The challenges of the blast furnace

Carbon monoxide is one of the most dangerous substances in the steel industry. Is there a way to reliably monitor this toxic gas? Security management and the plant's fire brigade at ArcelorMittal in Eisenhüttenstadt, in the German state of Brandenburg, joined forces with Dräger to develop a holistic gas detection system, tailor-made to the requirements on site.

A lethal toxin in a harsh environment

Extreme temperatures, noise and heavy machinery: steel is produced and processed under some of the toughest conditions imaginable. Yet, the greatest danger creeps up silently and is often hardly noticeable: carbon monoxide, or CO, for short. This poisonous and highly flammable gas occurs whenever materials containing carbon are combusted without sufficient oxygen supply – a common chemical reaction in many processes in the steel industry, from pig-iron production to surface refinement.

Blast-furnace gas, for example, which occurs as a by-product inside the blast furnace and is used as a fuel gas for heating up the blast-heating systems to generate hot air, contains twenty to twenty-five percent carbon monoxide. Converter gas, which is produced whenever carbon is extracted from pig iron in the converter plant by oxidation, is around sixty-five percent carbon monoxide.

Blast furnaces and converters are open areas of the plant. Gases can escape here just as easily as with leaks or defects in closed areas like gas tanks or pipes. Constant monitoring of ambient air is absolutely essential, using stationary gas detection systems in all gas-hazardous areas of the plant as well as individual, portable gas detection systems incorporated into personal protective equipment.

The designs for monitoring systems and the requirements for gas-measurement technologies are defined by extensive regulations in most countries, such as Germany's Social Accident Insurance (DGUV) regulations 109-601 (production of raw iron and steel) and 113-004 (tanks, silos and confined spaces).

WHAT MAKES CARBON MONOXIDE SO DANGEROUS?

CARBON MONOXIDE

Chemical formula	CO
Description	colourless, odourless gas
Identification number	CAS 630-08-0
Required labelling	highly flammable, toxic
Density	1.25 kg/m^3 – slightly less dense than air
Explosive limits in % by vol.	LEL 10.9/UEL 74.0
Ignition temperature	605 °C
Toxicity data	LC at 5 min. inhalation 16,000 ppm
Occupational exposure limit (OEL)	30 ppm (8 hrs. mean value)
Short-time value	60 ppm (15 min. mean value)

Acute danger, long-term consequences.

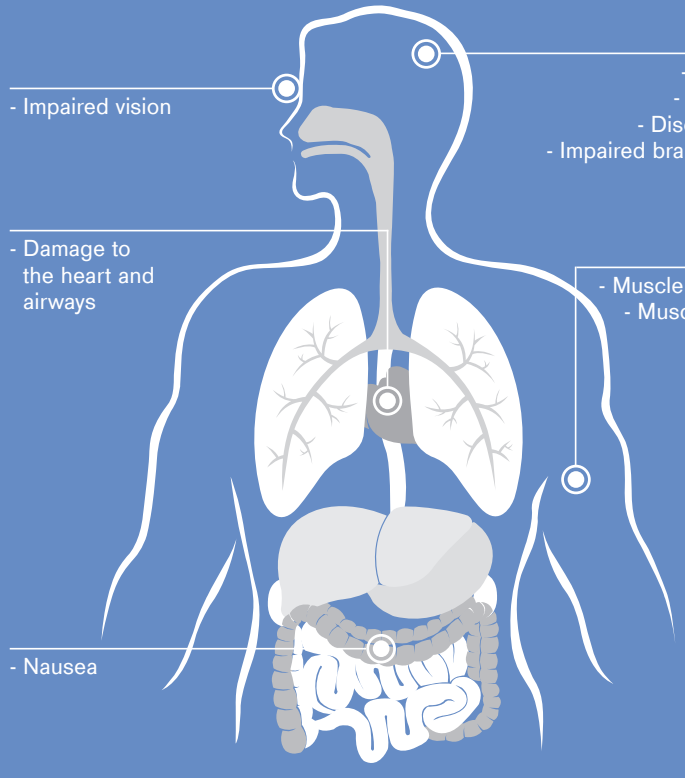
Carbon monoxide is absorbed via the airways, quickly entering into the bloodstream. Once in the blood, CO molecules attach to red blood cells, suppressing the body's oxygen intake. The severity of the damage depends on the CO concentration and the length of exposure. If CO escapes undetected and a worker is exposed to a concentration of 660 ppm, after just two and a half hours, fifty percent of his or her red blood cells, responsible for the transport of oxygen necessary for life, will be blocked.[1] This shortage of oxygen causes damage to the brain and heart, and can result in disorientation, heart failure or stroke. Even if the victim survives the acute stage of intoxication, in ten to forty percent of cases, he or she will subsequently develop damage to the heart and nervous system within three weeks.[2]

