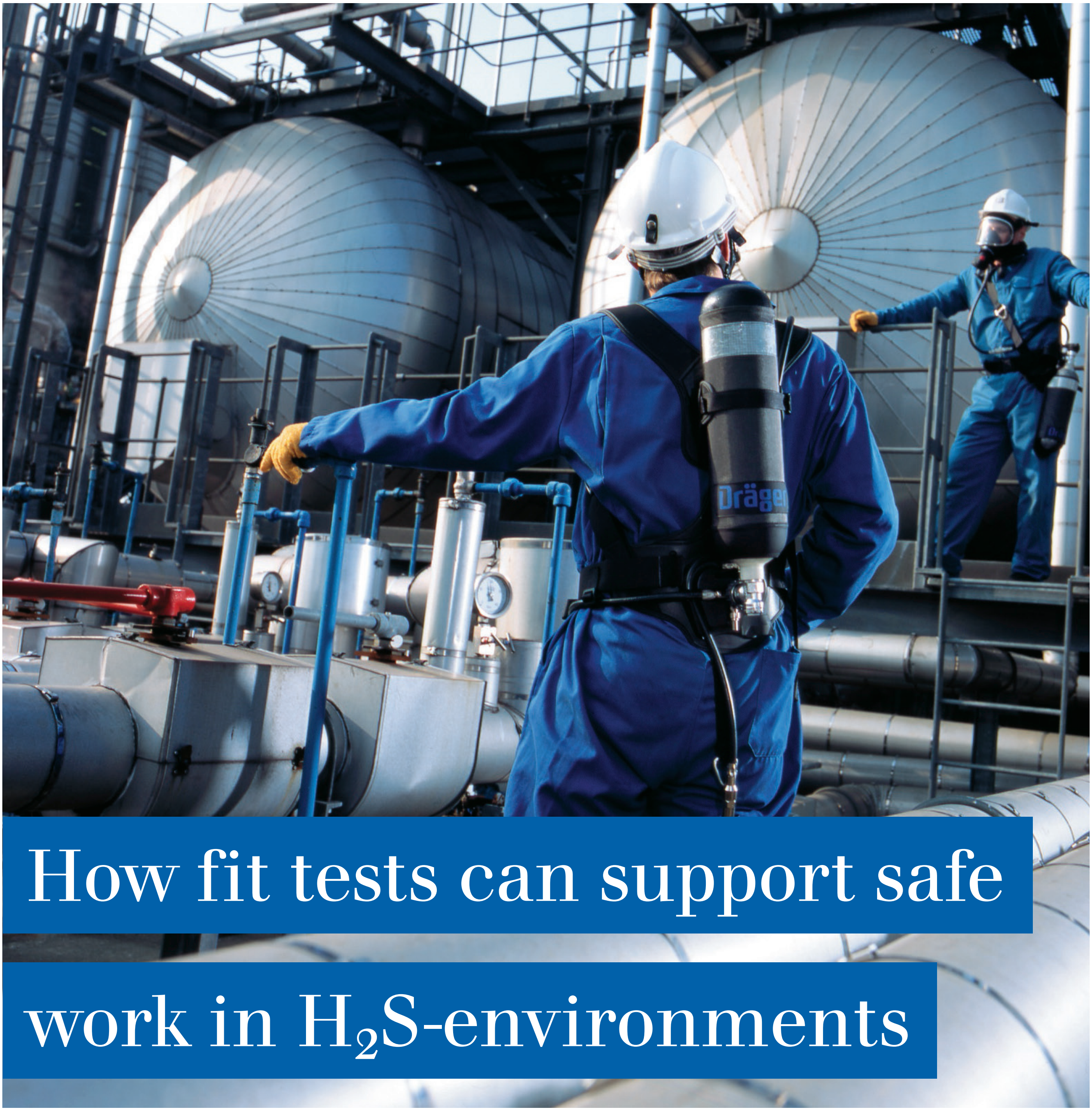


How fit tests can support safe work in H_2S-environments

Hydrogen sulphide is one of the most toxic and treacherous gases in the oil and gas industry. If a gas leak takes place, it can quickly come to a life-threatening concentration. Personal escape devices with high level of protection, optimally suited to the individual wearer, can protect workers from coming to harm in emergency situations.

