HealthTech

Pre-project report

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Overview	
Project name	HealthTech
Organizational unit	New Build
Company	Aker Solutions

Document review					
Review No.	**Review**	**Issue Date**	**Made by**	**Reviewed by**	**Approved by**
01	Preliminary report	19-12-2024	Claudio Paliotta		
02	Pre- project report	25-04-2025	Claudio Paliotta, Åsmund Andersen, Roya Doshmanzariani		

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Project Description

The primary objective of this pre-project is to mitigate work-related illnesses in the industrial sector, with a particular focus on yard environments, through the implementation of advanced technology for data collection on occupational hygiene risks. This initiative aims to provide enhanced insights into both personal and environmental exposures.

Our pre-project endeavors to significantly improve health conditions within yards by addressing critical issues such as vibration, dust, and noise exposure. By systematically collecting and analyzing data on exposure risk levels across various occupational groups—including welders, metal sheet workers, pipe fitters, and surface protection workers—we aspire to elevate workplace safety and environmental monitoring standards.

With a total budget of 1.7 MNOK, this project receives support from the *Inclusive working life program in the oil and gas supply industry* (Norwegian: *IA-bransjeprogrammet til leverandørindustrien til olje- og gassnæringen*) with funding of 600 k NOK though the IA- program, alongside of 1.1 MNOK from Aker Solutions. The *Inclusive working life program in the oil and gas supply industry* is a Norwegian governmental program headed by Norsk Industri, Offshore Norge, NAV, the Norwegian Ocean Industry Authority and representatives from several Norwegian unions.

The pre-project is led by Aker Solutions, focusing on improving health conditions in yards, and NTNU is the partner providing technical expertise for the selection, qualification, procurement, and testing of sensors for these use cases.

The culmination of these efforts will provide a comprehensive assessment of the sensors' effectiveness in monitoring occupational hygiene risks. This will lead to well-informed recommendations for a larger project, highlighting how to implement and manage this technology effectively. This pre-project also aims to ensure compliance with health and safety regulations and foster a proactive culture of workplace well-being and environmental stewardship.

The pre-project started in June 2024, and it ended in March 2025.

Report description

The final report, completed in Q1-2025, provides a comprehensive assessment of the sensors' effectiveness in monitoring occupational hygiene risks. It includes results from large-scale tests, GDPR compliance guidelines, recommendations for data platforms handling sensor data, and next steps for project continuation. Additionally, the report presents a preliminary business case for digitizing health hygiene monitoring and offers recommendations for scoping the larger project initiated from this pre-project.

Pre-Project Objectives

The pre-project aims to harness advanced technology to gather data on occupational hygiene risks in the industrial sector, especially within shipyards, with the goal of mitigating work-related illnesses. By providing enhanced insights into personal and environmental exposures, we strive to elevate workplace safety and environmental monitoring standards.

To achieve these objectives, our pre-project will deliver the following:

- Assessment of available market sensors that provide insights on the health and hygiene conditions of shipyard workers.
- Execution of small-scale tests to evaluate the most relevant sensors and make purchasing decisions for larger-scale tests.
- Execution of larger-scale tests to obtain a comprehensive assessment
- Clear recommendations on the sensors to be used to monitor occupational hygiene conditions.
- Guidelines ensuring the selected sensors comply with GDPR regulations.
- Recommendations on data platforms for handling sensor data.
- A preliminary business case to support decision-making on the digitalization of health hygiene monitoring.
- Recommendations on the next steps for the project.

By Q4-2024, we managed to:

- Assess market sensors that provide insights on the health and hygiene conditions of yard workers.
- Conduct small-scale tests to evaluate the most pertinent sensors and decide on their purchase for larger-scale tests.
- Provide preliminary recommendations on the sensors for monitoring occupational hygiene conditions.
- Initiate GDPR compliance discussions regarding the use of the selected sensors
- Begin discussions on suitable data platforms for handling sensor data.
- Offer preliminary recommendations on the next steps, including internal work to implement sensors for digitalizing occupational hygiene monitoring, and exploring the possibility of a cross-industry project with Equinor, NTNU, and IA-bransjeprogrammet to define standards spanning across the value chain of projects handled by Aker Solutions.

By Q1-2025 we managed to:

- Conduct larger-scale tests to obtain more comprehensive feedback from the workers.
- Define a preliminary process to handle data flow and information from the sensors, which will be used to design a data platform for the eventual final application.
- Formulate initial GDPR compliance recommendations based on a proposed process for managing the data flow and information provided by the sensors.
- Develop a high-level business case that discusses the feasibility of the project.
- Collaborate with NTNU and recruit four B.Sc. students and one M.Sc. student to research sensor solutions for musculoskeletal issues during yard work activities.

Sensors

To enhance workplace safety and environmental monitoring, we conducted extensive market research to identify sensors that align with our specific needs and requirements. After evaluating various options, we selected a range of sensors tailored to monitor critical factors such as noise, pollutants, vibration, and motion, supporting our commitment to health, safety, and environmental (HSE) standards.

Our market research on available sensors for workplace safety revealed several limitations and challenges. Key findings include:

- **Restrictive IP and Data Ownership Policies:** Some companies imposed strict policies, limiting our control over the data and its usage.
- **Unresponsive Vendors:** Certain manufacturers were unresponsive, creating challenges in communication and support.
- **Combined Physiological and Environmental Sensors**: Some sensors integrated physiological data (e.g., heart rate, breathing rate) with environmental monitoring, classifying the data as personal, which falls outside the scope of this project phase.
- **High Costs**: Many sensors were expensive and designed for professional hygienists, making them unsuitable for general workforce use.
- **Lack of Wearable Technology for Heavy Metals:** The current technology does not support wearable sensors for monitoring heavy metals in welding fumes and similar environments. While dust monitoring sensors are available, even particulate monitoring devices tend to be large and require periodic calibration and maintenance, which limits their practicality for continuous, on-the-go use by workers.
- **No API Access**: Some sensors lacked API access, hindering seamless data integration with other systems.
- **Manual Data Logging**: Certain sensors did not use cloud services, requiring manual syncing and cable connections to access logged data.

- **Limited Display-Only Functionality**: Some devices only displayed results locally without cloud integration, making them unsuitable for future resource management platforms.
- **Single Hazard Monitoring:** Many sensors were designed to monitor only a single hazard, such as dust or a specific gas, rather than providing comprehensive multi-factor monitoring.

For data collection in phase I & II, we selected several sensors based on their strong alignment with our technical, legal, and operational requirements. These sensors comply with GDPR and data privacy standards, ensuring responsible handling of personal and environmental data. Additionally, their EU-based servers simplify legal compliance by meeting our jurisdictional and data protection needs.

Another key consideration was the availability of API access, which facilitates seamless integration with our existing systems and allows for future scalability. Additionally, we had a positive impression of the companies behind these sensors, particularly their responsiveness, and commitment to supporting our needs during the pre-project. Moreover, these sensors offered a balance of advanced technological features and ease of use, making them suitable for both our testing objectives and eventual deployment in real-world environments.

Below is a summary of the selected sensors for evaluation and testing. Each device addresses specific safety and monitoring needs within our operational environment, contributing to our proactive approach to improving HSE practices.

- **Smart Alert from Minuendo**[1]

  Minuendo smart alert earplugs offer dual functionality by providing noise protection while monitoring both ambient noise and the noise levels entering the ear. The earplugs have listen-through technology. These earplugs allow users to maintain situational awareness and communicate seamlessly with coworkers without needing to remove their hearing protection. The sensor provides real-time noise exposure monitoring, alerting users if their protection is insufficient to shield them from hazardous noise levels. The recorded noise measurements are also accessible through a cloud platform, enabling users to review and analyze their exposure data.

  - *Capabilities*: Provides noise protection with real-time warnings delivered directly to the earplugs.
  - *Data Storage*: Servers located in Norway.

[1] https://www.minuendo.com/smart-alert

- *API Access*[2]: Available.
- *Status*: Ordered and tested.
- *Price*: 5500 NOK per earplug unit (excluding charging dock and platform access[3]).

- **R-link from Reactec[4]**

  The R-Link smart watch by Reactec is a cutting-edge workplace wearable designed to address hand-arm vibration exposure when operating hand-held power tools. Easy to deploy and cost-effective, R-Link empowers organizations to prevent workplace health issues while driving operational efficiency and safety improvements. The watch is equipped to alert users with alarms and notifications when they are overexposed, ensuring timely intervention. Additionally, data is live-streamed and seamlessly integrated into a cloud-based solution, Reactec Analytics, providing real-time insights and comprehensive analytics for enhanced decision-making and compliance.

  - *Capabilities*: Continuously monitors vibration exposure levels and delivers real-time feedback to users.
  - *Data Storage*: Servers in the UK.
  - *API Access*: Available.
  - *Status*: Ordered and tested.
  - *Price*: R-link watch at 5000 NOK (excluding charging station and platform access).

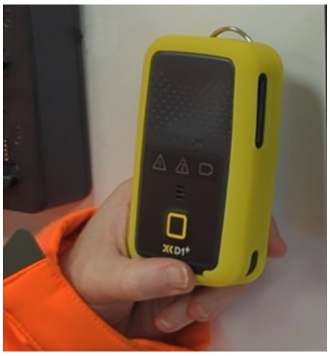
[2] Application Program Interface (API) is a tool to fetch raw data from the sensors. This gives the possibility for a deeper data analysis and more freedom for data interpretation.
[3] The Minuendo platform is a proprietary SW platform to collect and read data from the sensors. It also facilitate the data capture phase.
[4] https://www.reactec.com/products/r-link/

- **Trolex XD1+ from Reactec[5]**

  The Trolex XD1+ is a state-of-the-art personal dust monitor designed to revolutionize dust exposure management in the workplace. Paired with Reactec's advanced wearables and cloud-based analytics, the XD1+ provides real-time monitoring of respirable dust levels, and sets a new standard in personalized, effective dust monitoring and management. The device is quick and easy to set up, lightweight, and simple to use requiring no filters, pumps, tubes, or replaceable parts. Fully compatible with the R-Link system, it allows users to view dust exposure levels directly on their watch face and access real-time data for fast, decisive action.

  - *Capabilities*: Continuously monitors Dust (particulate matters) exposure levels and delivers real-time feedback to users.
  - *Data Storage*: Servers in the UK.
  - *API Access*: Available.
  - *Status*: Ordered and tested.
  - *Price*: R-link watch at13000 NOK (excluding charging station and platform access).

- **Muse from 221e[6]**

[5] https://www.reactec.com/products/dust-monitoring/
[6] https://www.221e.com/muse-miniaturized-multi-sensor-imu

Muse is a compact, advanced multi-sensor IMU device designed for real-time motion and environmental data acquisition, leveraging state-of-the-art sensor and AI technology. It captures a wide range of data, including acceleration, angular rates, 3D rotation, magnetic fields, temperature, humidity, proximity, ambient light, ambient pressure, voice, and acoustic signals. This sensor was chosen to support our efforts in exploring motion data to develop posture estimation algorithms aimed at preventing musculoskeletal disorders.

- *Capabilities*: Monitoring and logging motion and environmental data.
- *Data Storage*: Servers in Italy.
- *Status*: Ordered and tested.
- *Price*: 1700 NOK.

- **Aeroguard from PLYMOVENT[7]**

The AeroGuard Air Monitor is an advanced stationary sensor designed to provide real-time insights into indoor air quality, offering transparency and assurance for healthier environments. This all-in-one device measures a comprehensive range of eleven pollutants and climate factors, including particulate matter (PM1, PM2.5, PM4, PM10), Volatile Organic Compounds (VOCs), Carbon Dioxide CO2), Temperature, Humidity, Sound, Atmospheric Pressure, and the Indoor Air Quality (IAQ) Index. The device features a user-friendly LED ring for real-time alerts and integrates seamlessly with a free mobile app and web portal, providing detailed data for quick action and thorough analysis.

- *Capabilities*: Monitors multiple pollutants and climate factors with LED-ring notifications.
- *Data Storage*: Servers in the Netherlands.
- *API Access*: Not available.

[7] https://www.plymovent.com/en/products/aeroguard

- *Status*: Ordered and tested.
- *Price*: 33,000 NOK per unit (with a pre-project price of 22,000 NOK).


- **MākuSafe**[8]

  The MākuSafe is a safety solution designed to enhance worker health, safety, and productivity. Combining wearable technology with a safety management software platform, MākuSafe provides real-time access to Environmental, Health, and Safety (EHS) data, offering predictive insights into workplace risks and hazards. The device is easily clicked into a holster on an armband, worn on the worker's upper arm on the outside of clothing. The system collects leading indicator data on strain, exertion risks, slips/trips/falls, noise exposure, air quality, and more, while the MākuSmart cloud platform analyzes this data using AI and machine learning to detect trends and generate alerts with actionable recommendations for safety leaders. In addition, the wearable allows workers to record near-miss voice memo reports, good catches, and observations from the front lines with the push of a button This sensor has been selected for potential testing but is currently on hold for order and testing due to legal and data privacy restrictions.