Because it is a colourless, flavourless and odourless gas, carbon monoxide occurs with no direct warning. Contrary to a common misconception, it causes no shortness of breath. The first signs of mild intoxication are dizziness and headache. Victims often mistake these for common cold or flu symptoms. In some cases, CO intoxication may initially cause no symptoms, and goes unnoticed until the victim loses consciousness. The only way to reliably determine whether dangerous CO concentrations are present in the air is to use special gas detection technologies.

1 Jessel, Wolfgang: Gase - Dämpfe - Gasmesstechnik: ein Kompendium für die Praxis [Gases - Vapours - Gas Detection Techniques: A Practical Compendium], Lübeck: Dräger Safety AG & Company KGaA, 2001
2 Source: See above

CO BLOCKS THE TRANSPORT OF OXYGEN THROUGH THE BLOOD

What are the effects of carbon monoxide on the human body?



30 ppm

Occupational exposure limit (OEL) for continual exposure to CO over an **eight-hour period**

400 ppm

Headache occurring within **one to two hours; life-threatening** after **three hours**

12,800 ppm

Death within **one to three minutes**

What does gas detection technology do?

There are various technologies for detecting carbon monoxide, such as CO sampling tubes or electrochemical sensors. Steelmaking plants must constantly monitor for adherence to the OEL, and require precise, stable measurements over a long period of time. Sensor technology is better suited for this than sampling tubes, not to mention more cost-effective for long-term use. All decisions related to detection technologies are based on the hazard analysis.

Three common means of carbon-monoxide detection are

- personal gas detection devices to protect the workforce, including the normal employees as well as the plant's fire brigade;
- monitoring the atmosphere in gas-hazardous areas of the plant;
- clearance measurement before entering confined spaces and tanks on the premises for repairs or maintenance.

Meanwhile, CO is not the only hazardous substance that occurs during steel production. Many areas must be monitored for other substances. Generally, these include carbon dioxide (CO_2) and hydrogen sulfide (H_2S), not to mention the concentration of oxygen and various explosive gases in the air. As a result, depending on the location, multi-gas detection systems are also necessary.

High standards at Eisenhüttenstadt

"Journey to Zero" is the motto chosen by the safety management team at ArcelorMittal, the world's largest steel company, which operates its second-largest plant in Eisenhüttenstadt, in the German state of Brandenburg. This integrated plant, containing a blast furnace, steelworks as well as hot and cold rolling mills, produces nearly two million tons of pig iron each year, which it refines into various products. The plant employs 2,500 workers of its own, plus nearly the same number of external employees from various contractors.

"Zero Accidents": when it comes to carbon monoxide in the steel industry, this is an ambitious goal. No one in Eisenhüttenstadt knows this better than engineer Uwe Starun, who started working for the plant's occupational health and safety (OHS) team in 1984. Since 1991, Starun has been in charge of technique in the plant's fire brigade, where he has built up and expanded ArcelorMittal's gas detection system.

INTERNATIONAL OELS FOR CARBON MONOXIDE

	OEL	OSHA (PEL)	NIOSH (REL)	ACGIH® (TLV®)
STEL	30 ppm	50 ppm	35 ppm	25 ppm
STEL/CEIL(C) (15 min.)	60 ppm	200 ppm	200 ppm	400 ppm

ACGIH® and TLV® are registered trademarks of the American Conference of Governmental Industrial Hygienists. STEL/CEIL(C) = Short-term exposure limit / TLV-C (=ceiling).

In charge of the plant's fire-safety technologies for over thirty years: Uwe Starun.

