating temperatures or 10–20 °C above saturation, in practice within the temperature range of 65 to 75 °C **2**.

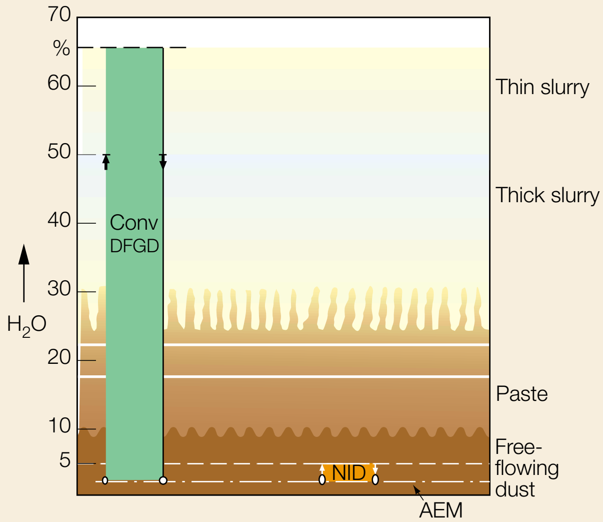
NID process description

The NID process **3** is based on the absorption of SO_2 by a dry absorbent containing lime (CaO) or dry hydrated lime, $Ca(OH)_2$. As an alternative, fly ash con-



Global installed capacity of FGD per year **1**

Blue *Dry flue gas desulfurization*
Red *Wet flue gas desulfurization*



Moisture history of reagent. In the NID process, water is injected into the flue gas such that the dust particles have a water content of just a few percent. **2**

AEM *Adsorbed equilibrium moisture*
DFGD *Dry flue gas desulfurization*
NID *Novel integrated desulfurization*

taining an appropriate amount of alkali can be used.

Water is added to the absorbent in a humidifier prior to its introduction into the flue gas. A unique feature of the NID technology is that all the recycled absorbent is wetted in the humidifier, which optimizes the utilization of the recycled absorbent. After activation/drying, the dried recycle dust is separated from the flue gas in a high-efficiency dust collector, preferably a fabric filter. From here, the dust is again fed to the humidifier, with make-up lime also added. Water is fed to the humidifier in a quantity sufficient to maintain a constant outlet flue gas temperature. The control system uses a feed forward signal with back trim, based on the inlet and outlet flue gas temperatures, supplemented by a signal indicating the gas flow. The outlet SO_2 concentrations plus the flue gas flow determine the lime flow to the system.

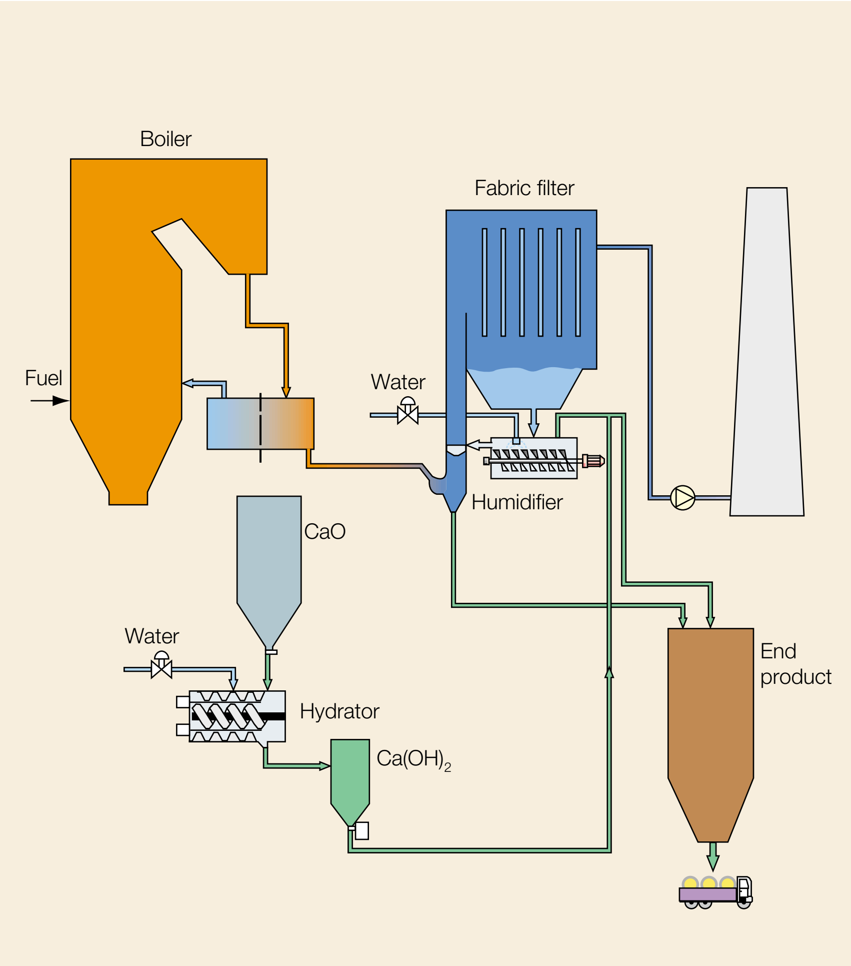
The NID process is thus characterized by a very high recycle rate and maximum utilization of the reagent. The large surface area allows rapid evaporation of the injected water, thus enabling the volume of the reactor/dryer in the NID process to be an order of magnitude smaller than the corresponding equipment in a conventional dry flue gas cleaning system based on spray dryer technology.

