



(RESEARCH ARTICLE)



GAS DETECTION AND RESPIRATORY PROTECTION AT HIGH-HAZARD OIL AND GAS SITES: PLANNING BOTH FROM ONE RISK ASSESSMENT

Altair Jilgildiyev *

MSA Safety Company Atyrau, Kazakhstan

* Corresponding Author

World Journal of Advanced Research and Reviews, 2026, 31(03), 1963–1968

Publication history: Received on 21 August 2026; revised on 27 September 2026; accepted on 29 September 2026

Article DOI: <https://doi.org/10.30574/wjarr.2026.31.3.2487>

Copyright © 2026 Author(s) retain the copyright of this article. This article is published under the terms of the Creative Commons Attribution License 4.0

ABSTRACT

At most oil and gas sites, two decisions are made by different people. Engineers choose the gas detectors. Purchasing staff buy the respirators. The two choices are rarely compared with each other, and both are weaker as a result. This paper sets out a way to plan them together, from a single assessment of risk. The approach was built by reviewing published work in four areas: lung disease caused by breathing harmful substances at work, the materials used in gas sensors, how well respirators perform in real use, and the effect of a company's safety culture. It has four steps. Step one lists the harmful gases at each unit and the jobs that bring workers near them. It keeps everyday low concentrations separate from sudden releases. Step two sorts those situations into three risk levels. The levels are described in words, not in invented numbers. Step three sets the detection each level needs: the type of sensor, where it goes, and what each alarm means. Step four sets the respiratory protection the same level needs: the class of mask, the checks on how it fits, and the escape equipment that must be within reach. The paper then explains three things. Sensors behave differently in hot and humid air. Laboratory filter ratings promise more protection than a worker actually gets. And neither measure works if the organisation does not support it.

Keywords: Gas Detection; Respiratory Protection; Occupational Risk Assessment; Oil And Gas Facilities; Gas Sensors; Safety Culture

1 INTRODUCTION

Workers at oil and gas sites can breathe several harmful substances in one working area. Hydrogen sulphide escapes from sour crude oil and sour gas. Hydrocarbon vapours come off tanks during gauging and sampling. Treatment units release amine and glycol mists. Refrigeration circuits can leak ammonia. Welding makes fume, and drilling fluids make fine droplets. Inside tanks, sumps and pits there may be too little oxygen to breathe. All of this sits next to the risk of fire and of pressurised equipment.

These exposures are not steady. They come in short bursts, tied to particular jobs: opening a pipeline, changing a filter, cleaning a line with a pig, entering a confined space, working through a shutdown. That changes how the risk must be measured. Suppose a site judges its air only by long-term averages. The averages will look acceptable. Meanwhile, individual workers still take in high doses during those short jobs. The average hides the peak.

The medical evidence says both the peaks and the everyday background matter. The American Thoracic Society and the European Respiratory Society issued a joint statement on this. Harmful substances in workplace air are still common worldwide. They add a great deal to the amount of lung disease in the population. That includes asthma, chronic obstructive lung disease, scarring of lung tissue, allergic inflammation of the lung, and some lung infections. The statement also said that these cases can be prevented [1].

Irritant gases matter most for workers who already have a lung condition. Once a person has become sensitive to a substance, a very small amount can set off a reaction. Irritants also make the airways more likely to tighten [2]. Two conclusions follow. Control has to cover the slow everyday exposure as well as the sudden release. And the health of the workforce is part of the risk, not a paperwork detail.

Detection equipment has improved a great deal. Sensors can now be built from metal oxides, conducting polymers, carbon nanotubes and other very thin materials. Between them, these materials respond to a wide range of gases. Each one has its own balance of properties: how small a concentration it can find, how well it tells one gas from another, how steady it stays over time, and how hot it must be kept [3]. Titanium dioxide shows how much the structure of the material matters, because changing how it is made changes how it responds. Sensors of this kind have been demonstrated for hydrogen, acetone, ammonia and ethanol [4]. Ammonia detection alone has produced a large body of research [5]. So an engineer now has more options than before. What the research does not say is which device belongs at which point on the site. Nor does it say what should happen when that device sounds an alarm.

Respiratory protection has the opposite difficulty. The equipment is well established, but its effect in real use is harder to pin down. Reviews of filtering masks found a gap that will not close: a filter performs better in a laboratory than on a working face [6]. A review of protective equipment used against highly infectious material found two things. The type of equipment affects how much contamination occurs. So does the way it is put on and taken off. The authors also judged the evidence behind these findings to be weak [7]. The behaviour of the organisation matters too. Offshore installations in the North Sea were compared over time. Measures of safety culture predicted the accidents that workers reported, and installations were able to improve measurably [8].