  - *Capabilities*: Gathers data on ever-changing environmental conditions, potentially hazardous human motion, proximity and location.
  - *Data Storage*: Servers located in the US.
  - *API Access*: Available.
  - *Status*: On hold.
  - *Price*: 50,000 NOK for a package of 20 sensors (discounted pre-project price).

[8] https://makusafe.com/hardware/

- **Modjoul**[9]

  The Modjoul Worker Safety Bundle provides a comprehensive solution to protect your workforce from injuries on-site. Featuring the Modjoul SmartBelt, the bundle uses patented technology to monitor and provide real-time feedback on ergonomic and musculoskeletal risks. It tracks lumbar strain by measuring bending and twisting angles, duration, and frequency, and helps prevent accidents involving forklifts or other industrial vehicles through collision avoidance features. Additionally, the system ensures PPE compliance, alerts employees to extreme temperature conditions, and monitors lone worker safety by detecting inactivity. Repetitive motion thresholds are also set, triggering alerts when limits are exceeded, offering a holistic approach to workplace safety. This option is currently on hold for testing due to GDPR and data protection complexities.

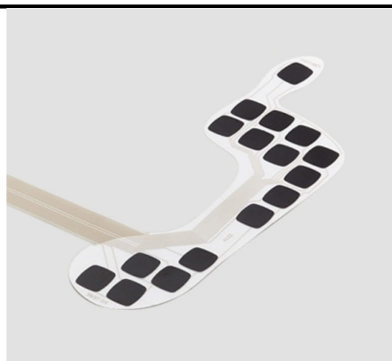
  - The *Capabilities*: Protects against ergonomic and musculoskeletal injury.
  - *Data Storage*: Servers located in the US.
  - *API Access*: Available.
  - *Status*: On hold.
  - *Price*: 50,000 NOK for a package of 10 sensors.

[9] https://modjoul.com/worker-safety/

- **Mitch and Yeti Smart Soles** [10]

  Mitch can measure acceleration, angular rates and magnetic fields. YETI is a membrane sensor for Gait Analysis designed to be a plug-and-play with Mitch system. It can be used for foot pressure points measurement by healthcare professionals, trainers, biomedical engineers, scientists and researchers. YETI detects and measures contact, touch, force and rate of change of an applied load. This in-shoe sensor behaves like a Force Sensing Resistor (FSR), exhibiting a resistance value inversely proportional to the amount of force applied. As the applied pressure increases, the equivalent resistance of the sensor decreases.

  - The *Capabilities*: Monitoring and logging motion and environmental data in addition to measuring contact, touch, force and applied load by smart soles.
  - *Data Storage*: Servers located in Italy.
  - *API Access*: Available.
  - *Status*: Ordered and tested.
  - *Price*: 5,000 NOK for a pair of soles and the Mitch sensor.



Musculoskeletal sensors and NTNU students

The market currently lacks clear solutions for addressing musculoskeletal issues in the workplace. To tackle this challenge, AKSO has partnered with NTNU, engaging four B.Sc. students and one M.Sc. student to develop their theses on the use of off-the-shelf wearable sensors. This collaboration aims to explore the potential of these sensors in mitigating workplace musculoskeletal problems. The goal of this project is to leverage machine learning to identify and estimate physical activities and body postures in real time by monitoring industrial tasks. Using data-driven models, students will explore the potential of combining Inertial Measurement Units (IMUs) with environmental sensors—including pressure, biometric, and environmental exposure

[10] https://www.221e.com/shop/product/mitch

sensors—to track industrial activities and detect harmful postures. This approach will provide valuable insight into the actual exposure workers face while performing their tasks. Additionally, the system will estimate the duration of each task. Ultimately, the project aims to develop a biofeedback framework that alerts workers when they are at risk of overexposure, helping to prevent long-term health issues.

For data collection the team will test Muse/Mitch/Yeti sensors on convenient positions on the body to find the optimal mounting position.

Data Collection – Phase I

In the first phase of testing, our primary focus was to evaluate the usability and practicality of the selected sensors focusing on noise, air quality, and vibration1. This involved assessing how easy they were to set up and use, as well as gathering feedback from participants who wore the devices for extended periods. The goal was to understand the user experience, including comfort, ease of integration into daily tasks, and any challenges faced during use. Participants feedback was collected through questionnaires, providing insights into how well these devices align with real-world requirements. In the following, we summarize the findings from this phase and the feedback received from users.

Experiments Overview

- **Date and Location of Execution**: Phase I was held during week 45 2024 at the Egersund yard.

- **Participants:** The experiments were conducted to assess exposure risk levels across various occupational groups, including welders, metal sheet workers, pipe fitters, and surface protection workers.
- **Wearable Sensors**: We ensured that the sensors posed no safety risks to participants and did not interfere with the use of personal protective equipment (PPE).
- **Stationary Sensors**: The sensor was securely positioned in the workshop to avoid accidents and prevent interference with normal work activities. 1.

Description of the test

The test campaign was conducted over a period of four days, during which two employees (with welding, grinding, pipe fitting and sandblasting specialties) participated each day, working the morning shift from 7:00 AM to 3:00 PM.

Each participant was assigned one noise sensor, one dust sensor, and one vibration sensor, with all devices checked for functionality before use. A stationary air monitoring sensor was placed in the workshop to continuously record air quality data. Participants were verbally briefed on the experiment's purpose, instructed on proper sensor use and placement, and guided on handling the sensors during their shift to prevent damage. Sensors recorded data throughout the day. Feedback was collected through questionnaires at the shift's conclusion. The wearable sensors were charged overnight in preparation for the next day.

Results from Phase I

SUS Questionnaire[11]:

The System Usability Scale (SUS), developed by John Brooke, is a widely used, low-cost tool designed to provide a reliable measure of system usability across various contexts. It consists of a 10-item questionnaire using a 5-point Likert scale to capture subjective assessments of usability, with alternating positive and negative statements to minimize response bias. After user interaction with a system, SUS evaluates aspects like ease of use, integration, and support needs. Scoring involves calculating item scores, summing them to a range of 0–40, and multiplying by 2.5 to normalize the score to 0–100. The following section provides an interpretation of these results, offering insights into user experiences and the usability of the sensors tested during the experiment. Detailed information about the System Usability Scale (SUS) is provided in the appendix for reference.

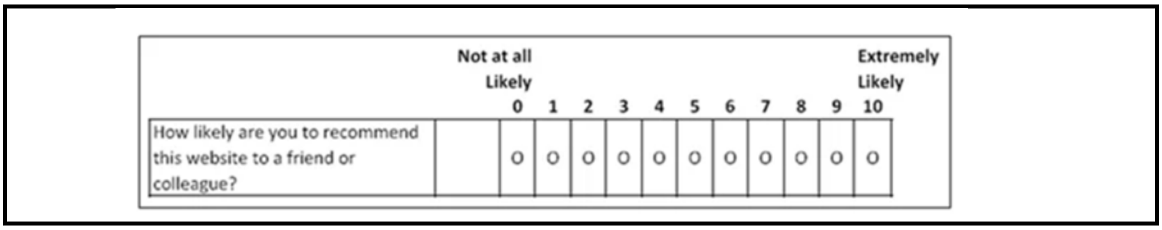
Interpreting SUS[12]:

- **Percentiles**: Raw SUS scores can be converted into percentile ranks. The average score (at the 50th percentile) is 68. That means a raw SUS above 68 is above average and below 68 is below average. A SUS of 75 is at the 73rd percentile (scoring better than 73% of the scores in the database). A raw SUS of 52 falls at the 15th percentile (scoring worse than 85% of the scores in the database).
- **Grades**: Closely related to percentile rankings are grades; the same type of grading system you likely had (and maybe hated) in school. Grades range from A, which indicates superior performance, to F (for failing performance), with C indicating "average."
- **Adjectives**: Building on the idea of using words instead of numbers to describe an experience, Bangor et al. scores above 85 are associated with "Excellent." "Good" was just above average at 71 and "OK" for scores at 51.
- **Acceptability**: Another variation on using words to describe the SUS is to think in terms of what's "acceptable" or "not acceptable." Bangor et al. (2008) assigned these terms for when the SUS was well above average or well below average. Acceptable corresponds to roughly above 70 (above our average of 68) and unacceptable to below 50 (closely corresponding to our designation of

[11] Brooke, J. (1996). SUS: A quick and dirty usability scale. *Usability Evaluation in Industry*
[12] The questionnaire is given in the Appendix of this document.

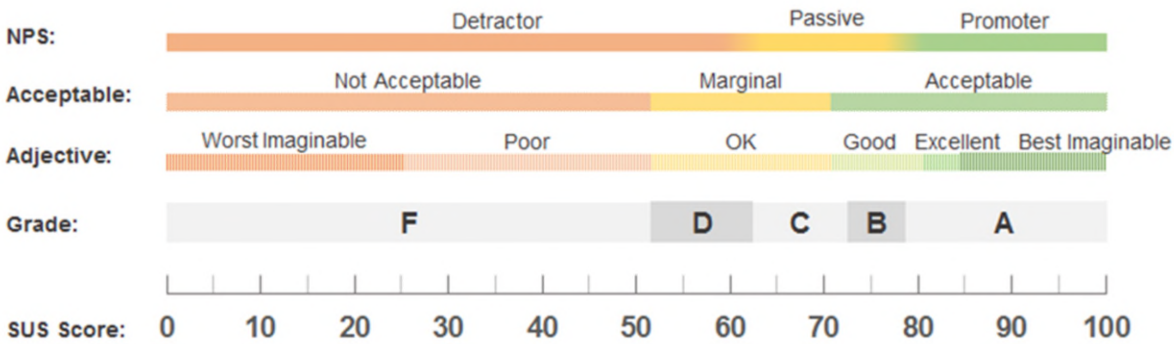
scores lower than 51.6 with a grade of F). They designated the range between 50-70 as “marginally acceptable,” which encompasses a range from C to D in our curved grading scale.

- **Promoters and Detractors**: a strong correlation between the SUS and the Net Promoter Score. The NPS uses a single Likelihood to Recommend question (“How likely is it that you would recommend our company to a friend or colleague?”) with 11 scale steps from 0 (Not at all likely) to 10 (Extremely likely), as shown below.



On average, the SUS explains between 30% and 50% of the variation in users’ likelihood to recommend. The NPS designates three classes of recommenders based on their responses to the 11-point (0 to 10) likelihood to recommend question. Promoters score 9 and 10; passives, 7 and 8; and detractors, 6 and below. While promoters (as the name suggests) are most likely to recommend the product/website/app to a friend, detractors are more likely to discourage rather than recommend.

The table and figure below summarize the scoring system and interpretation framework for the System Usability Scale (SUS).