Experience with NID

In June 1994, the Polish power company ‘Elektrownia Laziska’ placed an order with ABB for a high-efficiency fabric filter system downstream of unit 2, where it would collect the fly ash. The boilers of units 1 and 2 at Laziska burn pulverized coal and each has a rated output of 120 MWe. The fuel is domestic hard coal from nearby mines. Initially, the fabric filter systems were designed to collect fly ash only, and had no desulfurization capability. These filter systems handle all of the flue gas from the boilers and are capable of treating gas at a nominal rate of 2 × 518,000 Nm³/h.

An agreement was signed between Elektrownia Laziska and ABB, whereby ABB would install and test the new NID concept on one of the compartments of the new fabric filter.

The NID demonstration unit **4** was installed on a compartment of the fabric filter of unit 2. Initial supportive testing in the ABB R&D laboratory at Växjö, Sweden, focused on dust wetting and the operating performance of the full-scale unit. Efficient and homogeneous dust wetting is important for the success of the NID process. The wetting aspects were studied separately in a semi-commercial-scale humidifier, utilizing a mixture of fly ash and lime. On conclusion of this study, the humidifier was added to an aerodynamic flow model, which



NID process flow diagram **3**

allowed testing of the combined systems for wetting and dust dispersion into the flue gas. These activities were supported by computational fluid dynamics (CFD) modelling.

The flue gas is taken from a common inlet flue gas duct into a vertical duct acting as inlet to the NID reactor. In the reactor, the flue gas is thoroughly mixed with wetted dust consisting of a mixture of absorbent and recycled material, ie reaction products of SO_2 and absorbent, mixed with fly ash. The NID reactor is connected directly to the fabric filter such that the gas flows horizontally into the filter bags, where the particles are separated from the flue gas.

The filter is cleaned by pulses of compressed air, which dislodges the dust. The filter hopper catches the dust, to which make-up absorbent is added before it is sent to the humidifier immediately below the hopper for recycling. In the humidifier, a controlled amount of water is added to the recycled material to maintain the desired outlet flue gas temperature.

The lime powder is stored in a silo, from which it is transported pneumatically to the filter hopper, thus being introduced into the flow of recycled material. The amount of lime added is controlled via a signal from an SO_2 meter at the outlet duct which sets the speed of a rotary feeder at the silo discharge. The demonstration plant was started up in February 1995, and a number of test programmes have been run in the meantime.

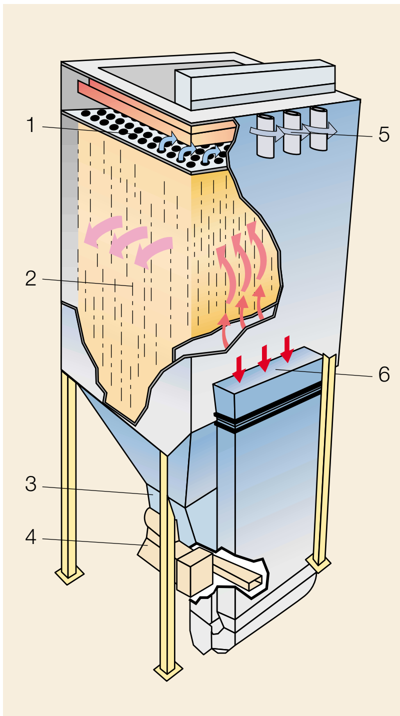
Based on the results from the demonstration plant, Elektrownia Laziska placed orders with ABB for the extension of the NID technology to their two 120-MW boilers (units 1 and 2). Both full-scale units **5** were commissioned during 1996.

