eVitroKhem. 2023; 2:5
doi: 10.56294/evk20225

REVIEW

Occupational exposure to hydrogen sulphide in the oil industry

Exposición ocupacional al sulfuro de hidrógeno en la industria petrolera

Agostina Constansa Rodriguez[1], Hernan Carlos Hoyos[1]

[1]Universidad Siglo 21, Licenciatura en Higiene Seguridad y Medio Ambiente del Trabajo. Argentina.

Cite as: Rodriguez AC, Hoyos HC. Occupational exposure to hydrogen sulphide in the oil industry. eVitroKhem. 2023; 2:5. https://doi.org/10.56294/evk20225

Submitted: 20-07-2022 **Revised:** 10-10-2022 **Accepted:** 22-12-2022 **Published:** 05-01-2023

Editor: Prof. Dr. Javier Gonzalez-Argote

ABSTRACT

Introduction: the study analysed hydrogen sulphide (H_2S) exposure in the hydrocarbon industry of the San Jorge Gulf Basin, one of the most relevant regions for oil and gas production in Argentina. This area, located between Chubut and Santa Cruz, presented demanding working conditions and high risks, especially due to the presence of toxic gases. The research sought to assess the level of exposure to H_2S and propose actions to protect the health of operational personnel.
Development: different work activities were identified, such as welding, maintenance, civil works and field operations, where personnel were in direct contact with possible H_2S emissions. Companies such as YPF, PAE and CAPSA implemented safety measures such as the use of gas detectors, personal protective equipment (PPE) and work permits. However, a lack of documented and specific procedures was detected, which increased operational risk. Through field measurements, regulatory analysis and recognition of critical tasks, it was observed that workers operated in hostile environments and with constant exposure to gas, especially in confined spaces, hot work and supervisory tasks.
Conclusions: the research made it possible to determine the degree of occupational exposure to H_2S, highlighting the need to strengthen documentation, improve environmental controls and implement more rigorous prevention policies. It also proposed concrete actions to mitigate risks, contributing to a safer, more responsible industry aligned with current health and safety regulations.

Keywords: Hydrogen Sulphide; Occupational Safety; Hydrocarbons; Hydrocarbon; Occupational Exposure; Prevention.

RESUMEN

Introducción: el estudio analizó la exposición al sulfuro de hidrógeno (H_2S) en la industria hidrocarburífera de la Cuenca del Golfo San Jorge, una de las regiones más relevantes para la producción de petróleo y gas en Argentina. Esta zona, situada entre Chubut y Santa Cruz, presentó condiciones laborales exigentes y riesgos elevados, en especial por la presencia de gases tóxicos. La investigación buscó evaluar el nivel de exposición al H_2S y proponer acciones para proteger la salud del personal operativo.
Desarrollo: se identificaron distintas actividades laborales como soldadura, mantenimiento, obras civiles y operaciones de campo, donde el personal estuvo en contacto directo con posibles emisiones de H_2S. Empresas como YPF, PAE y CAPSA aplicaron medidas de seguridad como el uso de detectores de gases, elementos de protección personal (EPP) y permisos de trabajo. Sin embargo, se detectó la falta de procedimientos documentados y específicos, lo que incrementó el riesgo operativo. A través de mediciones de campo, análisis normativo y reconocimiento de tareas críticas, se observó que los trabajadores operaban en entornos hostiles y con exposición constante al gas, especialmente en espacios confinados, trabajos en caliente y tareas de supervisión.
Conclusiones: la investigación permitió determinar el grado de exposición laboral al H_2S, destacando la necesidad de reforzar la documentación, mejorar los controles ambientales y aplicar políticas de prevención

más rigurosas. Asimismo, propuso acciones concretas para mitigar los riesgos, contribuyendo a una industria más segura, responsable y alineada con las normativas de salud y seguridad vigentes.

Palabras clave: Sulfuro de Hidrógeno; Seguridad Laboral; Hidrocarburos; Exposición Ocupacional; Prevención.