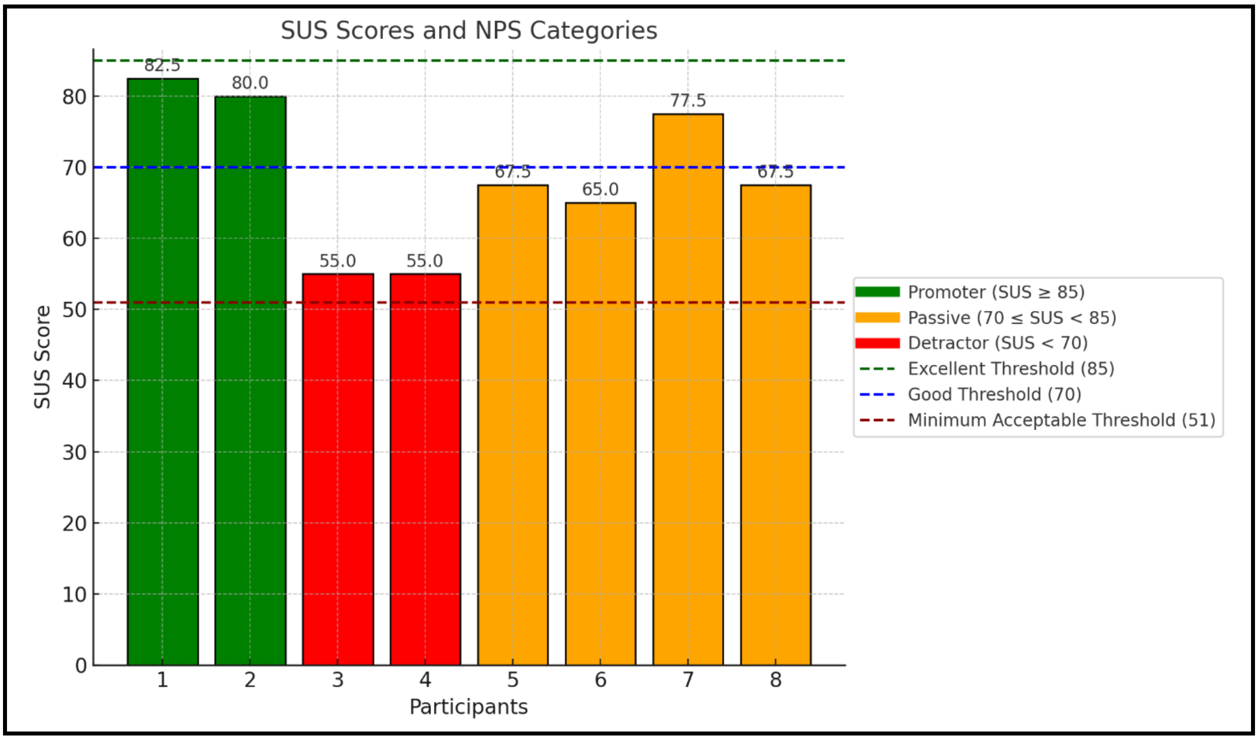


Grade	SUS	Percentile range	Adjective	Acceptable	NPS
A+	84.1-100	96-100	Best Imaginable	Acceptable	Promoter
A	80.8-84.0	90-95	Excellent	Acceptable	Promoter
A-	78.9-80.7	85-89		Acceptable	Promoter
B+	77.2-78.8	80-84		Acceptable	Passive
B	74.1 – 77.1	70 – 79		Acceptable	Passive
B-	72.6 – 74.0	65 – 69		Acceptable	Passive
C+	71.1 – 72.5	60 – 64	Good	Acceptable	Passive
C	65.0 – 71.0	41 – 59		Marginal	Passive
C-	62.7 – 64.9	35 – 40		Marginal	Passive
D	51.7 – 62.6	15 – 34	OK	Marginal	Detractor
F	25.1 – 51.6	2– 14	Poor	Not Acceptable	Detractor
F	0-25	0-1.9	Worst Imaginable	Not Acceptable	Detractor

Below are the scores provided by users for the vibration, dust and noise sensors, reflecting their feedback on usability and overall experience. The scores, along with their respective Net Promoter Score (NPS) categories—Promoter, Passive, or Detractor—are presented. Additionally, key insights derived from other measures are summarized to highlight user feedback and areas for improvement

Vibration (R-Link)

Participant	SUS Score	Grade	Percentile Range	Adjective	Acceptability	NPS
1	82.5	A	90–95	Excellent	Acceptable	Promoter
2	80	A-	85–89	Very Good	Acceptable	Promoter
3	55	D	15–34	OK	Marginal	Detractor
4	55	D	15–34	OK	Marginal	Detractor
5	67.5	C	41–59	Marginal	Acceptable	Passive
6	65	C	41–59	Marginal	Acceptable	Passive
7	77.5	B+	80–84	Very Good	Acceptable	Passive
8	67.5	C	41–59	Marginal	Acceptable	Passive

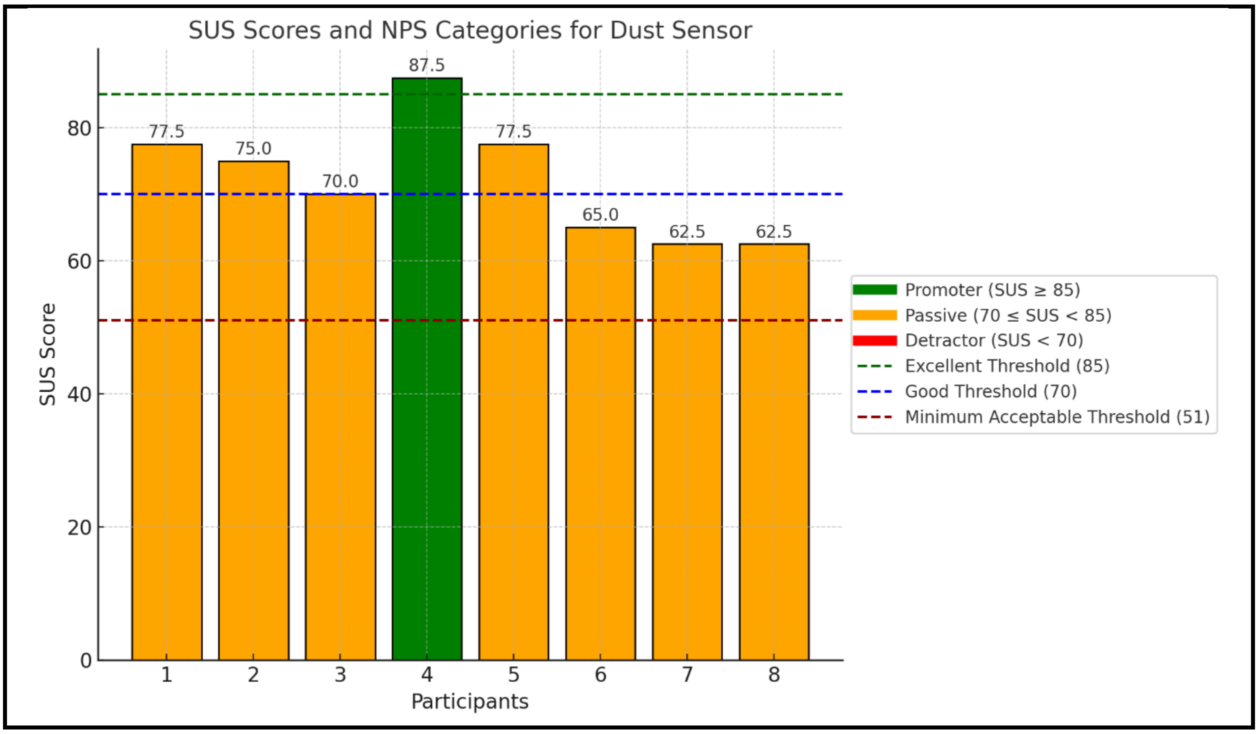


Key Insights (The average score is 68.75 ± 9.92):

- Participants **1 and 2** (SUS scores of 82.5 and 80) fall into high usability categories (Grades A and A-), reflecting excellent usability and high satisfaction.
- Participants **3 and 4** (SUS scores of 55) show low usability (Grade D) and are potential detractors.
- Participants **5, 6, and 8** (SUS scores of 65–67.5) reflect marginal usability but are still acceptable.
- Participant **7** (SUS score of 77.5) indicates good usability but is a passive rather than a promoter.

Dust Sensor (Trolex)

Participant	SUS Score	Grade	Percentile Range	Adjective	Acceptability	NPS
1	77.5	B+	80–84	Very Good	Acceptable	Passive
2	75	B	70–79	Good	Acceptable	Passive
3	70	C	41–59	Marginal	Acceptable	Passive
4	87.5	A+	96–100	Best Imaginable	Acceptable	Promoter
5	77.5	B+	80–84	Very Good	Acceptable	Passive
6	65	C	41–59	Marginal	Acceptable	Passive
7	62.5	C-	35–40	Marginal	Marginal	Passive
8	62.5	C-	35–40	Marginal	Marginal	Passive

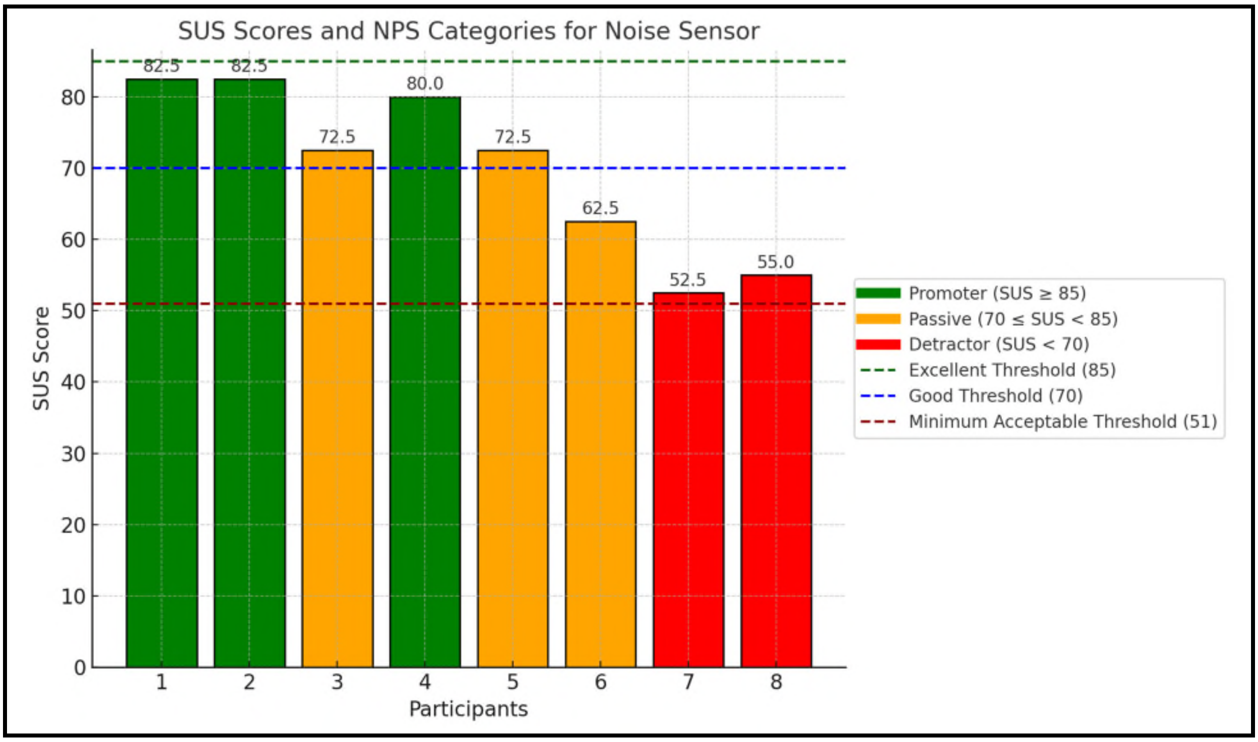


Key Insights (The average score is 72.19 ± 8.24):

- **Participant 4** (SUS score 87.5) falls into the highest grade (**A+**), representing "Best Imaginable" usability and a **Promoter**.
- Participants **1, 2, and 5** (SUS scores between 75 and 77.5) are in the **B+ and B** grades, representing good usability. However, they are classified as **Passives** rather than Promoters.
- Participants **3, 6, 7, and 8** (SUS scores 62.5–70) reflect marginal usability, with grades **C** or **C-**. These scores indicate acceptable but unimpressive usability.

Noise Sensor (Minuendo)

Participant	SUS Score	Grade	Percentile Range	Adjective	Acceptability	NPS
1	82.5	A	90–95	Excellent	Acceptable	Promoter
2	82.5	A	90–95	Excellent	Acceptable	Promoter
3	72.5	C+	60–64	Good	Acceptable	Passive
4	80	A-	85–89	Very Good	Acceptable	Promoter
5	72.5	C+	60–64	Good	Acceptable	Passive
6	62.5	C-	35–40	Marginal	Marginal	Passive
7	52.5	D	15–34	OK	Marginal	Detractor
8	55	D	15–34	OK	Marginal	Detractor



Key Insights (The average score is 70 ± 11.25):

- **Participants 1, 2, and 4** (SUS scores 80–82.5) fall in **A** and **A-** grades, indicating **Excellent** usability. They are **Promoters**, showing high satisfaction.
- **Participants 3 and 5** (SUS scores 72.5) are in the **C+** grade, classified as **Good** usability. They are **Passives**, reflecting neutral satisfaction.
- **Participants 6, 7, and 8** (SUS scores 62.5–55) fall in **C-** and **D** grades. Their usability ratings are **Marginal** or **OK**, with Participants 7 and 8 classified as **Detractors**.

Lesson learnt - Medical Doctor's Perspective

The ultimate goal of using real-time sensors is to prevent the onset of work-related illnesses by empowering workers and supporting evidence-based interventions. Preliminary results from the pre-study suggest that this goal is achievable, with workers reporting positive experiences and actionable insights.

Real-time exposure data serves as a valuable resource for both the workers and occupational health physicians. For workers, it acts as an immediate alert system, prompting the use of personal protective equipment (PPE) or other mitigating actions to reduce exposure risks. For occupational health physicians, it offers an objective, quantifiable basis to assess and address workplace hazards.