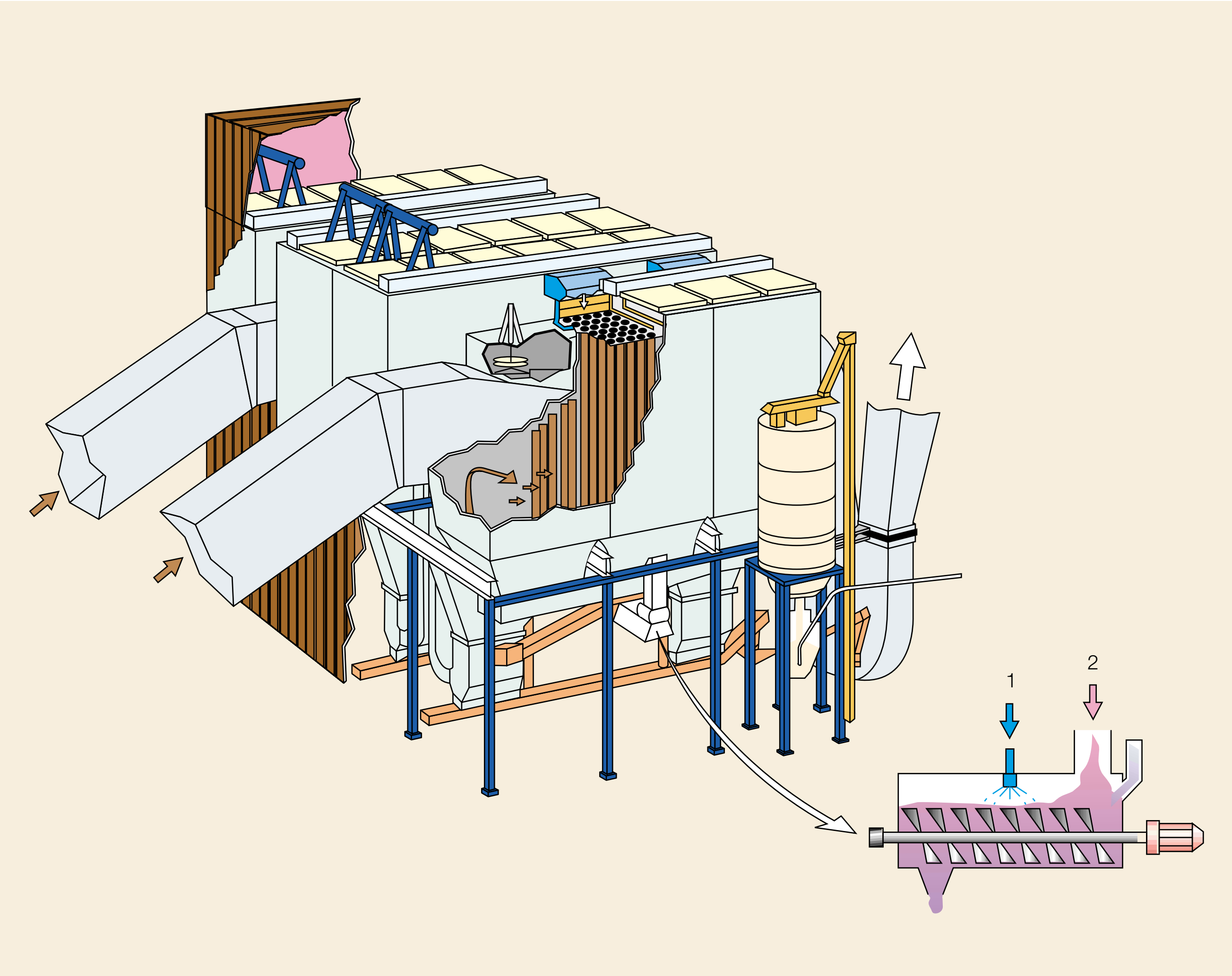
For the full-scale plant, it was decided to install a commercial dry lime hydrator. Although operation with quicklime alone was proven, it was felt that this would add unnecessary risk to the project. Quicklime is fed from a silo into the dry hydrator, from which the dry hydrated lime is transported by pneumatic means to the two FGD units.

The flue gas to the fabric filter is transported in two main flue gas ducts, each

Operating principle of the NID demonstration unit **4**

1 *Outlet plenum*
2 *Filter bags*
3 *Rotary feeder*
4 *Humidifier*
5 *Outgoing flue gas/damper*
6 *Incoming flue gas*





Full-scale NID installation at Laziska 1 *Water* 2 *Lime* **5**

with its own induced-draft flue gas fan. The main flue gas ducts branch off into two filter compartments, both of which can be isolated by inlet and outlet dampers. Thus, there are four separate FF compartments, each equipped with a hopper for recycled dust from the filter bags. The recycled dust from these four hoppers is fed to the humidifiers by means of rotary screws. Finally, after wetting in the humidifiers, the recycled dust is fed back into the inlet ducts via short air slides. This arrangement allows for part-load operation with individual compartments and mixers off line.

Performance of the full-scale NID plant

Commissioning and testing of the full-scale plant took place in steps. The first full-scale humidifier was installed in the NID system of unit 1 in February 1996. Aerodynamic tests and optimization of the plant followed. It was concluded that the fabric filter hopper/rotary feeder/humidifier operated as expected. It was further confirmed that the pressure drop over the unit is fully within the range that could be expected on the basis of the laboratory tests and CFD modelling.

In August 1996, all the gas paths of unit 1 were successfully brought on line. Start up of unit 2 followed later in the autumn of 1996. The performance data for the NID installation at Laziska are summarized in *Table 1*.

Comparison with conventional DFGD

The NID process requires considerably less sophisticated equipment than conventional dry FGD. Neither a rotary atomizer with its high-speed machinery nor dual fluid nozzles with their need for compressed air are required. The power needed to mix the recycled material and reagent in the humidifiers is much lower than for the corresponding items in a

Table 1:
Performance data

Parameter	Data/results
Size	2 × 120 MW
Flow rate	2 × 518,000 Nm^3/h
Inlet temperature	165 °C
SO_2 concentration	1,500–4,000 mg/Nm^3
SO_2 removal	
guaranteed	80 %
measured	95 %
Reagent	CaO
Dust loading	22,000 mg/Nm^3
Particulate emission	
guaranteed	50 mg/Nm^3
measured	15 mg/Nm^3

conventional dry FGD system. An important consequence of using humidifiers rather than nozzles or rotary atomizers is that all the equipment the operator has to attend to is situated near ground level in an enclosure shared with the fabric filter, lowering costs and making maintenance easier.

Finally, since water is added directly to the NID humidifier there is no slurry handling, which would require special pumps, etc. The high recycle rate also means that only dry material is handled by the system. This ensures that the gas ducts, etc, are free of build-up, for example due to wet slurry impacting on the surfaces of the installation.