This paper therefore sets out a way to plan gas detection and respiratory protection together. Both follow from the same assessment of risk. The paper has three aims. The first is to show how the harmful substances, and the jobs that expose workers to them, can be listed and sorted by risk. The second is to show how the detection and the equipment for each level of risk should then be chosen. The third is to state plainly what this approach cannot yet claim, since it comes from published work and not from measurements at a working site.

2 MATERIALS AND METHODS

This is a conceptual paper. It draws published evidence together. It reports no new measurements. Eight sources were chosen to cover the four areas that any combined plan has to rest on:

- what breathing harmful substances at work does to health;
- the materials and devices used to detect gases;
- how protective equipment performs in practice;
- how the behaviour of the organisation affects safety results.

Each source was described in the same four terms: what kind of study it was, what it examined, what it measured, and which decision it could reasonably support. No figures were taken from the sources and combined into new numbers. The sources differ too much in kind for that to be sound.

2.1 Step one: list the substances and the jobs

For every process unit, the harmful substances are written down. Next to each one goes the way it can escape. Each entry then falls into one of four groups:

- a small amount released all the time during normal running;
- a burst released by a particular job;
- a large release caused by equipment failure;
- gas building up, or oxygen running low, inside an enclosed space.

The group decides how often the air has to be measured. A small continuous release can be followed by fixed detectors at well-chosen points. A burst tied to a job cannot. What the worker breathes then depends on where that worker is

standing at the moment the gas escapes. Those cases need a monitor carried by the worker, or placed at the work position.

2.2 Step two: sort the jobs into risk levels

How likely and how serious each situation is described in words. No invented numbers are used. Likelihood takes account of three things: how often the release happens, how many workers can realistically be there, and how long the job lasts. Seriousness takes account of four: how toxic the substance is, whether a worker can notice it in time, whether oxygen can fall too low, and the lung conditions known to follow from this kind of work.

Some substances give no warning at all. Others cause harm at concentrations that sound harmless. Both are moved up a level. This follows from the finding that sensitive people react to very small amounts of an irritant [2]. The result is a risk level attached to a situation, not to a substance on its own. The same gas can sit at different levels in different parts of the site.

2.3 Step three: decide what detection each level needs

Sensor choice follows the properties reported in the materials research. Table 1 sets out the three main families.

Table 1: Main sensor families and what each one is good and bad at [3, 4, 5]

Sensor material	Strengths	Weaknesses	Practical consequence
Metal oxide	Cheap and easy to make; finds small amounts; stays steady over time	Poor at telling similar gases apart; must be kept hot	Good general-purpose choice, but expect false alarms where several gases are present
Conducting polymer	Works at ordinary temperature; responds to many organic vapours	Affected by moisture in the air	Unreliable on sites where the air stays humid for months
Carbon nanotube	Chemically and mechanically robust; responds to nitric oxide and ammonia	Usually has to be chemically modified first	Specialist choice; the modification belongs in the purchase specification

Two further points follow from the research. Where the structure of the sensing material changes the response, the way that material is made belongs in the purchase documents. It should not be left to the supplier [4]. And where ammonia is the hazard, the sheer number of available approaches is a reason to write down why one was chosen [5].

Placement depends on three things: how the gas escapes, whether it is heavier or lighter than air, and how the area is ventilated. Alarms are set at three levels with three meanings: take note, take action, leave the area. Known weaknesses, such as response to the wrong gas or to humidity, are written down as faults to be managed. They are managed by a calibration schedule and, where it is justified, by fitting more than one type of sensor at the same point.

2.4 Step four: decide what respiratory protection each level needs

The class of equipment is set by the risk level. It also depends on whether the air in that situation could kill or injure a worker straight away. Escape sets and self-contained breathing apparatus are kept for situations where detection cannot give warning in time.

A good filter rating is necessary, but it is not enough on its own. Laboratory efficiency does not carry over directly into protection at work [6]. At the higher levels, three things become mandatory rather than advisable: a check that the mask seals on that particular worker's face, the worker's own seal check each time the mask goes on, and a written order for putting the equipment on and taking it off. This follows from the finding that both the equipment and the way it is handled affect how much contamination occurs [7]. Training and supervision are stated for each level. Table 2 shows how the whole mapping looks once it is written out.

Table 2: An illustrative mapping from risk level to detection and protection. The levels are examples of how the rules can be written, not a published standard.