H_2S – the deadly threat in the oil and gas industry

Hydrogen sulphide (H_2S) is a vicious gas: at a concentration of up to 200 ppm it causes physical discomfort and dizziness and the sense of smell is numbed. Concentrations above 500 ppm lead to unconsciousness and, within 30 to 60 minutes, to death. Concentrations above 1,000 ppm cause death within minutes. In the international oil and gas industry, the possibility of hydrogen sulphide leaks during crude oil drilling and gas extraction is an ever-present threat to workers. Any work areas, rest areas and living quarters in critical zones on the plant must constantly be monitored in terms of H_2S concentrations. On so-called sour gas fields – that's to say in drilling fields with extremely-high occurrences of natural H_2S – it may also be that work in "red zones" is only possible with the use of permanent, self-contained breathing apparatus.

The particular importance of proper-fit seals in H_2S environments

This requires a breathing-protection solution with a demonstrably secure seal and a minimal leakage value. Such devices are verified with the help of special tests both on real test subjects and in the laboratory. The test results in turn build the basis for certification of the devices in respective markets, as well as for the derivation of the protection factor – from which it is possible to determine if a particular device is suitable for a specific application.

Requirements for fit tests

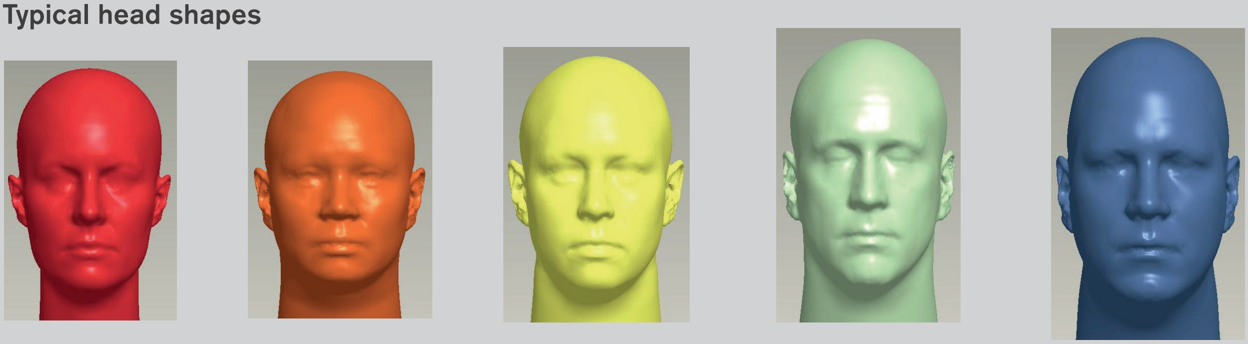
Head shape

There are many requirements that need to be met before it even gets to the point of making a reliable fit test. For one thing, in choosing the optimal mask type, it must be considered that each person has a different head shape.

Many industrial nations are by now aware of the importance of user-centred design approaches when it comes to the concept and range of respiratory protection devices – which should protect the user to the highest extent possible while also maintaining a high degree of wearing comfort. For this reason, different nations have reached an agreement to draw up an internationally-applicable ISO-RPD-Standard[1]. This is (as of August 2018) still in the making. In this context, even the sensors would be standardised. This is designed to verify leakage values and standards after breathing apparatus has been serviced.

Breathing masks can't be individually customised for efficiency reasons; because of this, a compiled raster based on 3,000 head-shape scans will come into use in future. Five pre-defined head shapes – small (S), short-wide (SW), medium (M), long-narrow (LN) and large (L) – will represent between 5 and 95% of all existing head shapes.

Typical head shapes



Small (S) Short-wide (SW) Medium (M) Long-narrow (LN) Large (L)

Beards, spectacles and jewellery

Another important requirement for a secure fit along the seal line is whether the wearer of the full-face mask has a closely-shaved head. Even a little bit of beard hair on the seal line could cause the mask to let in outside air. The same goes for unsuitable spectacles or jewellery along the seal line.

How is testing performed?