Flakt-Hydro seawater FGD

Coal has its origin mainly in the large marine and submarine forests that existed during the Carboniferous Period some 350 to 280 million years ago. Oil originates from sea organisms that settled on the bottom of prehistoric seas.

The organic material was later covered by silt, preserved and fossilized in an anaerobic environment (with little or no free oxygen) within the seabed sludge, and finally ended up as coal or oil **6**.

Since sulfur bacteria were active in the same anaerobic environment, naturally abundant seawater sulfate subsequently converted to sulfides, which were deposited in the organic material. Sulfur thus became a constituent of fossil fuels.

The Flakt-Hydro process absorbs SO_2 from flue gas in seawater and oxidizes it to sulfate prior to discharge; in other words it returns sulfur to the sea in the form in which it originally appeared – as dissolved sulfate.

Laboratory tests, long-term bioassay testing and recipient follow-up have detected no significant effects of the effluent discharged by the Flakt-Hydro system.

Seawater FGD process

The Flakt-Hydro process utilizes seawater's inherent capability for absorbing and neutralizing sulfur dioxide. Seawater is used in large amounts at coastal power plants as the cooling medium in condensers. This seawater can be reused downstream of the condensers to control SO_2 emissions.

The SO_2 is absorbed through close contact between the seawater and flue gas in a counter-current flow. Low-density packing is used to optimize the gas/liquid contact. No reagent is added or needed **7**. Seawater is naturally alkaline, and therefore has a large neutralizing capacity.

The acidic effluent flows to the Sea Water Treatment Plant (SWTP), where the absorbed SO_2 is oxidized by aeration to form harmless SO_4^{2-}, which is discharged into the sea.

The sulfate is totally dissolved in the seawater. Since sulfate is a natural constituent of seawater, the seawater returned to the sea has only a slightly higher sulfate content. This increase lies well within variations occurring naturally in seawater, and the difference from the background level can no longer be detected just a very short distance from the point of discharge.

As the Flakt-Hydro seawater process is a once-through system, the flue gas is sub-cooled as it passes through the absorber. The flue gas typically requires reheating before being discharged to the atmosphere; however, wet stacks can also be employed.

Performance of seawater FGD

Chemically, the Flakt-Hydro system is very similar to the established wet limestone/gypsum process, with the difference that no solid reagent is required and precipitation of solids is not needed. Hence, the system exhibits a similar performance and is capable of meeting stringent emission requirements for low to medium sulfur coals.

The effluent discharge from the Flakt-Hydro seawater process has been extensively studied by independent environmental agencies.

Long-term bioassay testing

A long-term bioassay test programme was carried out several years ago at the Cabras power station on the island of Guam. Plankton, shellfish and other marine organisms were kept in aquariums filled with effluent water from a Flakt-Hydro seawater treatment plant. The same organisms were also kept in fresh seawater aquariums for comparison.

No harmful effects on the marine life could be determined over the test period of one year. The test was carried out by marine biologists from R.W. Beck and associates and was monitored by the USA Environmental Protection Agency (EPA).

University of Bergen

The decision was taken at the Statoil refinery in Norway to start a recipient follow-up programme around its seawater outlet. The refinery installed the Flakt-Hydro process to absorb SO_2 in the flue gas from their residual catalytic cracker and in the off-gases from a sulfur recovery unit. The purpose of the investigations was to determine the influence of the seawater FGD on the local flora, fauna and marine sediments. Sampling was conducted before and after installation of the new seawater FGD outlet.

The survey was carried out by the Department of Fisheries and Marine Biology at the University of Bergen, Norway.

The first samples were taken in March 1989, prior to start-up of the flue-gas desulfurization system. Repeated testing took place in March 1990, after approximately six months of operation. Since then, sampling has been carried out on a yearly basis.

No harmful impact on the benthos was observed after the plant was started up. The amount of organic material, sulfates and trace metals remains within the natural range for marine sediment. No distinguishable difference in the environmental conditions in the area before and after the FGD system was deployed is evident after 52 months of continuous operation.

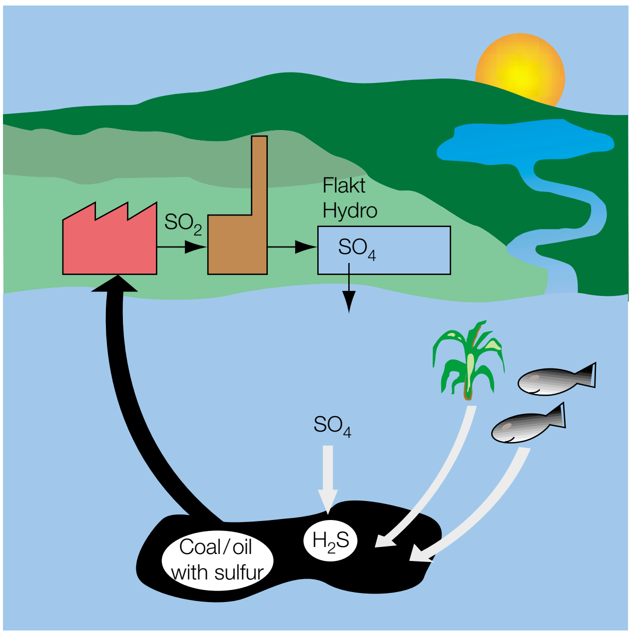
US EPA

The EPA region II of New York evaluated the process in connection with a 2 × 150-MWe coal fired IPP power project in Puerto Rico. In their draft permit they stated: 'Our review of the proposed seawater FGD technology indicates that the seawater scrubbing technology has been in use successfully since 1933. In particular, it has been applied at over a dozen facilities in Europe and Asia. Accordingly, EPA consider this a proven technology. EPA determine that the seawater scrubbing would be appropriate for this project.'