The pre-study revealed significant benefits of sensor use. For example, data logging showed that on Day 1, a worker operating a grinder remained within the safe (green) zone. However, on Day 2, the same worker, using a different tool, entered the yellow zone, indicating increased vibration exposure. While no immediate action was observed during the testing phase, this highlights the potential for workers to benefit from real-time alerts in the future. By being more informed about these alerts, workers can take immediate action, such as switching tasks or adjusting their workflow, to prevent potential health issues like Hand-Arm Vibration Syndrome, a severe and irreversible condition. Therefore, there is significant potential to educate workers about the purpose and benefits of real-time monitoring to foster acceptance and engagement. With increasing awareness, workers could come to view these sensors not as intrusive monitoring devices, but as valuable tools for safeguarding their health. Such a mindset shift could, in the future, encourage more active participation in risk mitigation strategies and proactive responses to exposure alerts.

From a medical perspective, real-time exposure data offers a breakthrough in occupational health assessments. Unlike traditional evaluations that rely on workers' recall of exposure, which is prone to bias or inaccuracies, sensor data provides an accurate, objective record. This enables physicians to correlate clinical findings with precise exposure histories, improving diagnosis and recommendations for preventive or corrective actions.

Preliminary sensors recommendations

The sensors evaluated in the Data Collection – Phase I have demonstrated their usability for both medical doctors and yard workers. Therefore, we recommended procuring additional units of the tested sensors, specifically R-Link, Trolex, and Minuendo. We suggested conducting a larger-scale test to further evaluate their performance, reliability, and wearability over an extended period.

The New Build segment granted extra budget to source more of these sensors. More details on how these were tested are given in the following Data Collection – Phase II Section.

Data Collection – Phase II

The objectives of Phase II data collection included enhancing employee engagement and awareness by introducing sensors and clearly communicating their purpose for health, safety, and productivity. We aimed to increase acceptance by reducing resistance to change and improving proper usage through education.

Additionally, we evaluated the ease of use and comfort of the sensors, assessing how easily participants could set up and operate them, as well as identifying any ergonomic concerns during prolonged wear. Scalability and implementation challenges were investigated, focusing on barriers to larger-scale adoption such as logistics, training requirements, and sensor compatibility with different PPE and tasks. Feedback was gathered to develop strategies for smoother integration across diverse work environments.

Finally, we determined how effectively sensor data could be utilized by medical doctors, occupational hygienists, and leadership, assessing the relevance of the collected data in providing insights and guiding decision-making regarding workplace safety.

Several occupational groups participated in the data collection. Each occupational group tested the sensors for one full working week (5 consecutive days), with data collection occurring during their regular shifts each day.

On the first day of each week, an introductory workshop was organized by medical professionals to explain the purpose, benefits, and proper usage of the sensors. Participants learned about sensor functionality and how the data would be used for safety improvements. Each participant was issued wearable sensors at the start of their shift. Assistance was provided to fit and adjust the devices, such as earplugs for noise, ensuring correct sizing of ear tips and ear hooks. It was verified that each sensor was operational, charged, and paired. Noise, dust, and vibration sensors (the same as those tested in Phase I) were tested.

At the end of each shift, a brief daily questionnaire was completed, capturing technical issues (e.g., sensor malfunctions, battery problems), comfort and ease of use, and any notable challenges or environmental factors. Participants docked and charged the devices overnight, preparing them for next-day use. At the end of the week, participants answered the SUS questionnaire, which focused on overall comfort, acceptance, alignment with PPE, usability, and perceived usefulness of the sensors after a full week of use.

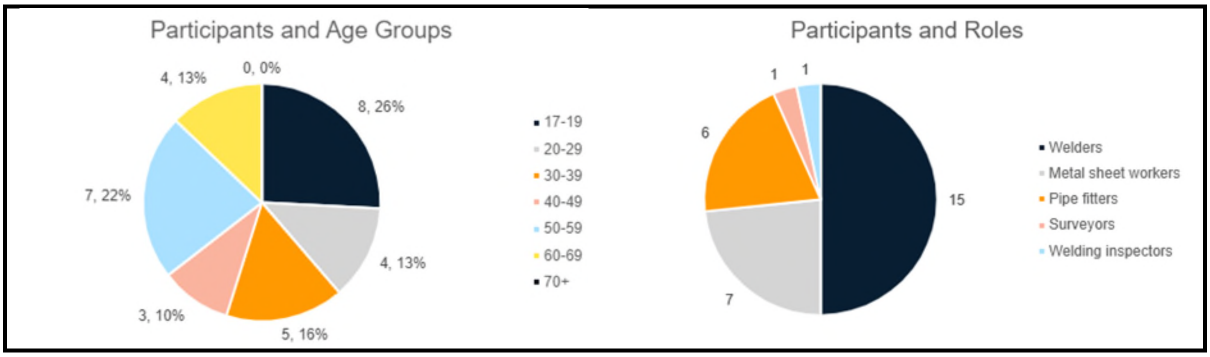
In the following, the results from the daily and weekly SUS questionnaires are presented, and the questionnaires are added to the appendix.

Participants

Phase II data collection involved workers from various job categories at the yard, ensuring representation across different roles and experience levels. A total of 32 participants were involved in this phase, covering key occupational groups such as welders, pipefitters, metal sheet workers, surveyors, foremen and welding inspectors. These participants were selected to reflect the workforce distribution in the yard. More specifically, the tests covered 23% of all welders, 16% of metal sheet workers, 29% of pipe fitters, 2% of foremen, 20% of welding inspectors, and 25% of surveyors in the yard.

To ensure statistical relevance, the participant demographics included individuals from multiple age groups, ranging from 17-19 years to 60-69 years, providing insight into how different experience levels influence usability perceptions. The data collection spanned 4 weeks in February 2025, capturing real-world exposure conditions to vibration, dust, and noise hazards in their daily tasks.

The following figures illustrate the distribution of participants by job role and age group.



Feedback from participant – personal well-being and proactive health work

The use of sensors in the workplace can enhance employees' sense of pride, well-being, security, involvement, and co-determination in matters concerning their health. These benefits collectively contribute to improved quality of life and increased job satisfaction. Research shows that higher job satisfaction reduces the likelihood of employees taking sick leave for minor health issues. According to NAV, only 5% of workplace absences occur without any residual work capacity, meaning the decision to stay home or continue working is often linked to job satisfaction. By fostering greater engagement and satisfaction, these sensors have the potential to positively impact sick leave rates and contribute to a healthier workforce.

Proactive health initiatives focus on preventing work-related health issues before they develop into long-term conditions leading to absence and sick leave. This approach ensures that employees can work smarter and safer, ultimately reducing health-related productivity losses.

Thus, "soft values"—such as employee well-being and engagement—are directly connected to measurable financial outcomes. By improving workplace satisfaction and preventive health efforts, companies can make a strong case for reducing sick leave rates and lowering costs. To explore this connection further, participants were asked to respond to the following questions at the end of the working week, along with the SUS questionnaire:

Personal Well-Being

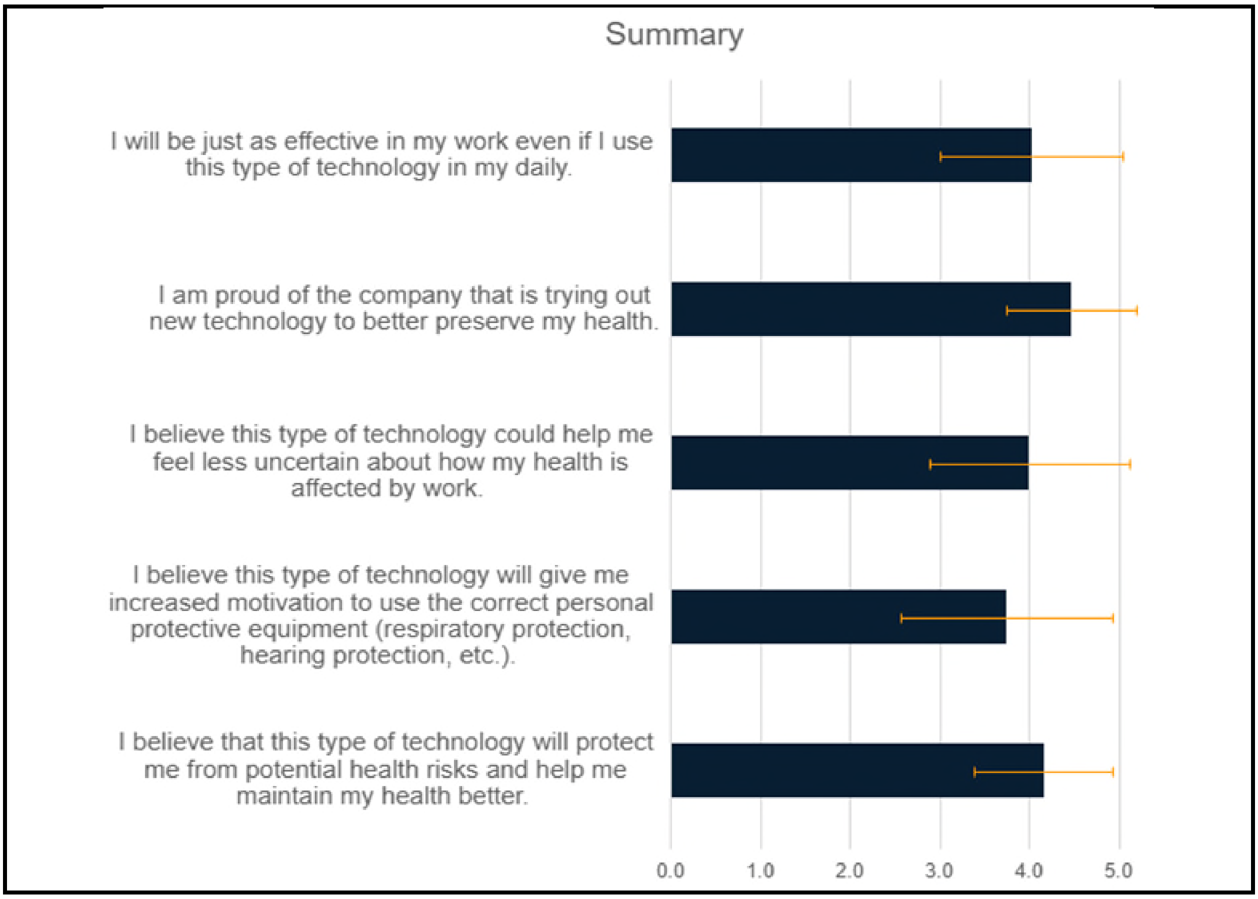
- I believe that this type of technology will protect me from potential health risks and help me maintain my health better.

- I believe this type of technology will give me increased motivation to use the correct personal protective equipment (respiratory protection, hearing protection, etc.).

Proactive Health Initiatives

- I believe this type of technology could help me feel less uncertain about how my health is affected by work.
- I am proud of the company that is trying out new technology to better preserve my health.
- I will be just as effective in my work even if I use this type of technology in my daily tasks.

The figure below illustrates the participant feedback on personal well-being and proactive health initiatives, showing the perceived benefits of implementing sensor technology in daily work.