INTRODUCTION

The hydrocarbon industry is one of the most significant economic activities in southern Argentina, and the Golfo San Jorge Basin is a pivotal historical and operational hub.[1] Strategically located between the provinces of Chubut and Santa Cruz, this region accounts for a significant portion of the national oil and gas production, encompassing both onshore and offshore areas of the continental shelf. The importance of this basin extends not only to its energy contribution but also to the complexity and risks inherent in the tasks carried out there.[2,3,4]

Oilfield work involves a series of specialized technical activities, such as drilling, production, maintenance, civil works, and engineering. This work is often carried out in hostile environments, with extreme weather conditions and constant exposure to hazardous chemicals, such as hydrogen sulfide (H_2S).[5,6] This highly toxic gas, characterized by its distinctive 'rotten egg' odor, poses one of the primary health risks to workers. Its presence is familiar in various industrial processes related to oil and gas and can have serious consequences for both people and the environment.[7]

Against this background, occupational safety and compliance with environmental and industrial hygiene regulations become fundamental pillars of safety. The use of gas detectors, personal protective equipment (PPE), standardized procedures, and risk analysis are essential practices for mitigating associated hazards. Likewise, operating companies such as YPF, Pan American Energy (PAE), and CAPSA establish specific protocols and work permit systems to guarantee the safe execution of tasks.

In this context, this paper aims to assess the degree of exposure to H_2S in different work fronts within the oil industry. Through the recognition of specific tasks, field measurements, and analysis of regulatory compliance, the aim is to identify the sources of risk and propose concrete actions to reduce the impact of this gas on occupational health. This research, in addition to highlighting the lack of formal documentation in some operating procedures, aims to contribute to a safer, more responsible, and sustainable work culture within one of the country's most critical industries.

DEVELOPMENT

The Golfo San Jorge Basin is the leading producer and the oldest hydrocarbon-producing region in the country.[8] From a geological point of view, the basin is located in the central Patagonian area, extending for two-thirds along the plateaus comprising the provinces of Chubut and Santa Cruz and developing in the remaining third under the ocean towards the Argentinean continental shelf sector.

Workers in the industry carry out various tasks in the fields, including drilling, production, maintenance, engineering, and works, which involve the extraction, separation, and refining of hydrocarbons, as well as extracting water, gas, and crude oil.[9,10,11]

They are exposed to the presence of hydrogen sulfide H2S in their routine activities, plants, batteries, and refineries, as this colorless gas, also known as sewer gas,[12,13] is the cause of odor emissions in a natural way since the industry contains processes where the decomposition of organic matter is inevitable, producing an unbearable smell around the emitting sources.[14,15,16,17]

Hydrogen sulfide (H_2S) is present in significant proportions in natural gas, biogas, and fracking gas (also known as hydraulic fracturing).[18,19,20,21,22] Its toxic nature and the generation of sulfur oxides in its combustion (SOX),[21] together with nitrogen oxides (NOX), cause sulphuric acid (H_2SO_4) and nitric acid (HNO_3) to form in combination with water, respectively,[23,24,25] and can cause acid rain or corrosion in equipment and pipelines where they are present.[26,27,28] They can also contribute to the formation of sulfur smog (haze caused by sulfur or soot contamination of the air).[29]

Working in an oil field means anything but working under laboratory conditions: workers must deal with harsh and remote areas, dusty environments, and various climatic factors.[30] Even in such situations, gas detection equipment has to be reliable at all times, not just in emergencies. Sensors with fast response times and a wide temperature range are needed.[31,32,33] For a better understanding, a comparison is made with 3 (three) companies, dividing into groups the different jobs they perform and their environment; the personnel is authorized by the oilfields (YPF - PAE Pan American Energy - CAPSA) to perform their tasks in the different areas, they have a standardized good working practices manual and work permits according to the task, region and/or sector and, if applicable, a related certificate is issued.

The jobs are divided as follows:

- Welders: carry out welding on light metallic structures, joining metallic elements of thin and

medium thickness using oxyacetylene welding installations, electric arc welding with coated electrodes, and semi-automatic welding. They also perform metal-cutting work using manual and automated oxy-cutting and plasma-arc installations.

- Grinder: performs tasks that allow for various types of work, depending on the discs used, as well as the power and motor of the electric tool itself. It is used for sanding, polishing, roughing, and cutting certain materials, whether soft or hard.
    - They use materials and products with certifications that guarantee environmental management. In the welding of materials impregnated with chemical substances, venting is carried out, and pipes of different diameters are swept to minimize the generation of toxic emissions and explosive gases.
    - Comply with current environmental regulations for the activity (atmospheric emissions, noise, and vibration levels).
    - Smoke and gases: Applying the most appropriate techniques to avoid unnecessarily polluting emissions, properly using the equipment and filters installed to capture them. Use of detector and four gases O_2, CO, H_2S, LEL, this from 6 ppm long alarm.
    - Noise: Reduce these emissions by using less noisy machinery and tools and keeping equipment switched off when not in use.