European Union

Unión Eléctrica de Canarias, S.A (UNELCO) has two 2 × 80-MWe power stations in the Canary Islands, Spain. The plants are equipped with Flakt-Hydro seawater FGD and are designed to comply with all environmental regulations for air and water quality valid in Spain and within the European Union. The power stations started up in 1995/1996.

The natural sulfur cycle 6



Seawater FGD process flow diagram 7

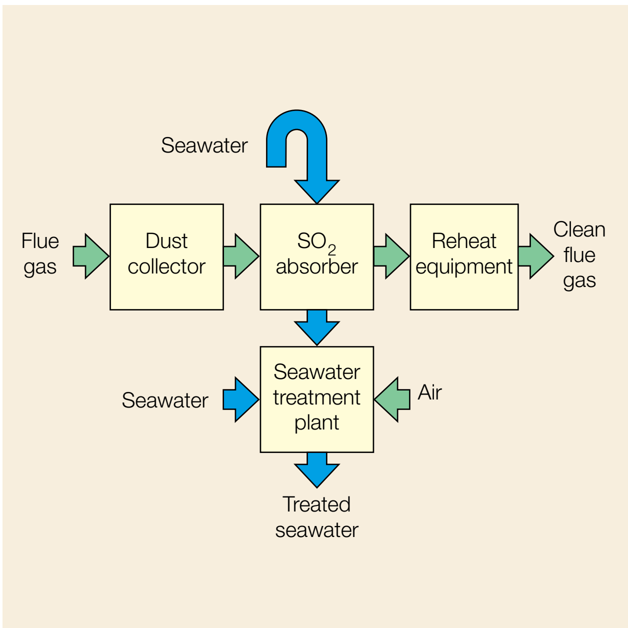


Table 2:
Basic design data for recent seawater systems

Plant	UNELCO	Paiton	Shenzhen
Location	Canary Islands, Spain	East Java, Indonesia	She Kou, China
Size	4 × 80 MWe	2 × 670 MWe	300 MWe
Fuel	2.7 % S oil 1.5 % S coal	0.4 % S coal	0.7 % S coal
SO_2 removal	91 %	91 %	90 %
Special features	GGH	Wet stack, concrete absorber	GGH, axial booster fan

Scottish Power also selected this system for its 2,400-MW Longannet plant, the third largest power station in Europe, in the event that FGD is installed. In the meantime, the authorities have approved the Seawater FGD system for use at Longannet and ABB's Flakt-Hydro process is considered the best practical environmental option (BPEO).

Experience

The seawater process was first introduced in the early 1970s in Norway, where it was used for desulfurization of flue gases from oil-fired boilers, smelters and refineries. The process was employed for the first time in a coal-fired power plant in India in 1988 (TATA's Trombay Power Station, Unit 5).

A total of 4,400 MW of equivalent electrical capacity has been put into operation or is under construction (*Table 2*).

Paiton, Indonesia

In September 1995, ABB received an order to deliver a Flakt-Hydro seawater scrubbing process for the 1,340 MW Paiton Private Power Project (phase 1) in East Java, Indonesia. The process will be used in conjunction with the plant's two 670-MW coal-fired boilers.

Each 670-MW boiler is equipped with two induced draft fans. The plant is designed to operate without the assistance of booster fans. Each of the boilers is fitted with two concrete absorber modules employing low-density packing.

The absorber inlet includes a flue gas quencher to protect the packing. The gas/liquid contact is countercurrent; the flue gas enters the absorbers through the bottom and leaves through the outlet at the top. The treated flue gas is discharged through a wet stack.

The FGD system includes an absorber bypass duct, designed to be used when conditions are disturbed and when carrying out maintenance on the FGD plant.

Seawater from the process downstream of the condensers is introduced at the top of the absorber packing. The acidified absorber effluent collects in the absorber sump at a sufficient level to ensure gravity flow to the SWTP and avoid having to pump this highly corrosive liquid.

A portion of the cooling-water discharge is routed directly to the SWTP to provide optimum conditions for the chemical reactions. In addition, ambient air is blown into the SWTP basins for the oxidation and oxygen saturation. The treated seawater is finally discharged through the existing cooling-water outlet system.

Shenzhen, China

ABB recently received the order for a Flakt-Hydro seawater system for the 300-MWe Shenzhen power plant in Shenzhen, South China.

A single absorber will be used to treat the flue gas from the boiler complex. The flue gas train will include a booster fan, a single absorber tower and a regenerative gas-to-gas heat-exchanger. The absorber employs low-density packing and is designed for 90 percent SO_2 removal.