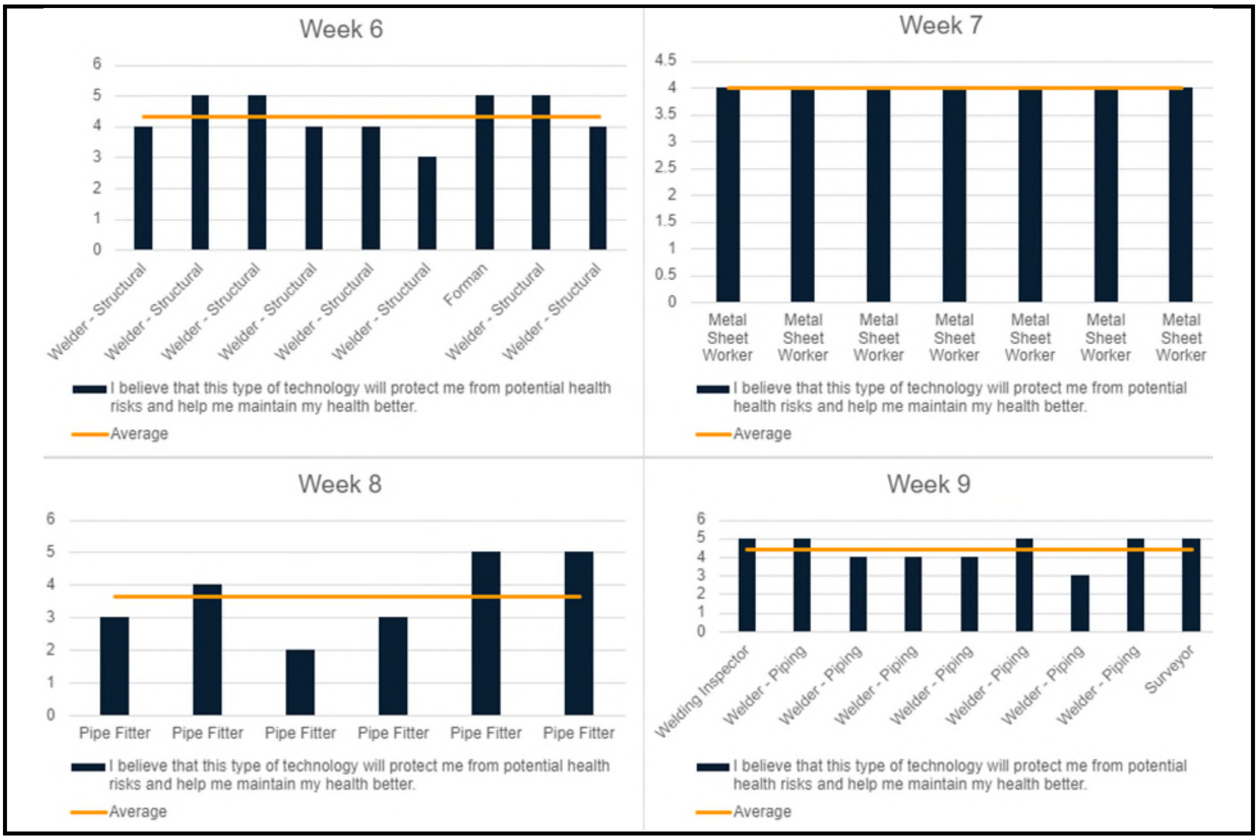


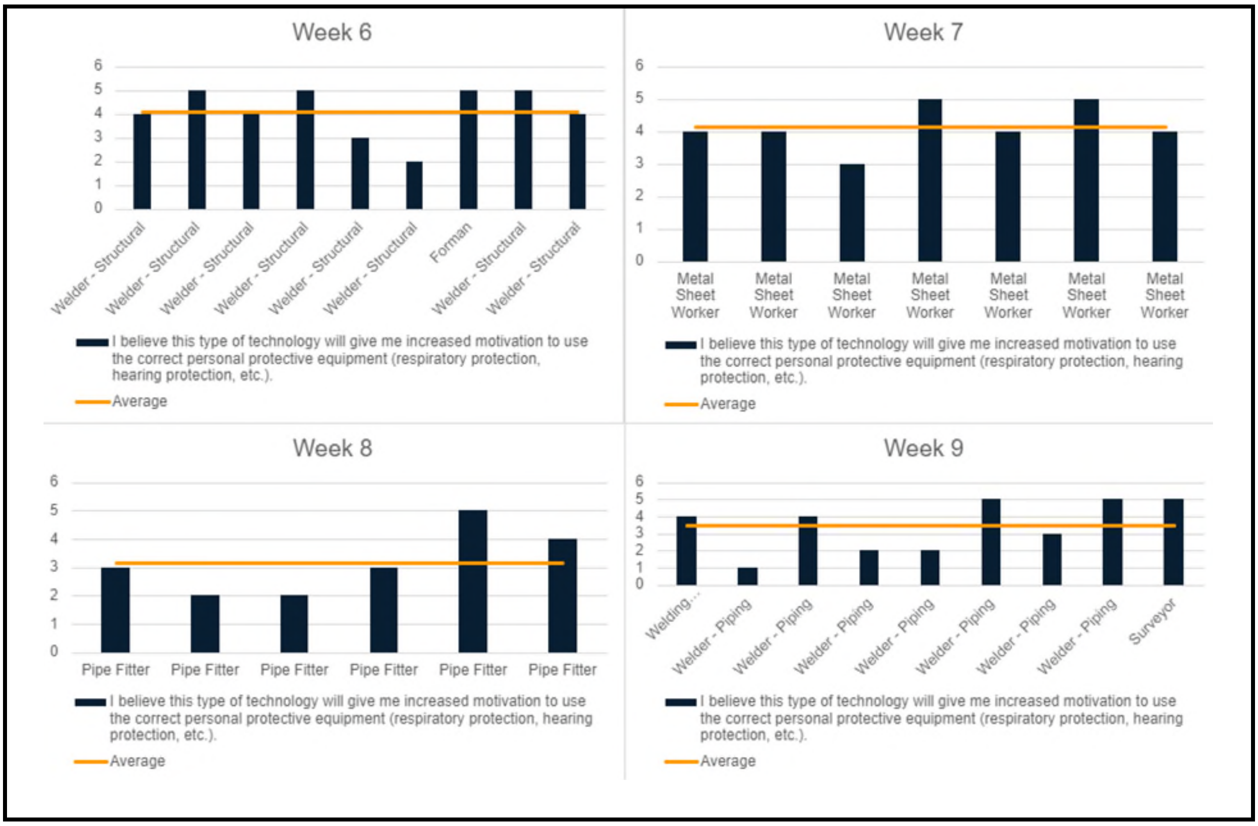
The participant responses to the survey questions were measured on a 5-point Likert scale, where 1 = Strongly Disagree and 5 = Strongly Agree. Key findings:

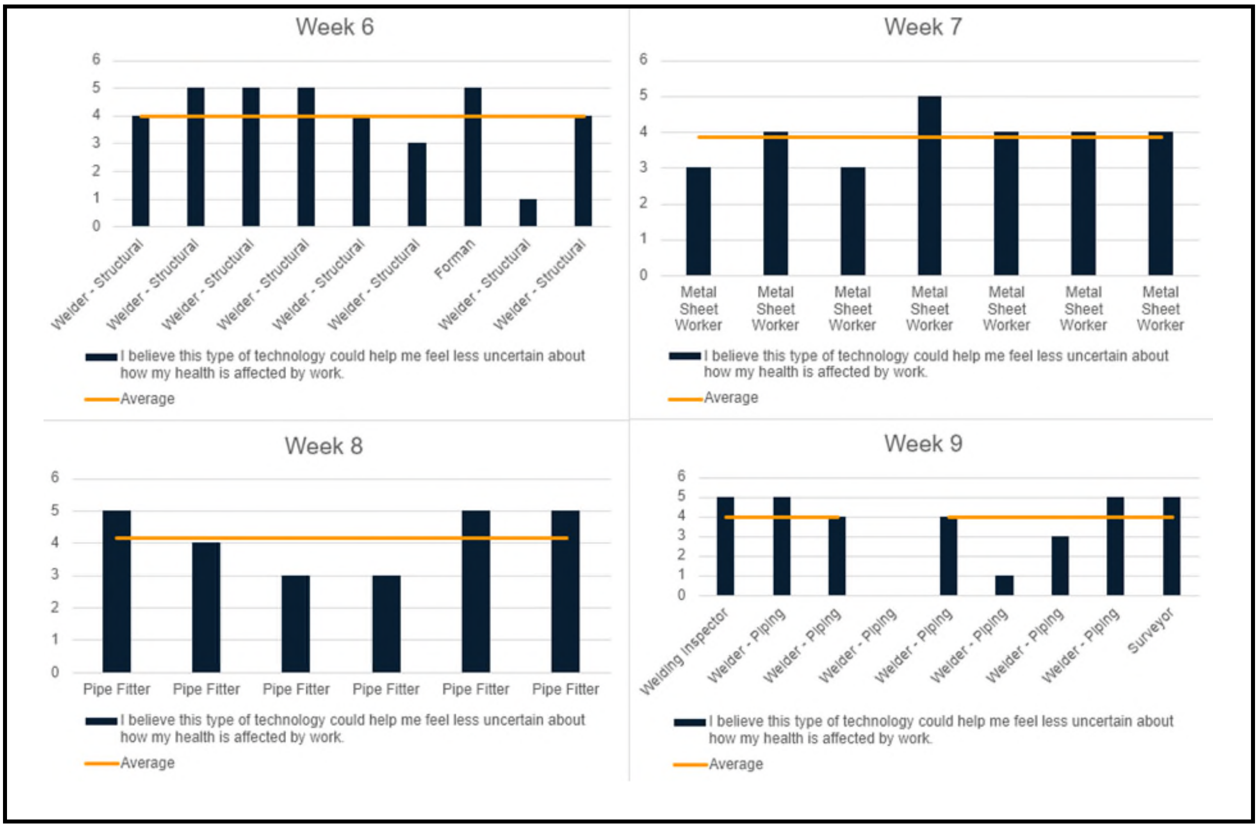
- The average scores range from 3.7 to 4.5, indicating that most participants agree or strongly agree that wearable sensor technology can enhance their well-being and proactive health efforts.

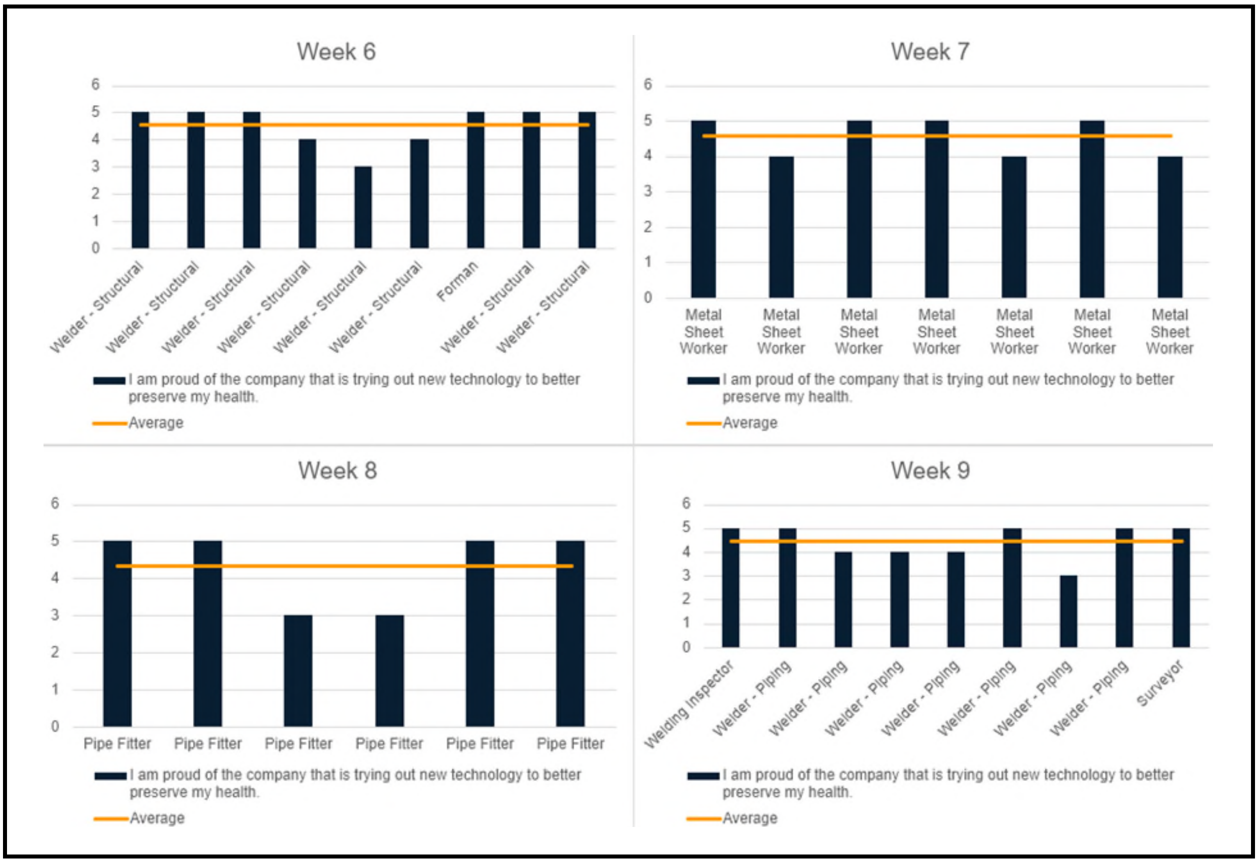
- The highest score (4.5, SD = 0.7) was for the statement: *"I am proud of the company that is trying out new technology to better preserve my health."* This suggests that employees appreciate the company's efforts in exploring innovative solutions to improve workplace health and safety.
- The statement "*I will be just as effective in my work even if I use this type of technology in my daily tasks*." scored 4.0 (SD = 1.0), suggesting that most participants do not see the technology as a hindrance to their productivity, but some may have concerns about its integration into their workflow.
- The statement *"I believe that this type of technology will protect me from potential health risks and help me maintain my health better."* received an average score of 4.2 (SD = 0.8), indicating strong agreement that the sensors contribute to workplace safety and health maintenance.

