



DELIVERABLE D4.3

EHS and Regulatory Recommendations for DeepU Technology

WP4

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Publishable summary

D4.3 is a Sensitive report which reviews the **E**nvironmental **H**ealth **S**afety and **r**egulatory conditions assessed as part of the development of the DeepU technology. The deliverable outlines recommendations aimed at supporting the next stages of development of the laser and cryogenic based drilling system in the context of the EHS methodologies adopted in the deep drilling sector. The report draws from the evolutions of the laser head, cryogenic gas flushing system and results of the laboratory tests completed as part of the project, to determine the necessary requirements for compliance of the DeepU drilling system on the basis of achieving acceptance from regulators responsible for drilling operational procedures and safety systems, compliance with industrial laser equipment, the use of industrial scale cryogenic gas systems and environmental compliance for geothermal drilling system completion and operation.

7 REFERENCES

- [1] European Industrial Gases Association. 2023. *Bulk Liquid Oxygen, Nitrogen, And Argon Storage Systems at Production Sites*. European Industrial Gases Association Asbl. DOC 127/23. May, 2023. <https://www.eiga.eu/uploads/documents/DOC127.pdf>
- [2] Slupski, P. Galaro, A. Sassi, R. 2024. *Assessment of rocks vitrification and vaporization in laboratory samples*. Deliverable D3.2, DeepU, December 2024.
- [3] P. Cerwenka, G. Steinmeier, O. Fischer, A. 2025. *Work Package 2 – Drilling Update*. Presentation to DeepU General Assembly – Month 37, May 2025
- [4] Planitzer, P. Cerwenka, G. Steinmeier, O. Fischer, A. 2024. *Temperature Management for process adapting to different rock types*. Deliverable 2.4 DeepU, May 2025
- [5] Dunphy, R. Mallin, K. Pasquali, R. 2023. *Legal & Regulatory Framework of Deep Drilling Technologies and Practices*. Deliverable 4.1 DeepU, February 2023.
- [6] Pasquali, R. Mallin K. 2024. *EHS comparison of DeepU with conventional drilling technologies*. Deliverable 4.2, DeepU, October 2024.
- [7] Slupski, P. Galaro, A. Sassi, R. 2024. *Petrophysical Effects Induced by laser on hard/soft rocks*. Deliverable D3.1, DeepU, April 2024.
- [8] Yanto, E. Hastriansyah, G. Fahmi Fanani, A. Saputra, M. B. Marastio, F. B. Pasaribu, F. Silaban, M. S. P. 2019. *Nitrogen Lifting Method To Discharge Geothermal Wells*. Proceedings of the 7th Indonesia International Geothermal Convention & Exhibition (IIGCE) 2019. Assembly Hall - Jakarta Convention Center Indonesia, August 13 - 15, 2019
- [9] Mutinelli, N. Chinello, M. Pockelé, L. Mallin, K. Pasquali, R. *DeepU drilling scalability and possible future on-site application*. Deliverable 5.2, DeepU, February 2025.
- [10] G. Montegrossi, A. M. N. M. A. G. R. P. (2025). *DeepU project - Deliverable D5.1: DeepU closed loop geothermal heating plant*. Deliverable D5.1, Deep U, February 2025.
- [11] Steinmeier, O. Cerwenka, G. Fischer, A. Planitzer, P. 2024. *Laboratory Testing and modelling of direct laser and gas interaction with rocks*. Deliverable 2.3, Deep U. June 2024.
- [12] European Parliament. 2010. Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (recast). November, 2010. <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32010L0075>
- [13] European Parliament. 2006. Management of waste from extractive industries. European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries and amending Directive 2004/35/EC. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=legisum:l28134>
- [14] Stanlik, M. Rogala, Z. Strzelecka, K. Kielar, J. Chorowski, M. *Assessment of minimal mechanical requirements for the cryogenic system based on experimental tests results*. Deliverable 8.3. DeepU, August 2024.
- [15] Banaszkiwicz, T. Piotrowska, A. Chorowski, M. 2024. *Risk Analysis of the laser drill cryogenic system*. Deliverable 8.4. DeepU, October 2024.