Before being discharged to the stack, the flue gas passes through the regenerative gas-to-gas heat-exchanger. Effluent seawater is treated in the

Table 3:
LS-2 size reduction

Size reduction	*Saving*
Absorber diameter	15–25 %
Overall height	20–30 %
Plate area	25–35 %
Plate weight	35–45 %
Liquid-to-gas ratio	20–40 %
Power consumption	10–20 %

SWTP before being discharged into the ocean.

LS-2 limestone wet FGD

ABB's newest limestone-based wet FGD system has been in operation at Ohio Edison's Niles Plant 9 since September 1995. Drawing on nearly 30,000 MW of worldwide wet FGD experience, ABB has incorporated several innovations into the Niles system which are designed to reduce the overall cost of compliance with SO_2 emissions requirements. Collectively, these improvements are referred to as LS-2 [1].

The turnkey system installed at the Niles plant is rated at 130 MWe and was designed and erected over a 22-month period. The system also produces wallboard-grade gypsum, all of which is sold to a local wallboard manufacturer.

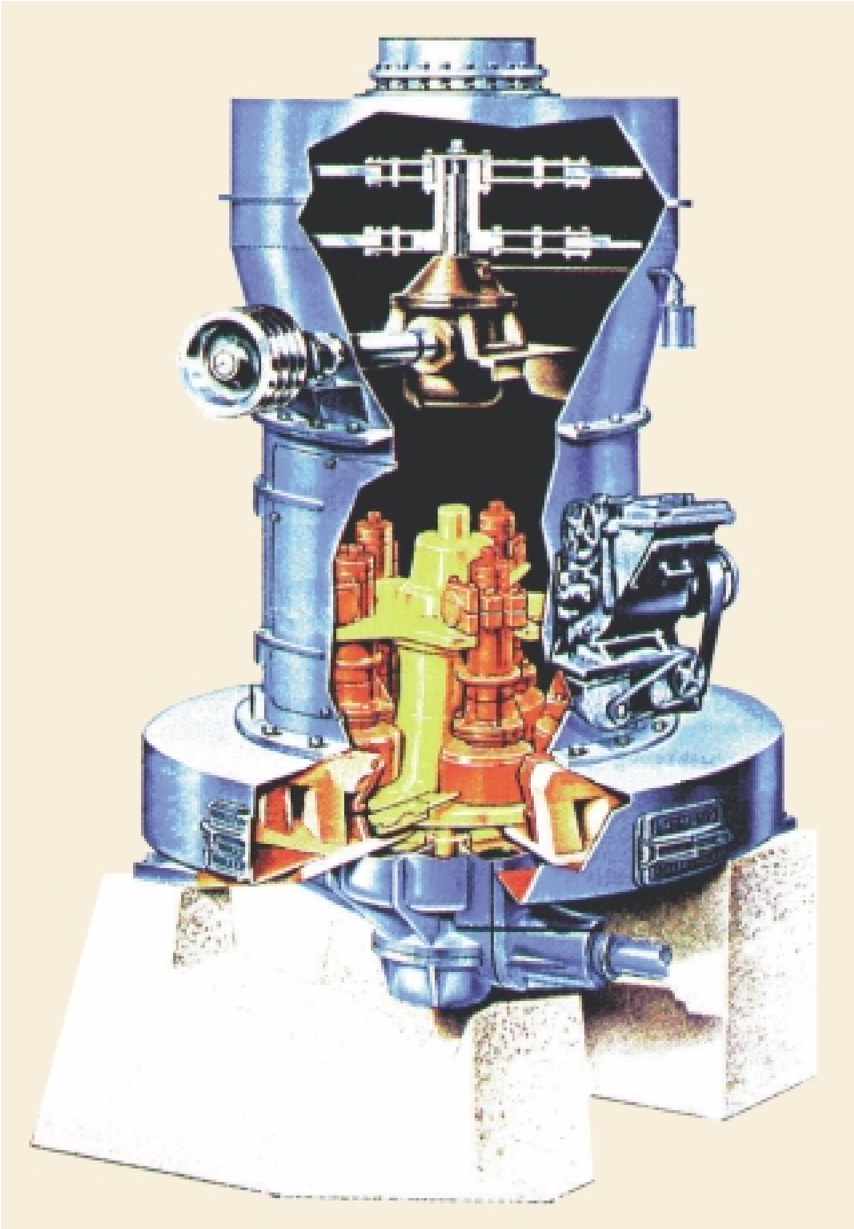


ABB dry roller mill. This limestone grinding mill forms the basis of the reagent system used in the LS-2 wet FGD process. 8