Risk level	How the air is watched	Respiratory protection	Checks required
Low. Small continuous release, good ventilation, the gas gives warning	Fixed detectors at chosen points	None for routine work; escape hood available	Calibration to schedule; routine gas check on each instrument
Medium. Short bursts tied to a job, warning still possible	Fixed detectors, plus a portable monitor at the work position	Filtering respirator of a stated class	Fit check on the worker's face; seal check each time the mask goes on
High. No warning, or oxygen may fall, or the air could injure at once	A monitor carried by each worker, plus a monitor covering the work zone	Supplied-air or self-contained breathing apparatus; escape set within reach	All of the above, plus a written put-on and take-off order and a trained observer

2.5 How the approach was checked

The checks were internal only. The approach was worked through four typical situations: sour gas processing, a tank farm, ammonia refrigeration, and entry into a confined space. The aim was to confirm that it gives consistent answers. Every rule was then traced back either to a cited source or to a stated engineering assumption. Whether a site could realistically apply it was considered using the safety culture evidence [8]. Nothing was tested against real exposure measurements or accident records. That limitation is carried forward into the discussion.

3 RESULTS AND DISCUSSION

3.1 Where the risk actually sits

Working the four situations through the sorting step gave a consistent result. The highest risk did not attach to the most toxic substances. It attached to particular combinations of substance, job and place. These were the cases where the worker gets no warning and the air is measured too rarely to catch a short burst.

Entry into confined spaces and the opening of pipelines came out at the highest level every time. Normal running of a well-ventilated unit with permanent detectors came out low. That held even where very toxic gases were on the inventory. The practical consequence is uncomfortable for budgets. Money spent adding more fixed detectors to areas that are already well understood buys less safety than the same money spent on two other things: monitors carried during short, high-exposure jobs, and making sure the equipment is used properly during those jobs.

3.2 Choosing sensors, and the risk of buying too much

Sensor choice is the most technical part of the approach. It is also the easiest to get wrong by over-specifying. Because each material has its own weaknesses, no single sensor type suits a site with several different hazards.

Consider a site where the air stays humid for months at a time. Conducting polymer sensors are affected by moisture [3]. On that site, the effect of moisture is not a footnote from a laboratory report. It decides whether anyone will believe the alarm. Titanium dioxide sensors make a different point. Their response can be improved by how the material is made, not only by how the signal is handled afterwards [4]. That is a reason to put material requirements into the purchase documents for difficult duties such as hydrogen or ammonia. Where ammonia is the main hazard, the choice should be justified against three things: the working temperature, the concentrations expected, and which other gases could confuse the sensor [5].

3.3 Alarms that people believe

The limiting factor throughout was not how little gas a sensor can find. It was whether its alarms can be trusted. A sensor that reacts to the wrong gas, or drifts away from its calibration, raises alarms when nothing is wrong. False alarms teach people to ignore alarms. Once that happens, a working detection system has become a decorative one. So the calibration interval, the routine gas check on each instrument, and a written response for each class of alarm matter as much as the detection limit.

Three kinds of monitoring are needed, and they answer different questions. Fixed detectors watch the plant and can trigger automatic action. Portable monitors cover temporary work zones. Personal monitors, carried on the worker, measure what that worker is actually breathing. Using one kind in place of another is a common and costly mistake.

Fixed detectors cannot tell anyone what a worker breathed. A personal monitor cannot protect a plant with nobody standing next to it.

3.4 Why the mask comes last, and must then be specified strictly

The approach puts respiratory protection after engineering measures and working rules. Where it is still needed, it is then specified strictly. There are two reasons for that order, and both come from the evidence.

The first is that the filter rating overstates the protection a worker gets. Air leaks between the mask and the face. Masks are not worn for the whole exposure. People adjust them and take them off [6]. The second is that the type of equipment, and the procedure for putting it on and taking it off, both affect how much contamination occurs. The review that found this also warned that the evidence behind it is weak [7]. Weak evidence is not a reason to stop caring. It is a reason to check locally: test the seal on each worker's face, watch how equipment is removed, and review what happened after incidents.

3.5 Linking the measurements back to health

If the only aim were to prevent sudden poisoning, alarm settings based on short-term limits would be enough. The medical evidence points to a wider aim. Breathing harmful substances at work also contributes to long-term airway disease, scarring of lung tissue, allergic inflammation of the lung and other non-cancerous conditions [1].

So slow, low-level exposure has to be watched in its own right. Here that is done by following the readings from personal monitors across jobs over time, rather than by counting alarms. Individual susceptibility is handled openly. A worker who already has asthma is given the more protective option. An irritant can make an existing airway condition worse at concentrations far below those that cause symptoms in other people [2].

3.6 The organisation decides whether any of this works

Safety culture was followed across offshore installations over time. Its elements were related to the accidents that workers reported. Large improvement also proved possible within a year, with the weaker installations catching up [8]. That is an argument for reviewing the organisation on the same cycle as detector calibration and mask fit checks, so the technical and the human indicators are read side by side. A site with drifting sensors and a relaxed attitude to seal checks is protected only on paper. And it is unprotected in exactly the situations that the sorting step marked as the most dangerous.