The specific personal protection element used for these tasks is a cap, which protects hair and scalp, especially when welding in different positions. Welding mask: protects the eyes, face, and neck and must be fitted with inactinic filters that are compatible with the process of current intensities applied. Face mask: protects the face from the projection of particles; personal protection elements include work clothes, safety footwear, ear protection, and gloves.

- Civil: They carry out construction tasks, including civil works, infrastructure, repairs, channeling, concreting, formwork, profiling, and manual work, among others.
    - Comply with the environmental regulations in force for the activity, Decree 911/96—health and Safety Regulations for the Construction Industry, operating procedures of companies and Operators.
    - Production corridors: Obtain the necessary information from producing wells, injectors, satellites, batteries, and collectors in the field to maintain, enhance, or detect decreases in asset production.
    - Use of mono hydrogen sulfide detector, which, from 6 ppm, triggers an alarm indicating the presence of H_2S.
    - Compliance with standard operating procedures. General maintenance tasks: general maintenance of pumping equipment, replacement of equipment elements, various maneuvers, and leaving the equipment in operation for crude oil extraction.
    - Use of mono hydrogen sulfide detector, which at six ppm or more triggers an alarm indicating the presence of H_2S.
- Middle management: field supervisors are responsible for generating work permits for tasks assigned to them, handing them over to operational personnel, and providing updates to operational personnel who do not require a work permit.

Operational staff verify:

- Environmental conditions on site are assessed through risk analysis of tasks to be performed, ensuring that work permits and risk assessments are always present.
- Work tools and equipment are checked before use, and atmospheric measurements are carried out according to the type of work.

These tasks are carried out by companies in their various activities and expose them to H_2S at the work front.

The PPE, defined as collective protection, protects a group of people or a crew simultaneously exposed to a particular risk. It is applied according to the work fronts previously analyzed. PPE is the measure used by the body, complementary to collective protection, but never a substitute for it.

The work permits to be generated from the management systems of the different sites are detailed below to enable the tasks to be carried out:

- Hot work: Task that may produce a source of ignition for flammable or combustible materials present in a Classified Area through tools or equipment that may produce sparks or generate heat.
- Cold work: Work that does not require the use of open flame, spark-producing, or heat-generating

equipment in a Classified Area.

- Excavation work: Excavation or trenching work in or outside a site, with a risk of trapping people and/or breaking risk of entrapment of persons and/or breakage of pipelines (oil pipelines, electro-ducts, etc.). Work in confined spaces: work inside storage tanks, basins, cellars, chambers, excavations or excavations, cellars, chambers, excavations or low spaces in areas with possible presence of contaminants or absence of oxygen which exceed 1,50 m in depth or which are closed enclosures. It also covers the entry of persons into other equipment, such as columns, ovens, furnaces, boilers, tanks, and drains, among others.
- Electrical work: tasks involving electrical risk.
- Work at height: tasks that involve fall risks due to lack of adequate physical protection or extraordinary tasks in equipment, buildings, or structures whose height difference between the work plane and the possible planes where the person would fall excedes 1,80 m.

Lockouts and Tagouts: All mechanical and electrical Lockouts and Tagouts.

In all hydrocarbon processing areas, verification of the absence of combustible or toxic gases or vapors in the area where the work is to be carried out is required to ensure this:

- Atmosphere test at the work site after verifying that the gas detector is certified and calibrated.
- Carry out atmospheric monitoring.

Once it is clear with the roles, taking of news, and work permits, according to the planning previously done, the personnel goes to the work front, and the talk is done writing the risk analysis in situ; this is a record where the step by step of the task to be done is indicated, the risks and dangers associated to the task or tasks and mitigation measures that are taken, being signed by all the personnel involved. When considering emergency roles, it is an obligation to be familiar with and comply with company and site policies.

- Alcohol and drug policy.
- Stop work policies.
- Environmental policy.
- Vehicle management policy.
- Work stoppage policy.

It is worth highlighting the lack of documentation on the part of the companies in field operating procedures; work permits replace these, and some records documents indicate accidents in the different processes which post-event the operators request the drafting of specific or general procedures, due to the complex and high permanent risk tasks of the operating personnel. In the absence of information on working conditions, the main objective of this research is to determine the following:

- To evaluate the degree of occupational exposure to H_2S hydrogen sulfide in the industry to ensure compliance with the permissible limits in occupational health and safety regulations.

With the specific objectives, I hope to:

- Recognize and Identify the tasks performed that are associated with exposure to H_2S hydrogen sulfide-emitting sources.
- To measure the degree of hydrogen sulfide concentration using field measurements guided by the Legal Regulations in force.
- Divide the necessary actions to reduce occupational exposure to H_2S hydrogen sulfide in the execution of tasks.