LS-2 process description

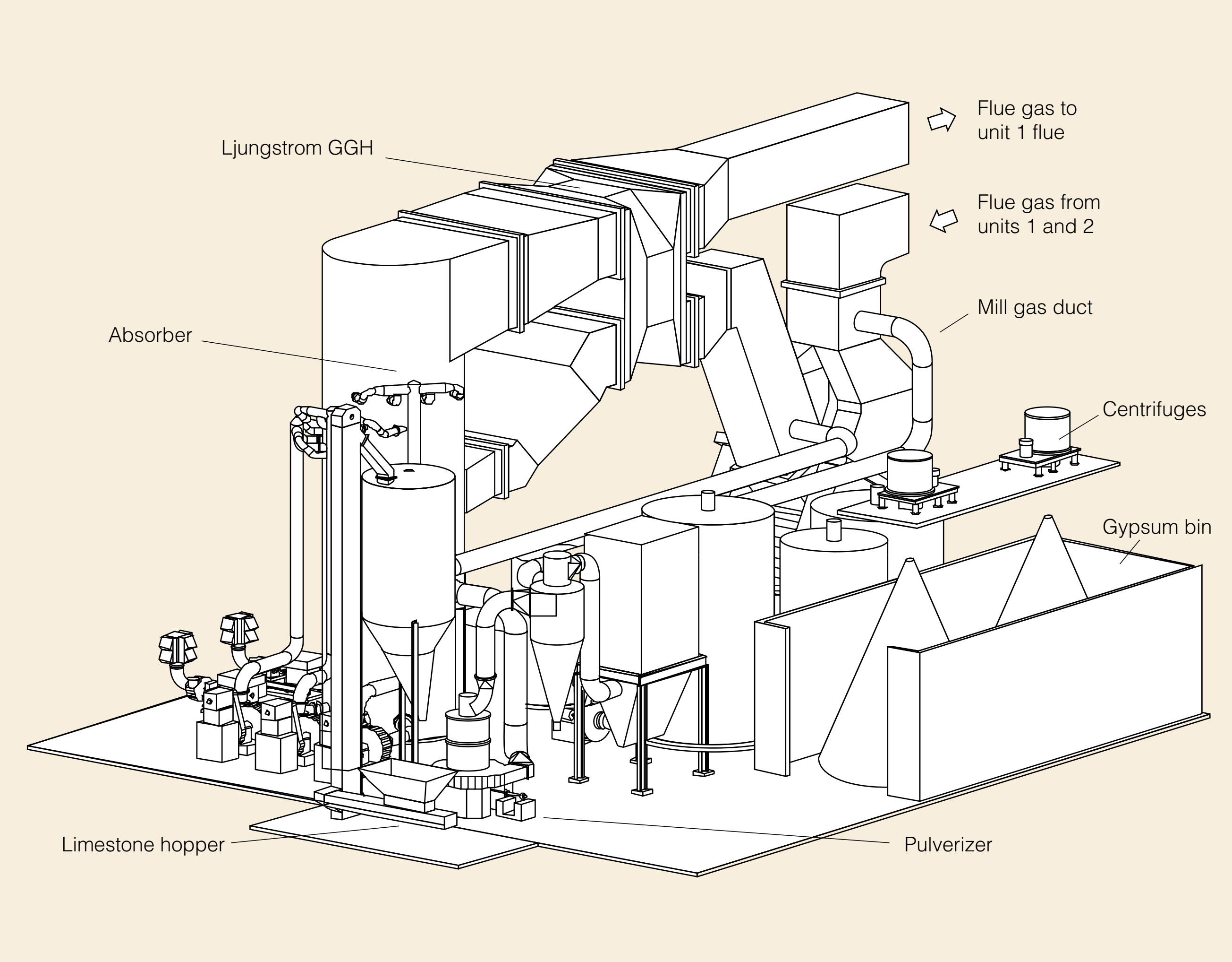
The LS-2 includes a number of innovative process improvements. The spray tower has the ability to run at velocities as high as 5.5 m/s, and features a compact spray zone with ABB's patented nozzle arrangement, plus a compact reaction tank. The reagent system is based on an ABB Raymond roller mill 8 which features a completely dry grinding circuit. This limestone grinding system is less costly both to construct and operate, yet produces a significantly finer grind. The primary dewatering system features fully integrated high-efficiency hydrocyclones followed by centrifuges for secondary and final dewatering.

Absorber

The design of the LS-2 absorber has evolved from ABB's open spray tower technology and employs a high superficial gas velocity and fine-grind limestone for a significant reduction in absorber size and recycle tank volume.

In addition, the LS-2 absorber employs a new patented spray header design which allows a higher spray density to be used, resulting in a smaller number of spray levels and a corresponding reduction in absorber height. The potential saving with the LS-2 absorber, compared with a current 400-MWe state-of-the-art absorber, is indicated in *Table 3*.

The spray zone is followed by a proprietary two-stage mist eliminator system with vertical flow bulk entrainment separator which is followed by a two-pass, horizontal-flow, chevron-type mist eliminator. The mist eliminator system is capable of operating at up to 10 m/s.



LS-2 installation at the coal-fired, 130-MW Niles generating station of Ohio Edison, USA **9**

Grinding System
The additive preparation system features an ABB Raymond roller mill **8**. The mill system accepts a limestone feed stock sized at less than 40 mm (1.6 inches). Untreated flue gas is used to dry and convey the limestone during mill operation. The flue gas leaving the milling system is returned to the absorber for processing.

The limestone preparation and handling system is completely dry and includes a wetting system just before the injection into the reaction tank.

The grinding system comprises a limestone loading area and a storage silo for pebble limestone. Ground limestone leaving the roller mill is collected in a cyclone and transported pneumatically to a storage silo.

The supply of ground limestone to the absorber reaction tank is based on demand. The limestone grind will typically be 99.5 percent less than 44 µm (325 mesh), although coarser grinds will be tested.

Dewatering
The dewatering system consists of hydrocyclones for primary dewatering and centrifuges for secondary dewatering. The hydrocyclones and the absorber loop are closely integrated to fully utilize their separation capabilities.