Limitations

The limits of this work are substantial and should restrain how it is used. The approach rests on a small set of sources that differ greatly from one another. Several of its rules rest on engineering reasoning rather than on direct evidence from oil and gas sites.

Much of the protective equipment evidence comes from hospitals, where the hazard is contaminated body fluid rather than toxic gas or lack of oxygen. Those conclusions can only be carried over in general terms. The sensor research has a similar limit. It reports performance under controlled laboratory conditions. It does not establish how the same sensor behaves in the field, alongside hydrocarbon vapours, salt spray and daily temperature swings. No numerical claim is made here, and none should be read into the text. The next step is to test the approach at working sites, against measured exposures, alarm records and accident data.

4 CONCLUSION

At high-hazard oil and gas sites, gas detection and respiratory protection are best planned as two parts of one plan. Both should follow from the same assessment of risk. The approach described here lists the harmful substances and the jobs that bring workers near them. It sorts those situations into risk levels described in words. It then derives both the detection and the protective equipment from the same level.

Its main finding is that risk concentrates in short jobs where the worker gets no warning. What happens during those few minutes matters more than the total number of detectors on the site. Sensors should be chosen against the conditions they will work in and the other gases present, not against the best figure in a catalogue. The trade-offs between sensitivity, selectivity, operating temperature and humidity are what decide how a sensor behaves in practice.

Respiratory protection remains the last line of defence, and it should be specified accordingly. The class of equipment is set by the risk level. At the higher levels, fit checks, seal checks and a written put-on and take-off order are mandatory

rather than good practice. The evidence behind particular equipment and procedures is not strong, which is an argument for checking locally instead of trusting published figures.

Two further points close the argument. The health aim should cover long-term lung disease as well as sudden poisoning, and workers who are already affected should be given the more protective option. And technical measures need an organisational one: safety culture belongs on the same review schedule as calibration and fit checking. This approach comes from published work and has not yet been tested in the field. Testing it at working sites, against measured exposures, alarm records and accident data, is the next step.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Acknowledgments

The author received no financial support for the research, authorship or publication of this article. There are no contributions requiring acknowledgement beyond those meeting the criteria for authorship.

Disclosure of conflict of interest

The author declares no financial or non-financial conflict of interest in connection with the research, authorship or publication of this article. The author previously held a commercial position in the safety equipment industry. No manufacturer, supplier or product is recommended in this article. No organisation took part in its preparation or reviewed it before submission.

REFERENCES

- [1] Blanc PD, Annesi-Maesano I, Balmes JR, Cummings KJ, Fishwick D, Miedinger D, et al. The occupational burden of nonmalignant respiratory diseases. An official American Thoracic Society and European Respiratory Society statement. *Am J Respir Crit Care Med*. 2019;199(11):1312-34. doi:10.1164/rccm.201904-0717ST.
- [2] Leikauf GD. Hazardous air pollutants and asthma. *Environ Health Perspect*. 2002;110(Suppl 4):505-26. doi:10.1289/ehp.02110s4505.
- [3] Nikolic MV, Milovanovic V, Vasiljevic ZZ, Stamenkovic Z. Semiconductor gas sensors: materials, technology, design, and application. *Sensors*. 2020;20(22):6694. doi:10.3390/s20226694.
- [4] Xu T, Cui X, Lai T, Ren J, Yang Z, Xiao M, et al. Gas sensors based on TiO₂ nanostructured materials for the detection of hazardous gases: a review. *Nano Mater Sci*. 2021;3(4):390-403. doi:10.1016/j.nanoms.2021.05.011.
- [5] Kwak D, Lei Y, Maric R. Ammonia gas sensors: a comprehensive review. *Talanta*. 2019;204:713-30. doi:10.1016/j.talanta.2019.06.034.
- [6] Rengasamy A, Zhuang Z, BerryAnn R. Respiratory protection against bioaerosols: literature review and research needs. *Am J Infect Control*. 2004;32(6):345-54. doi:10.1016/j.ajic.2004.04.199.
- [7] Verbeek JH, Rajamaki B, Ijaz S, Sauni R, Toomey E, Blackwood B, et al. Personal protective equipment for preventing highly infectious diseases due to exposure to contaminated body fluids in healthcare staff. *Cochrane Database Syst Rev*. 2020;(4):CD011621. doi:10.1002/14651858.CD011621.pub4.
- [8] Mearns K, Whitaker SM, Flin R. Benchmarking safety climate in hazardous environments: a longitudinal, interorganizational approach. *Risk Anal*. 2001;21(4):771-86. doi:10.1111/0272-4332.214149.