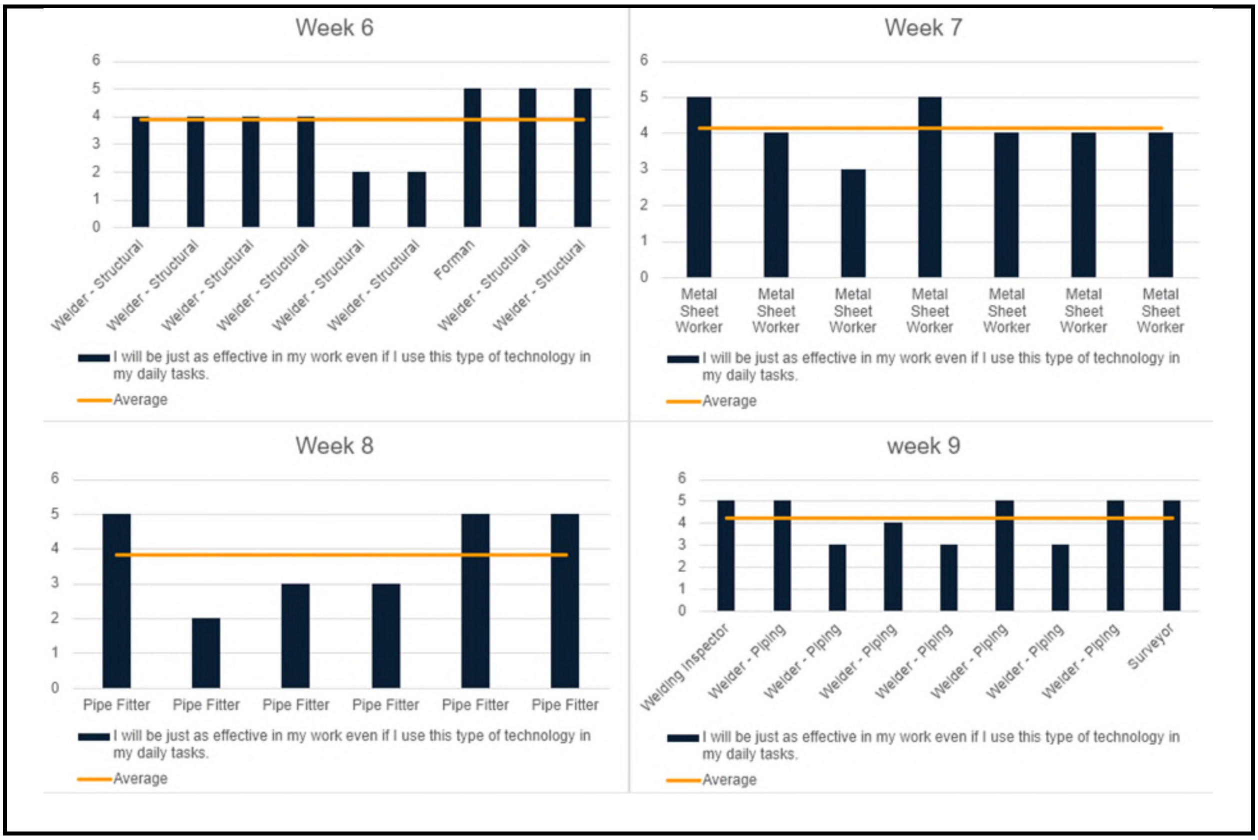
The figures below illustrate participants feedback, categorized by job roles and disciplines for clearer analysis.




Week 6
Welder - Structural
Forman
I believe this type of technology will give me increased motivation to use the correct personal protective equipment (respiratory protection, hearing protection, etc.).
Average
Week 7
Metal Sheet Worker
I believe this type of technology will give me increased motivation to use the correct personal protective equipment (respiratory protection, hearing protection, etc.).
Average
Week 8
Pipe Fitter
I believe this type of technology will give me increased motivation to use the correct personal protective equipment (respiratory protection, hearing protection, etc.).
Average
Week 9
Welding...
Welder - Piping
Surveyor
I believe this type of technology will give me increased motivation to use the correct personal protective equipment (respiratory protection, hearing protection, etc.).
Average


Week 6
Welder - Structural
Forman
I believe this type of technology could help me feel less uncertain about how my health is affected by work.
Average
Week 7
Metal Sheet Worker
I believe this type of technology could help me feel less uncertain about how my health is affected by work.
Average
Week 8
Pipe Fitter
I believe this type of technology could help me feel less uncertain about how my health is affected by work.
Average
Week 9
Welding inspector
Welder - Piping
Surveyor
I believe this type of technology could help me feel less uncertain about how my health is affected by work.
Average


Week 6
Welder - Structural
Forman
I am proud of the company that is trying out new technology to better preserve my health.
Average
Week 7
Metal Sheet Worker
I am proud of the company that is trying out new technology to better preserve my health.
Average
Week 8
Pipe Fitter
I am proud of the company that is trying out new technology to better preserve my health.
Average
Week 9
Welding Inspector
Welder - Piping
Surveyor
I am proud of the company that is trying out new technology to better preserve my health.
Average


Week 6
Welder - Structural
Forman
I will be just as effective in my work even if I use this type of technology in my daily tasks.
Average
Week 7
Metal Sheet Worker
I will be just as effective in my work even if I use this type of technology in my daily tasks.
Average
Week 8
Pipe Fitter
I will be just as effective in my work even if I use this type of technology in my daily tasks.
Average
week 9
Welding Inspector
Welder - Piping
Surveyor
I will be just as effective in my work even if I use this type of technology in my daily tasks.
Average

Conclusion

The results suggest that wearable sensors technology is positively received by employees, with a particularly high appreciation for the company's initiative in adopting health-preserving solutions. While most participants believe the technology will enhance safety, reduce health uncertainties, and encourage PPE use, the variability in responses (especially for PPE motivation) highlights the need for additional awareness or training to maximize engagement.

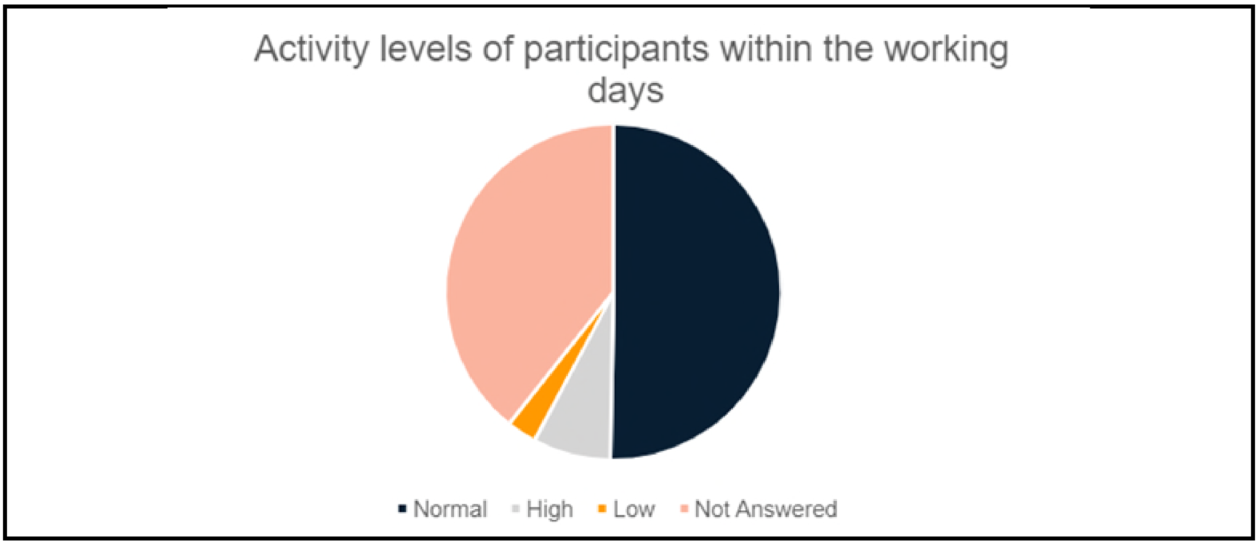
Daily and Weekly Questionnaires Results

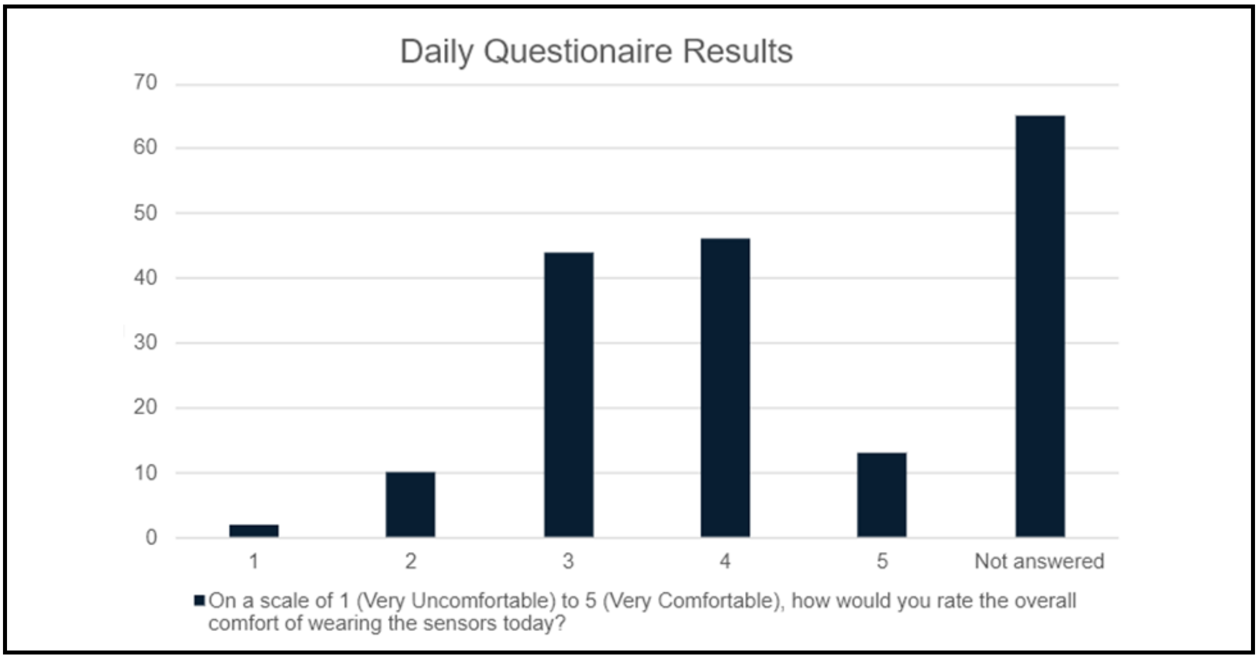
Daily Questionnaires

As part of the study, participants were asked to complete a short questionnaire at the end of each working day. The objective was to assess their experience with the sensors, identify any technical issues, and evaluate comfort, usability, and potential impact on their workflow. Additionally, the questionnaire aimed to gather insights into work activity levels, unusual incidents, and sensor notifications, helping to understand how workers engage with the technology in real-world conditions.

Participants were asked to rate their overall activity level during an 8-hour workday as Low, Normal, or High. The majority (87 responses) reported Normal activity, while 13 participants rated their activity level as High. Only 5 participants reported Low activity. Additionally, 68 responses were missing or not answered.

This distribution suggests that most participants experienced a typical workload during their shifts.

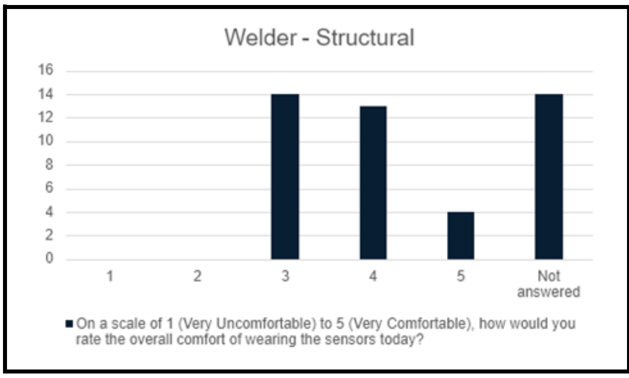


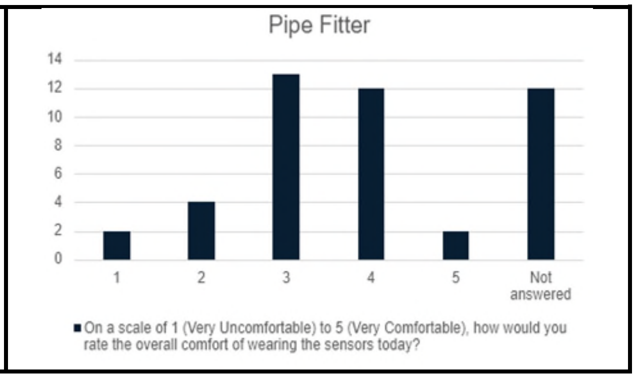


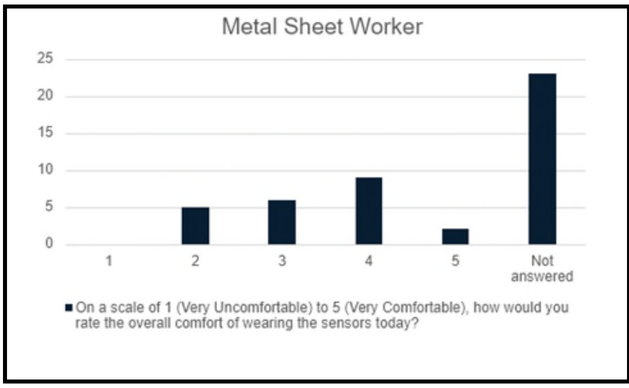
Based on participants' daily responses to the question, ***"On a scale of 1 (Very Uncomfortable) to 5 (Very Comfortable), how would you rate the overall comfort of wearing the sensors today?"***, the majority exhibited either a stable or positive trend in their ratings. This suggests that while the sensors may have been unfamiliar at first, their comfort level either improved or remained unchanged over time. This trend indicates that the majority of participants generally adapted to wearing the sensors, with no significant decline in perceived comfort.