Testing procedures vary greatly in different industrial nations. In the USA the occupational safety organisations OSHA[2] und NIOSH[3] prescribe breathing-mask fit tests on each actual wearer before they begin work.[4] This test takes approximately 20 minutes and must be repeated every year. The test results are valid only for the particular breathing mask model or filtering device that will then also be worn for the work. A distinction is made between **qualitative fit tests** – in which a test gas is used to evaluate the permeability of the mask based on the wearer's own sense of smell or taste – and **quantitative fit tests**. In quantitative tests, measurement technologies are used to evaluate the permeability of the mask while it is being worn. If results are not satisfactory, the test must be redone with other mask models and sizes. Usually, such tests are administered under some kind of external load, like walking or head movements.

TIL tests and protection factors

With the **Total Inward Leakage tests (TIL tests)** that are widely carried out in Europe, a number of trained test subjects wearing test masks or filters are exposed to a test gas in a closed chamber. The ratio between the test-gas concentration in the chamber and that inside the mask yields the leakage value as a percentage. The final leakage value given to the mask is based on the average of all tests undertaken.

In this way, the mask's so-called protection factor is calculated for the specific test gas. This protection factor is then assigned for the hazardous substance that has the same physico-chemical structure as the test gas. These protection factors serve as important selection criteria when choosing the optimal mask type or filter device for work in an area that is contaminated with a particular hazardous gaseous substance.

$$\frac{\text{Concentration of the test substance externally}}{\text{Concentration of the test substance internally}} = \text{Total inward leakage}$$

$$\frac{1}{\text{Total inward leakage}} = \text{Protection factor}$$

If the total inward leakage value in the test environment is remarkably high, the following causes might apply:

- The filter being tested is not removing all particles. This is not unusual – available breathing protection filters, depending on grade, can only filter out between 80 and 99.97 percent of particles
- The size of the mask is not ideal for the wearer
- Leaks on the seal edges (due to the shape of the face or facial hair)
- Leaks of the vents, seals or lenses
- Improper placement or sub-optimal servicing of breathing apparatus
- User-specific breathing patterns

At an international level, several parallel protection-factor designations are currently being used. They are based on varying test methods.

Nominal Protection Factor (NPF)
Guideline for the protection factor of a breathing protection device, determined by standard tests. Recommendation: only for use when no specific value exists.

Assigned Protection Factor (APF)
Correlates with OSHA und EN guidelines. Nationally-valid, specific value for the protection factor of a breathing protection device. If no APF exists, the NPF should be used.

Workplace Protection Factor (WPF)
A protection factor that is based on an internal company test conducted onsite under concrete workplace conditions and with genuine hazardous material exposure.

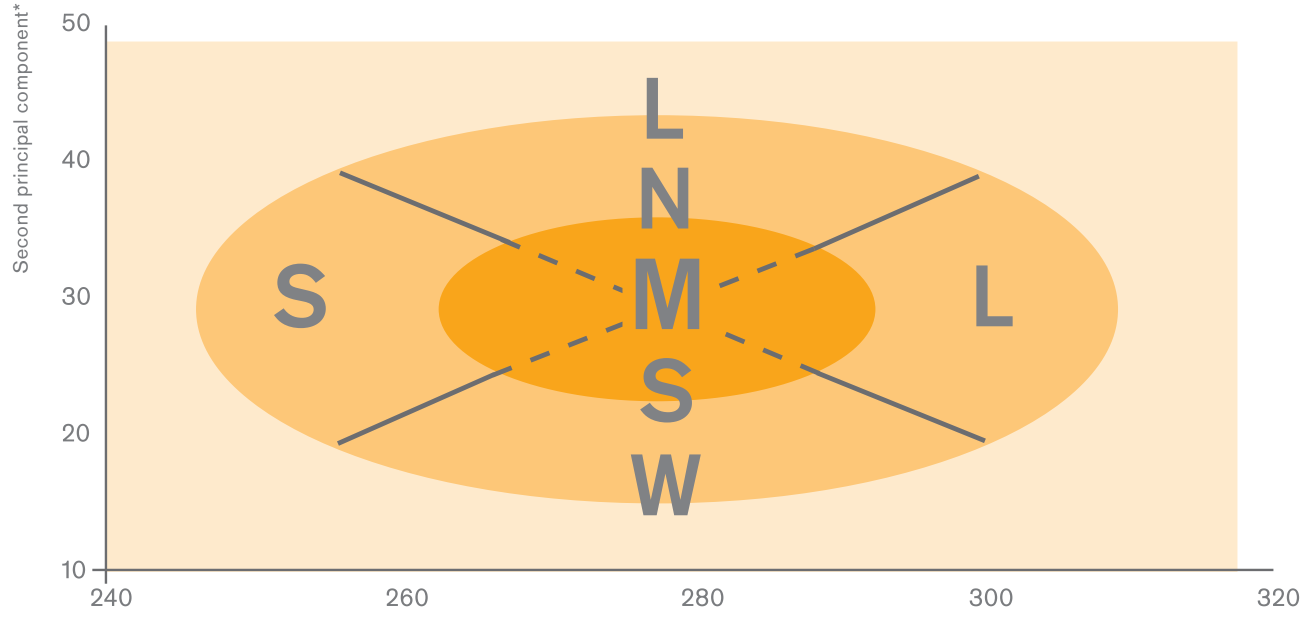
Simulated Workplace Protection Factor (SWPF)
A protection factor that is the outcome of a laboratory test using test gas in a realistic workplace setting; the actual hazardous substance and the maximum-expected exposure concentration of the work place should be very close to that in the test-environment settings.