Reliable monitoring at all critical points of the blast furnace

The mighty centre of the plant is blast furnace 5A. In operation since 1997, it produces around 5,000 tonnes of pig iron during an average of three taps each day. In the process, it produces 300,000 cubic metres of CO-containing blast-furnace gas every hour, which is discharged, purified and temporarily stored in a large gas holder.

This makes the blast furnace the focal point for carbon-monoxide monitoring at the plant as well. In addition to the tap hole, potential gas release points in the blast furnace include the furnace shaft, where cold-water pipes penetrate the steel jacket. Gases can also escape at the blower and surplus gas burner, or through unsealed valves, on the hot-blast stoves. Another critical point is the hot-air distribution pipe in unsealed coolers and injectors. Leaks may also occur in the blast furnace hearth.

Extraordinarily high CO emissions as a warning shot

Starun has experienced the dangers of carbon monoxide firsthand. In the late 1980s, in what was at that time East Germany, high levels of CO were emitted from what was then blast furnace 1, caused by long cracks in the outer shell. Yet the blast furnace had been due to keep producing pig iron for several more months before the next major repair was due. "It was a dramatic event, but it also had a positive effect", recalls Starun. Prior to that, ambient air had only been monitored for gas leaks periodically, using sampling tubes. "The extraordinary situation made one thing clear to us", says Starun, "we can only operate safely if we can guarantee constant personal air monitoring for the plant personnel." He recalls, "At a conference in Leipzig, Germany, we visited the Dräger stand and found out that they had already developed small, portable gas detection devices that were suitable for personal air monitoring. Our company bought five of them. These enabled us to guarantee gas safety so we could carry on operating the blast furnace for months."

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After that, ArcelorMittal began expanding its gas detection systems at the plant in Eisenhüttenstadt. Within a short time, the first stationary CO detection systems were installed at the exposed areas of the blast furnace and converter steelworks. Simultaneously, the company invested in additional portable gas detection devices for employees to use in personal air monitoring. Dräger was there from the very beginning.

Reliable CO monitoring - operate safely

Since then, the system has been expanded continuously. "ArcelorMittal is extremely safety-oriented", explains Starun. "Activities in gas-hazardous areas, for example, are regulated by a special directive that applies to all facilities within the corporation. In many ways, our directive goes beyond the legally required standards. For example, our warning-function limit for oxygen content in the air is between 19.5 and 22.5 percent by volume, which is stricter than the legal standard."

ArcelorMittal also places high demands on its gas detection technology. "As far as we're concerned", says Starun, "Dräger supplies the best solutions for our CO-related issues".

Sturdy devices

The tough conditions in the steelworks call for durable equipment. Personal warning devices are subject to mechanical wear and tear, while outdoor stationary equipment is exposed to the elements.

The sensors must withstand a wide range of temperatures, functioning just as precisely and reliably at -25 °C as at +50 °C.

H_2-compensating sensors

Most electrochemical CO sensors are cross-sensitive to hydrogen (H_2) and give off false alarms even at low concentrations. The CO sensor from Dräger almost fully compensates for the influences of H_2, producing by far the best results when tested in comparison with other brands.

Longlasting sensors

DrägerSensors® are extremely durable. This reduces maintenance effort and operating costs.

Clearly recognisable alarms

If dangerous concentrations of carbon monoxide occur, everyone working in the area must be warned immediately. Dräger devices put out clear visual and acoustic signals and vibration alarms.

A proud fleet: More than 2,200 portable gas detection systems protect the health and lives of employees.

Simple to operate

Operation should be as self-explanatory as possible. "Not too many buttons, or overly complicated devices", as Starun says. "Otherwise, the chances of making a mistake are simply too high. Personal gas detection devices are also issued to our external contractors working in the plant who may not be used to operating them. So, if a stress situation occurs, the devices have to be easy to read and use."

Supported by documentation

The devices should be able to save and transmit measurement data. The Dräger Pac® 7000 features a data-logger, which makes it easy to meet growing industry-wide documentation requirements. It also simplifies comprehensive analyses of measurement results, turning safety management into a learning system.

The right product for any job

Today, ArcelorMittal's Eisenhüttenstadt plant features a state-of-the-art gas detection system, which provides maximum safety, while remaining highly cost-effective and manageable. A total of 57 stationary Dräger Polytron® gas detection systems keep watch over all exposed areas of the plant. Ninety-five percent of the more than 250 detector heads are fitted with CO sensors.