CONCLUSIONS

Exposure to hydrogen sulfide (H_2S) in the hydrocarbon industry, particularly in the San Jorge Gulf Basin, represents a crucial occupational health and safety challenge. This region, the historical and operational hub of national oil and gas production in Argentina, presents complex working conditions due to geographical, climatic, and technical factors. The tasks carried out by personnel in the oilfields - from welding and maintenance to civil works, supervision, and operation - continuously expose them to this toxic gas, the danger of which requires strict and permanent controls.

The present work highlights the real risks faced by workers during their workdays. It emphasizes the importance of utilizing gas detection tools, on-site risk analysis, and task-specific personal protection equipment. Through the detailed description of job functions and the environment in which they are carried out, it is evident that, although there are procedures and protocols established by operators such as YPF, Pan American Energy, and CAPSA, there is still a significant lack of formal documentation on key operational processes, which increases the vulnerability of personnel to critical events.

The study also emphasizes the importance of adhering to current legal regulations, including environmental and health and safety standards and maintaining an organizational culture centered on prevention. Constant monitoring of the atmosphere, the issuance of appropriate work permits, and continuous staff training are essential to reduce exposure to H_2S and avoid serious health and environmental consequences.

As a concrete contribution, this research identifies critical tasks, measures H_2S concentrations using field data, and proposes specific actions to mitigate risks, such as the use of certified equipment, implementing appropriate lockouts and labeling, and strengthening internal safety policies. Additionally, it emphasizes the importance of recording and analyzing incidents to develop formal procedures that serve as preventive guidance.

In short, the assessment of the degree of exposure to hydrogen sulfide not only aims to preserve the physical integrity of workers but also to reinforce a safer, more responsible, and sustainable energy industry aligned with the highest standards in occupational safety and environmental protection.

BIBLIOGRAPHICAL REFERENCES

1. Argentina. Ley N° 25.675. Ley General del Ambiente. 2002. Disponible en: http://www.opds.gba.gov.ar/sites/default/files/LEY%2025675.pdf

2. Argentina. Ley N° 26.773. Régimen de Ordenamiento de la Reparación de los Daños Derivados de los Accidentes de Trabajo y Enfermedades Profesionales. 2012. Disponible en: http://servicios.infoleg.gob.ar/infolegInternet/anexos/200000-204999/203798/norma.htm

3. Argentina. Decreto N° 49. Listado de Enfermedades Profesionales. 2014. Disponible en: http://servicios.infoleg.gob.ar/infolegInternet/anexos/225000-229999/225309/norma.htm

4. Argentina. Superintendencia de Riesgos del Trabajo. Resolución SRT N° 463/2002. Listado de Sustancias y Agentes Cancerígenos. Disponible en: http://upcndigital.org/~legislacion/CYMAT/Riesgos%20de%20Trabajo/2009-Resolucion%20SRT%200463_textact.pdf

5. Argentina. Superintendencia de Riesgos del Trabajo. Resolución SRT N° 299/2011. Registro y Provisión de Elementos de Protección Personal (EPP). Disponible en: http://servicios.infoleg.gob.ar/infolegInternet/anexos/180000-184999/180669/norma.htm

6. Argentina. Resolución N° 310/03. Modificación del listado mezclas y explosivos [Internet]. Disponible en: http://servicios.infoleg.gob.ar/infolegInternet/anexos/75000-79999/79053/texact.htm

7. Argentina. Resolución N° 37/2010. Exámenes médicos [Internet]. Disponible en: https://www.argentina.gob.ar/normativa/nacional/resoluci%C3%B3n-37-2010-163171

8. Argentina. Resolución N° 801/2015. Sistema Globalmente Armonizado de clasificación y etiquetado de productos químicos (SGA/GHS) [Internet]. Disponible en: http://servicios.infoleg.gob.ar/infolegInternet/verNorma.do?id=245850

9. Argentina. Resolución N° 861/2015. Mediciones de contaminantes químicos [Internet]. Disponible en: https://www.srt.gob.ar/wp-content/uploads/2014/03/images_pdf_Resolucion_861-15_Contaminantes_quimicos.pdf

10. Instituto Argentino de Normalización y Certificación. Norma IRAM 3625. Espacios confinados [Internet]. 2003. Disponible en: https://higieneyseguridadlaboralcvs.files.wordpress.com/2012/07/iram3625-espacios-confinados.pdf

11. Ministerio de Desarrollo Productivo. Hidrocarburos [Internet]. s.f. Disponible en: https://www.argentina.gob.ar/eiti/hidrocarburos