Dräger: Specific testing methods for the determination of protection factors in H_2S environments

Dräger believes that for such leakage tests to be reliable, the test gas and environment should very closely approximate the real hazardous substance and work environment – and that's why Dräger favours the SWPF test for determining protection factors for our H_2S breathing protection devices. For this purpose, the harmless SF6 test gas is used which has a very similar physico-chemical structure to H_2S. Protection factors that are determined in this way give HSE managers a solid basis for the selection of breathing protection equipment to be used in work environments with highly-concentrated, deadly H_2S.

These specific tests with SF6 also take varying head shapes into account, pursuant to the ISO test panel and the number of tests to be carried out. Such tests, made with Dräger Panorama Nova®PP breathing protection full masks yielded a very high protection factor (SWPF) of 90,000 for 95 percent of all users (head shape: medium).

TIL-TEST RESULTS: SWPF FOR WORK AND ESCAPE APPLICATIONS



*Components are calculated parameters of single measured values of the head size and shape.

KEY: S = small (S); M = medium; L = large; SW = short-wide; LN = long-narrow

An SWPF of **90,000** applies to 95% of all users of the escape device Dräger Panorama Nova PP in a gas hazard zone.

An SWPF of **20,000** applies to all other users with special head shapes.

Which sort of breathing protection devices is suitable for which breathing exposures?

A starting point is always an application-based requirements analysis: from the relevant danger assessments and risk evaluations, it can be determined which concrete dangers can be expected. What hazardous material concentration (type and level) is to be considered in a worst-case scenario? What is the maximum national or company-defined occupational exposure limit? Which protection factor levels are legislated by law for these types of activities?

Following from this, a comparison of the requirements analysis and the product specifications of specific breathing products should take place. The EN standards, such as the EN 529 and other standards are a benchmark for this, according to which each device is certified. An EN standard delineation refers to the nominal protection factor of the device or the device type.

On the basis of this information, an evaluation of the device's suitability for a specific application can be made:

The maximum expected concentration level, divided by the currently-valid concrete occupational exposure limit (OEL) for a hazardous substance yields the protection factor requirement (minimum level):

$$\frac{\text{XX ppm (max. concentration)}}{\text{X ppm (OEL)}} = \text{protection factor}$$

Conversely, that means:

The currently-valid concrete occupational exposure limit for a hazardous substance multiplied by the specific device-type protection factor yields the maximum concentration level at which any specific breathing protection can be used in a contaminated atmosphere with a maximum concentration of Y ppm.

$$\text{X ppm (OEL)} \times \text{protection factor} = \text{Y ppm (max. concentration)}$$

From Dräger's point of view, it is advisable – in particular for the use of breathing protection apparatus in high-risk H_2S zones – to gather further detailed information on device performance. To this end, additional tests made under particularly realistic conditions and certificates can help to ensure suitability and inform selection decisions.

[1] *ISO-RPD – International Organization for Standardization-Respiratory Protective Devices*

[2] *OSHA – Occupational Safety and Health Administration*

[3] *NIOSH – The National Institute for Occupational Safety and Health*

[4] *https://www.osha.gov/video/respiratory_protection/fittesting_transcript.html; retrieval: 21/08/2018*

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