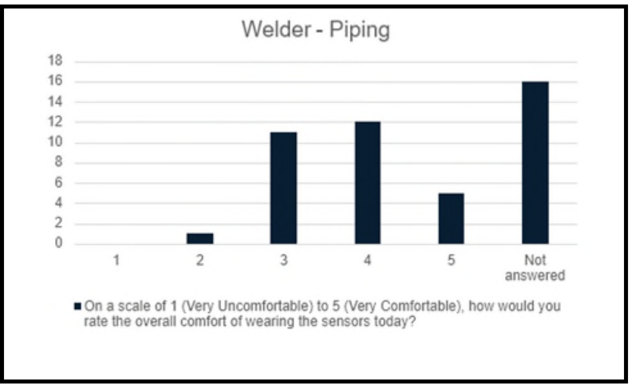
However, we also observed several participants whose ratings followed a negative trend, indicating a decrease in perceived comfort. This variation in responses highlights that the collected data represents a diverse range of experiences—some individuals are more adaptable to change, while others may be more resistant.

This diversity in feedback ensures that our findings account for different user preferences and adaptation levels, making the results more representative for larger scale implementation. The following plot presents the daily questionnaire results separated based on the roles and disciplines.





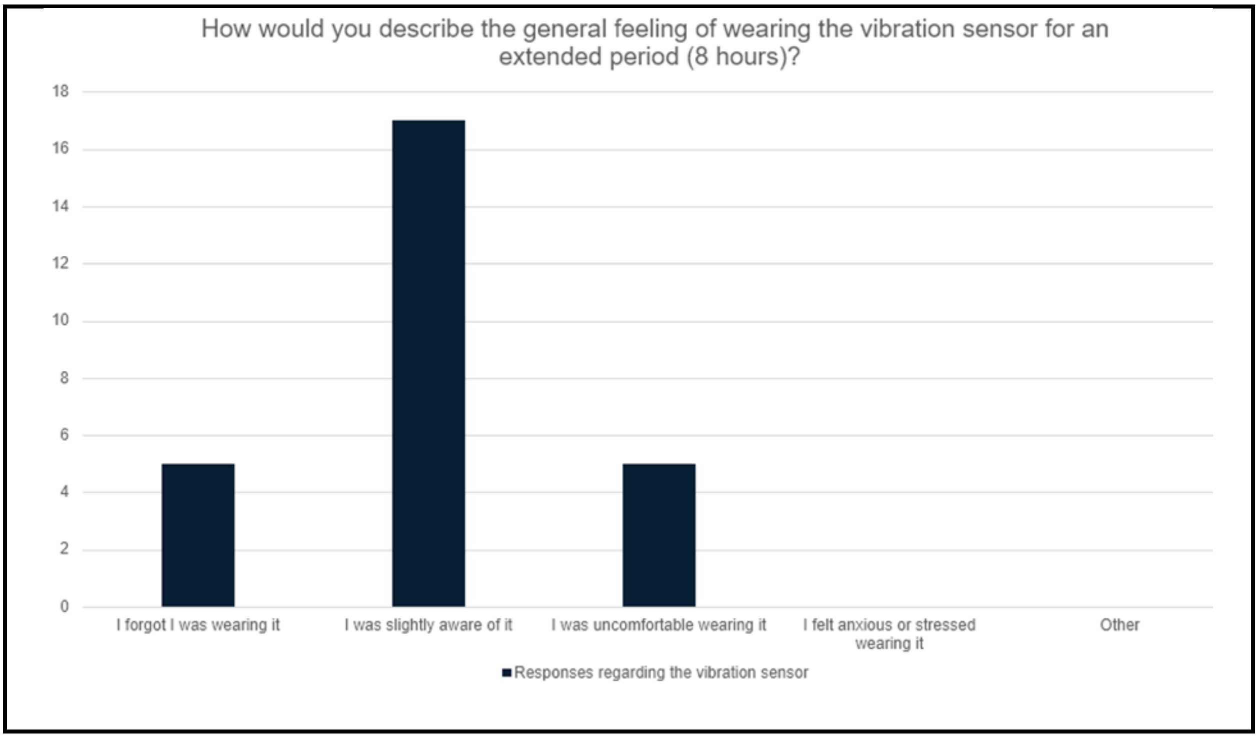




SUS- Weekly Questionnaires

To evaluate the usability and acceptance of the wearable sensors technology, participants were also asked to complete the System Usability Scale (SUS) questionnaire after one week of device usage. By administering the questionnaire after an extended period of use, we aimed to ensure that participants had sufficient hands-on experience with the devices before assessing their ease of use, comfort, and overall effectiveness. The results from the SUS questionnaire are presented in the following.

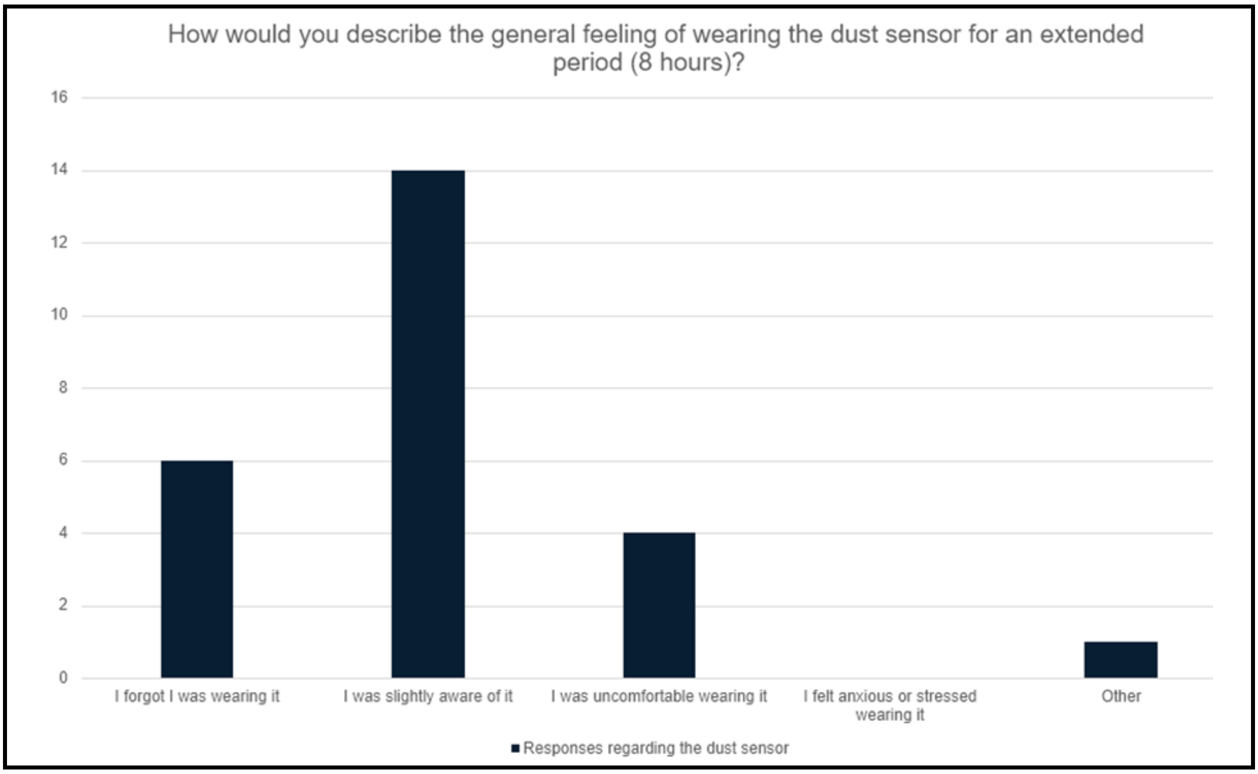
Vibration Sensor – R-Link



The responses indicate that most participants (17 out of 27) were slightly aware of the sensor, suggesting that while it was noticeable, it did not cause significant discomfort. Additionally, 5 participants reported that they forgot they were wearing it, indicating a high level of comfort for some users. Notably, no participants reported feeling anxious or stressed while wearing the device, and only 5 participants found it uncomfortable.

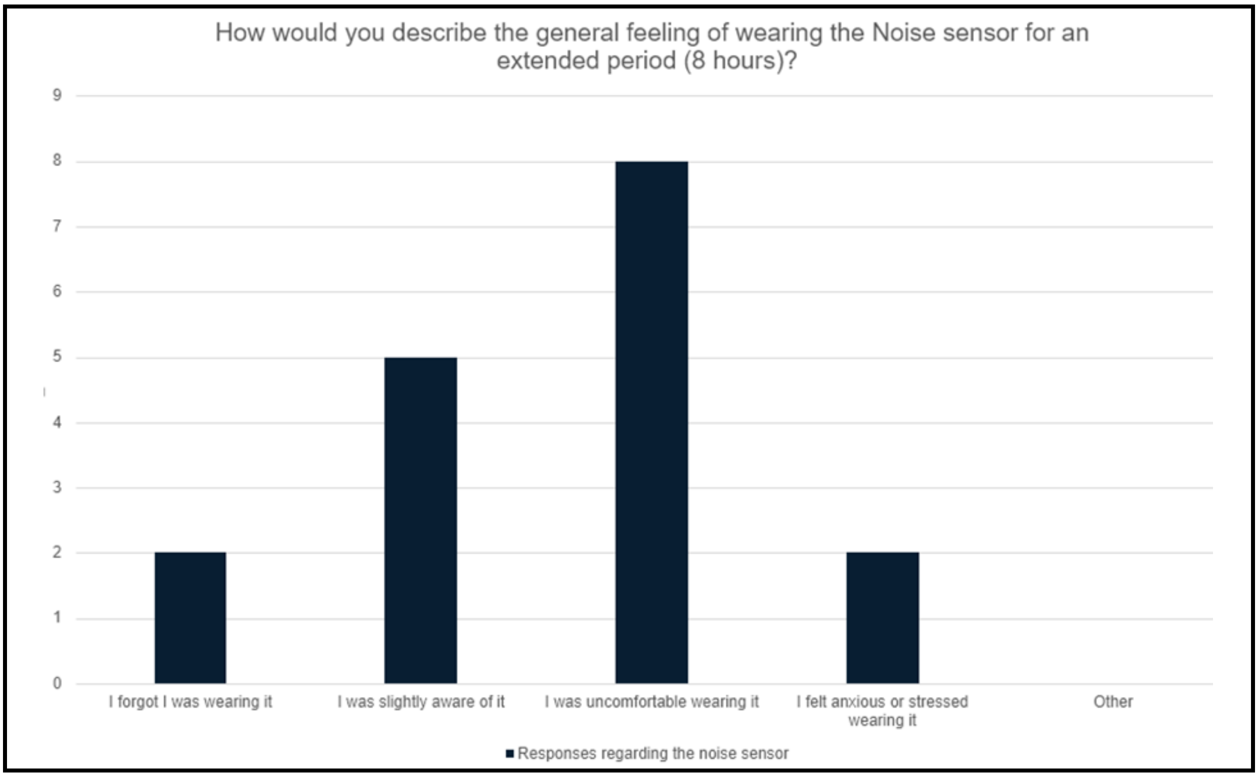
Dust Sensor – Trolex

Participant feedback on the dust sensor indicates that it was generally well tolerated, with 6 participants stating that they forgot they were wearing it and 14 participants reporting they were only slightly aware of it. This suggests that for most users, the sensor did not cause significant discomfort or interfere with daily tasks.