12. Agencia para el Registro de Sustancias Tóxicas y Enfermedades. [Internet]. s.f. Disponible en: https://www.atsdr.cdc.gov/es/phs/es_phs114.html

13. Gobierno de Navarra. Manuales de buenas prácticas ambientales: Soldadura [Internet]. s.f. Disponible en: https://www.uis.edu.co/webUIS/es/gestionAmbiental/documentos/manuales/Buenas%20Practicas%20Ambientales%20-%20Soldadura.pdf

14. Asociación Chilena de Seguridad (ACHS). Medidas preventivas ante emanaciones de ácido sulfhídrico [Internet]. s.f. Disponible en: https://www.achs.cl/portal/trabajadores/Capacitacion/CentrodeFichas/Documents_pdf/medidas-preventivas-ante-emanaciones-de-acido-sulfhidrico.pdf

15. Wang R. La función dual del sulfuro de hidrógeno. Investigación y Ciencia [Internet]. 2010. Disponible en: https://es.wikipedia.org/wiki/%C3%81cido_sulfh%C3%ADdrico

16. Air Liquide. Hoja de datos de seguridad del producto: Sulfuro de hidrógeno [Internet]. 2014. Disponible en: https://industrial.airliquide.com.mx/sites/industry_mx/files/sds/2018/07/12/alm-022_sulfuro_de_hidrogeno_rev_03.pdf

17. Mercuria. Hoja de datos de seguridad del producto: Petróleo crudo [Internet]. 2017. Disponible en: https://www.mercuria.com/sites/default/files/ES_SDS_Crude_SDS%20SGS%20GHS%20%28Reach%20ANNEXII%29_2015211_MERCURIA-370_0.pdf

18. Sebastián Boris. Elemento de protección personal: Proveedor [Internet]. s.f. Disponible en: https://www.sebastianboris.com.ar/

19. Boris Hnos. Elemento de protección personal: Proveedor [Internet]. s.f. Disponible en: https://www.borishnos.com.ar/inicio

20. Drägerwerk. H2S: Un reto creciente en la industria del gas y el petróleo [Internet]. 2010. Disponible en: https://www.draeger.com/library/content/h2s-e-book-9072501-es.pdf

21. Vidal S. Procedimiento corporativo: permisos de trabajos. C-S-PO-01. 2018.

22. Rodríguez S. Instructivo permiso de trabajo en caliente y frío. C-S-ITO 01.01. 2019.

23. Quesada I. Instructivo permiso de trabajo en altura. C-S-ITO 01.03. 2019.

24. Ulloa G. Instructivo permiso de trabajos en instalaciones eléctricas. C-S-ITO 01.04. 2018.

25. Díaz J. Instructivo permiso de trabajos de excavación. C-S-ITO 01.05. 2018.

26. Cantasano P. Sistema de permisos de trabajo. YFP-505-NO032-LG-AR. 2012.

27. YPF. Permiso de trabajo eléctrico. RG04.

28. YPF. Pruebas adicionales de gas. RG06.

29. YPF. Bloqueo mecánico y etiquetado. RG07.

30. PAE. Formulario: permiso de trabajo frío/caliente.

31. PAE. Certificado: trabajo en altura.

32. PAE. Certificado: confirmación de aislamiento de energía.

33. PAE. Certificado: espacios confinados.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTION

Conceptualization: Agostina Constansa Rodriguez, Hernan Carlos Hoyos.
Data curation: Agostina Constansa Rodriguez, Hernan Carlos Hoyos.

Formal analysis: Agostina Constansa Rodriguez, Hernan Carlos Hoyos.
Research: Agostina Constansa Rodriguez, Hernan Carlos Hoyos.
Methodology: Agostina Constansa Rodriguez, Hernan Carlos Hoyos.
Project management: Agostina Constansa Rodriguez, Hernan Carlos Hoyos.
Resources: Agostina Constansa Rodriguez, Hernan Carlos Hoyos.
Software: Agostina Constansa Rodriguez, Hernan Carlos Hoyos.
Supervision: Agostina Constansa Rodriguez, Hernan Carlos Hoyos.
Validation: Agostina Constansa Rodriguez, Hernan Carlos Hoyos.
Visualization: Agostina Constansa Rodriguez, Hernan Carlos Hoyos.
Writing – original draft: Agostina Constansa Rodriguez, Hernan Carlos Hoyos.
Writing – revision and editing: Agostina Constansa Rodriguez, Hernan Carlos Hoyos.