The centrifuges are designed to dewater the gypsum byproduct down to a moisture content of 8 percent or less. Also, they are located directly above a gypsum storage bunker. Hence, the centrifuges discharge directly into the storage bunker, eliminating the need for a costly solids handling system.

Wallboard-grade gypsum is loaded directly from the gypsum bunker into trucks for transportation to the wallboard manufacturer.

Experience at Niles

The LS-2 system was installed at the Niles station 9 in September 1995. Although the system is designed to process all the flue gas from one boiler, it is cross-connected to unit 1 and unit 2 boilers in order to maximize the flue gas availability and maintain a high FGD system capacity factor.

Each boiler is rated at 108 MWe net, the absorber system being rated at 130 MWe.

Treated flue gas is discharged into the existing unit 1 stack, which is carbon steel lined. In order to protect this lining, an ABB Air Preheater Ljungstrom type gas-to-gas heat-exchanger (GGH) was installed. The GGH features ABB's patented horizontal shaft orientation, which greatly reduces the amount and cost of expensive ducting. All ducting and plate surfaces on the cool side are lined with flake glass, while surfaces on the hot side are unlined carbon steel.

Table 4:
Typical LS-2 performance results

Parameter	*Goal*	*Test results*
Gypsum purity	>95 %	97–98 %
Gypsum moisture	<8 %	6–8 %
Gypsum chloride	<100 ppm	30–50 ppm
Sulfite oxidation	>99.5 %	99.9 %
Gypsum MMD	>30 µm	>50 µm
SO_2 removal	>90 %	>97.5 %
Limestone grind	99 %<44 µm	85.99 %< 44 µm
Gas velocity	>4.5 m/s	5.5 m/s
Reheat	>93 °C	>99 °C

Performance

All of the subsystems are operational and have met their design requirements. As of January 1, 1998, the system had been on-line for approximately 18,000 hours and produced 80,000 tonnes of gypsum to the given specifications. The gypsum purity has consistently exceeded requirements in terms of purity, moisture, and chloride content. The crystal size has lent itself to easy dewatering, and residual moisture levels down to 6 percent are easily achievable.

The LS-2 system was started up at a velocity of 3 m/s for initial checking and tuning. The velocity was quickly increased to 4.5 m/s and later to 5.5 m/s. The higher velocity provides a much improved gas/liquid contact, resulting in a reduced liquid-to-gas ratio. Thanks to the wall rings, there is superior gas/liquid contact close to the walls. The high velocity mist eliminator is working well.

The GGH has operated above expected heat transfer rates and the

Table 5:
Comparison of dry, seawater-based, and limestone-based wet FGD technologies

	Dry FGD	*Seawater WFGD*	*Limestone WFGD*
Name	NID	Flakt-Hydro	LS-2
Related experience	15,000 MWe	4,000 MWe	30,000 MWe
Type	Moist dust injection • Low moisture level • No spray dryer required • Fabric filter version • ESP version	Packed bed tower • Compact absorber • No chemicals • No byproduct	Open spray tower • Compact absorber • High velocity • Advanced spray header design • Fine grind
Reagent	Lime	Seawater	Limestone
Byproduct	Fly ash/calcium sulfite/lime	None	Gypsum
Sulfur	<2.5 % [1)]	<1.5 % on coal [2)] <2.7 % on oil	<5.5 %
Removal	>90 %	>95 %	>95 %
Power consumption	<1.0 %	<1.0 %	<1.5 %

1) Research to extend the sulfur level is ongoing.
2) The sulfur level can be extended by means of the lime boost process.

pressure drop has been controlled by regular soot blowing since start-up of the system.

The system routinely operates at an SO_2 removal level of 97.5 percent with two spray banks in operation and 3 percent sulfur coal as fuel.

The roller mill has been operated successfully with a wide variety of limestone grind sizes, ranging from 85 percent to 99+ percent less than 325 mesh (44 µm). The grind size is easily set by adjusting the speed of the dynamic classifier.

Based on data collected in the test programme to date, the LS-2 project has met or exceeded its design targets. *Table 4* summarizes recent test results.

Summary

The FGD system which is best for a particular installation will depend on many site-specific factors, some technically driven, others influenced by economic factors. Technical considerations include:

- Size of the plant
- Location (inland or coastal)
- Fuel sulfur level
- Emission level
- Disposal or salable byproduct
- New installation or retrofit (available space)

The financial considerations include:

- Investment cost
- Operating cost (electricity, reagent, disposal, maintenance)

The *NID system* offers a very low investment cost plus a respectable performance in terms of SO_2 removal on low to medium sulfur coals. This system is also ideal for retrofits, eg when space is limited, and for electrostatic precipitator upgrades or ESP to fabric filter conversions.

The *Flakt-Hydro process* has received international recognition through long-term environmental studies that have unanimously concluded that the environmental impact of the process is negligible. This system is ideal for power or industrial plants located close to the sea. Since no reagent is used, operating costs are minimized.

The *LS-2 system* represents a significant improvement on the well-established wet FGD limestone/gypsum process. It combines a very compact design with improved power consumption and SO_2 removal, in addition to producing a byproduct with commercial possibilities. LS-2 incorporates a novel spray header system with advanced flue-gas sneakage control.

A summary of the flue-gas desulfurization systems offered by ABB is given in *Table 5*. The comparison is generic; site-specific factors always have to be considered when selecting the optimum FGD process.

References

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