For personal air monitoring, 2,200 portable single-gas detection devices Dräger Pac® 7000 and 300 Dräger X-am® (types 2000 to 5600) multi-gas detection devices are on hand for plant personnel. In the various control centres, 70 bump-test stations are installed locally, ensuring that each worker can perform his or her work with equipment tested according to the respective regulations.

Whenever repairs or other maintenance activities need to be carried out on CO-producing parts of the plant, eight Dräger X-zone® mobile spot monitors are available to cascade hazardous locations.

Whenever a clearance measurement of confined spaces and tanks, including pipelines or pits, has to be done, the necessary measuring technology is available in a specially-equipped Dräger CSE kit.

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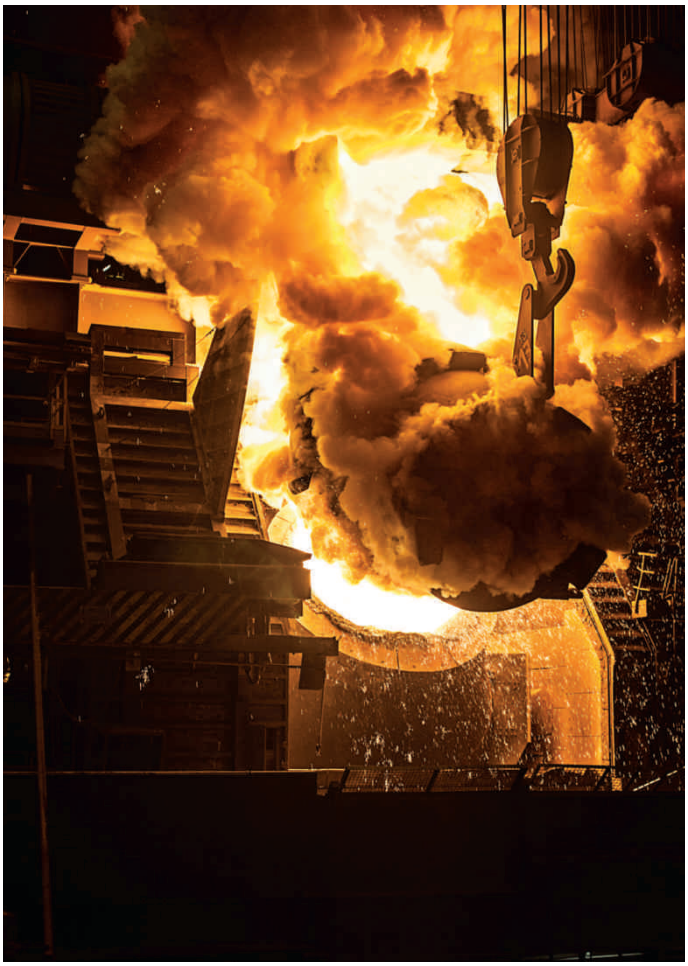
Safety as a holistic system

One factor for safety is the quality of the hardware; the other is the software and service. The combination of these different solutions creates true added value.

ArcelorMittal's Eisenhüttenstadt plant features a fully-equipped gas detection workshop, built in partnership with Dräger. Here, all the necessary calibrations and tests are carried out. The device-service technicians have been trained at the Dräger Academy in accordance with German Social Accident Insurance (DGUV) standards 213-056 (T021) and 213-057 (T023).



Every twenty minutes, things heat up in the converter. Ten gas detection systems with a total of 33 transmitters immediately alert plant personnel to any change in gas concentration.

A comprehensive maintenance agreement with Dräger Product Service ensures that there are always enough usable devices on site, and simplifies device maintenance with a straightforward, smooth process.

The workshop team also uses the Drägerware software to manage its extensive fleet of devices. This provides, for example, an up-to-date report on which devices are in need of inspection and can also display each device's complete maintenance history on request.

In case of exceptional situations (maintenance shutdown, for example) in which additional devices are necessary, Dräger Rental Service can quickly provide enough equipment, not to mention the necessary safety buffer.

This not only brings peace of mind, it also saves costs. Every breakdown or false alarm that's prevented equals time and money saved. Dräger sees safety not only holistically, but also in financial terms.

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