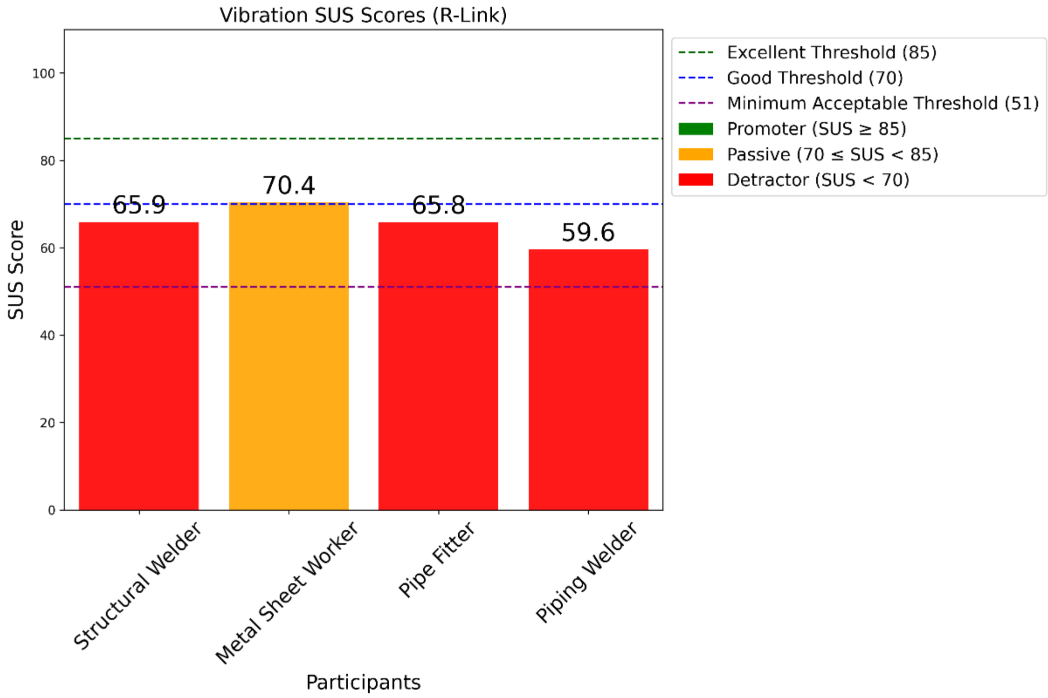


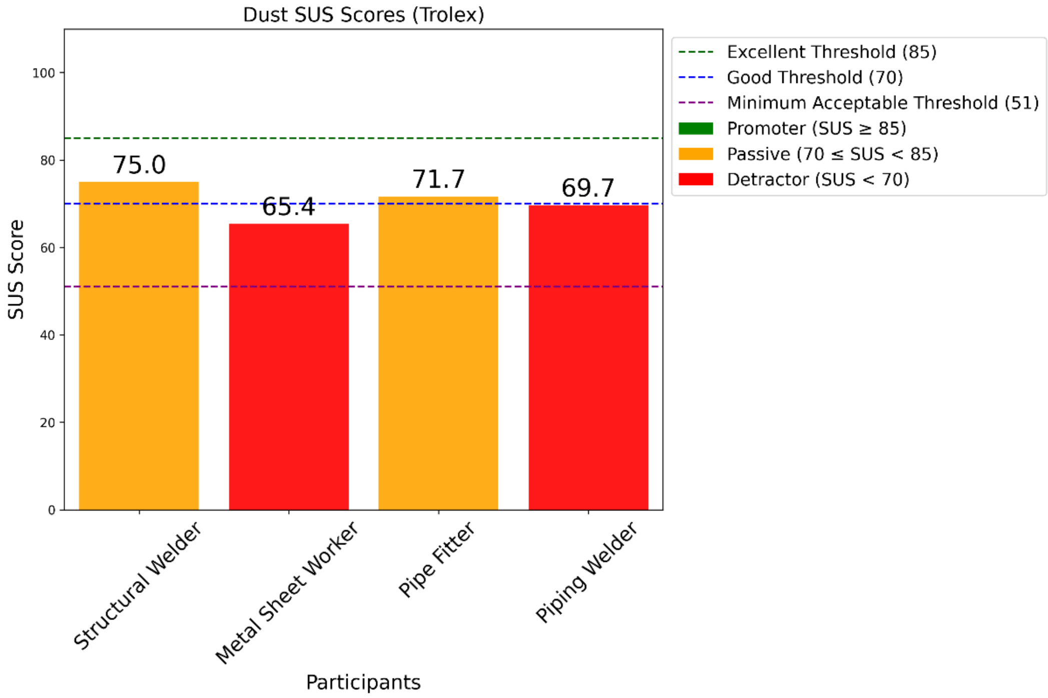
Noise Sensor – Minuendo

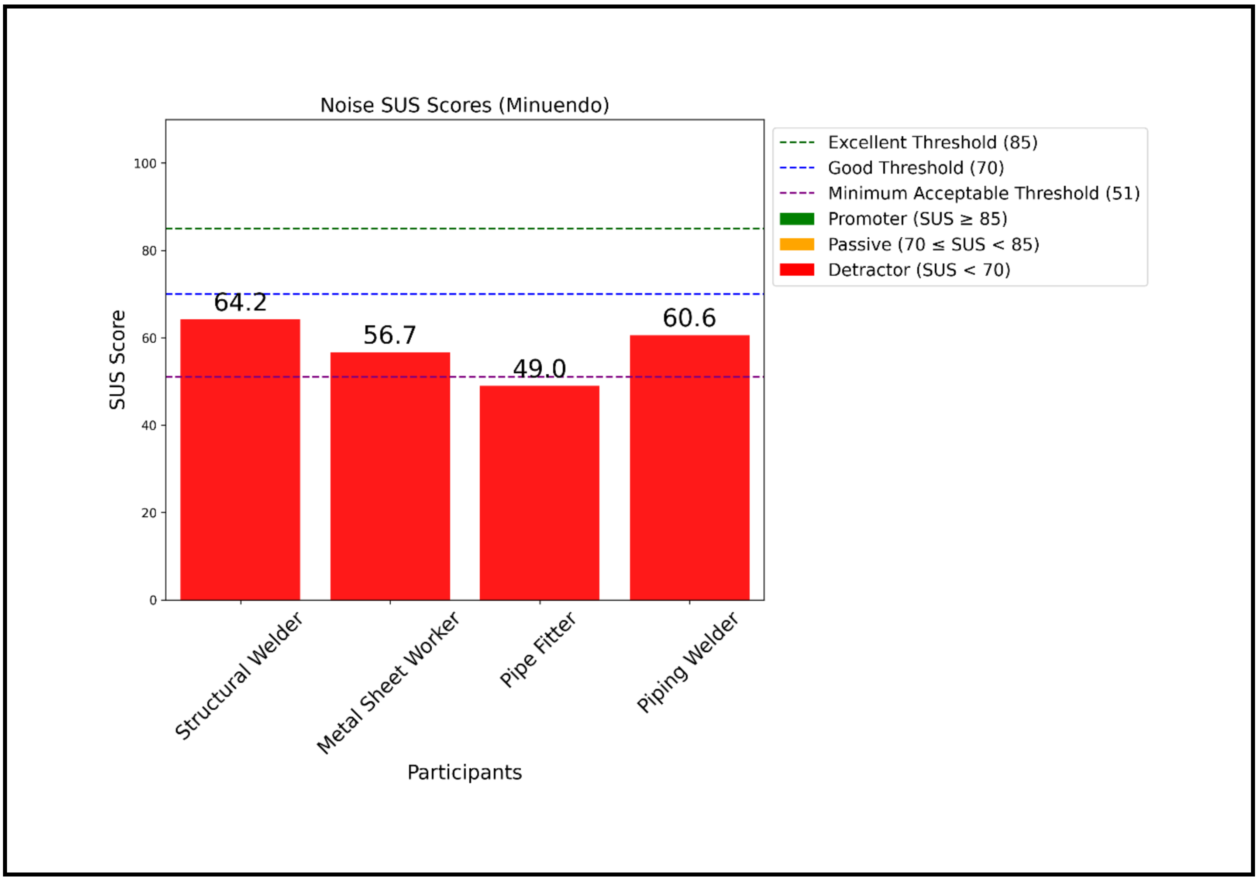
A notable number of participants (8) found the noise sensor uncomfortable, and 2 participants reported feeling anxious or stressed while wearing it. This suggests that while some users adapted to the sensor, a significant portion experienced discomfort.



The following plots present individual SUS scores, with plots categorized by test groups for clearer comparison.


Vibration SUS Scores (R-Link)
SUS Score
Participants
Structural Welder
Metal Sheet Worker
Pipe Fitter
Piping Welder
65.9
70.4
65.8
59.6
Excellent Threshold (85)
Good Threshold (70)
Minimum Acceptable Threshold (51)
Promoter (SUS ≥ 85)
Passive (70 ≤ SUS < 85)
Detractor (SUS < 70)


Dust SUS Scores (Trolex)
SUS Score
Participants
Structural Welder
Metal Sheet Worker
Pipe Fitter
Piping Welder
75.0
65.4
71.7
69.7
Excellent Threshold (85)
Good Threshold (70)
Minimum Acceptable Threshold (51)
Promoter (SUS ≥ 85)
Passive (70 ≤ SUS < 85)
Detractor (SUS < 70)



Vibration Exposure Data

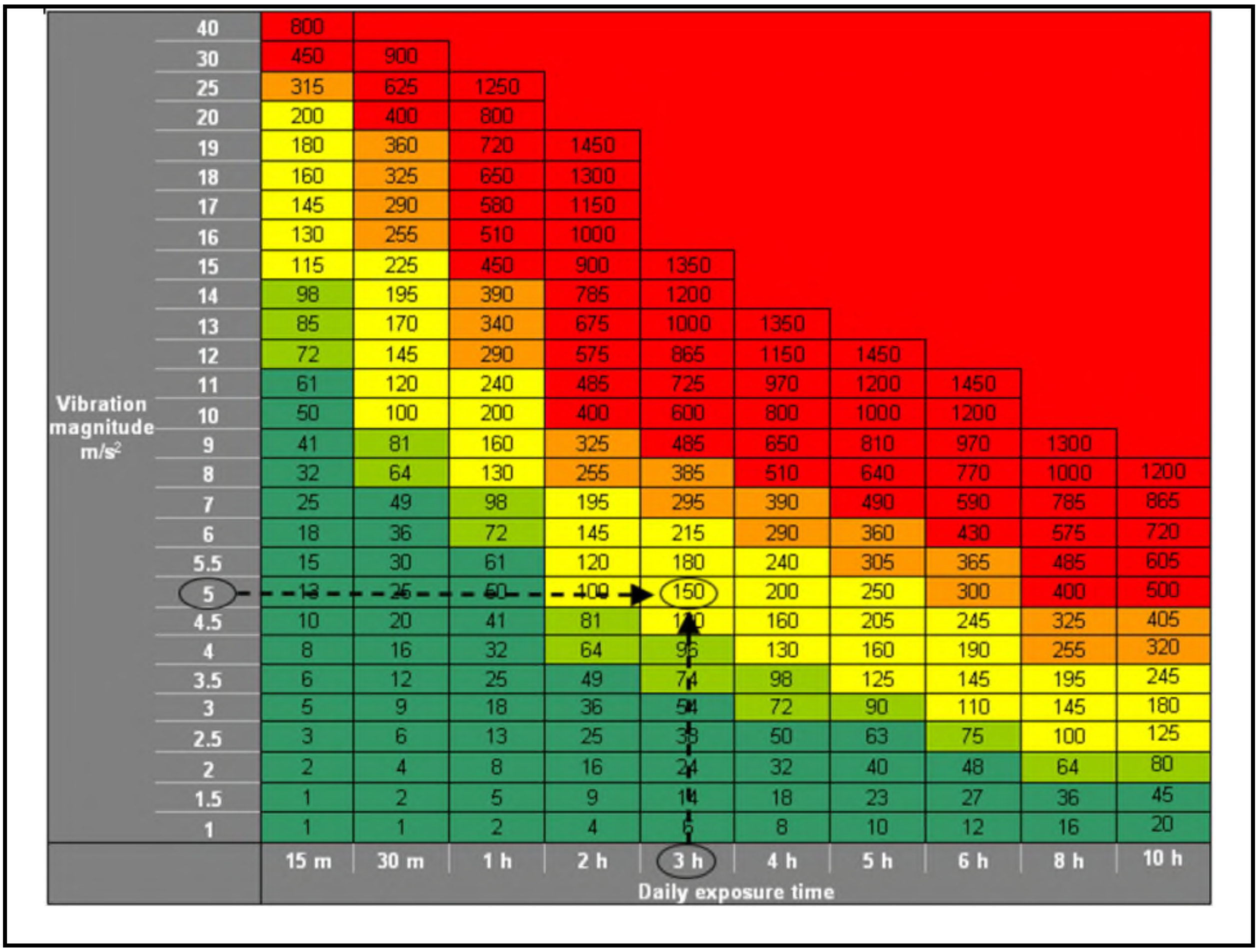
This section will present the vibration exposure data collected from participants throughout the experiment. It will include insights into the intensity and duration of vibration exposure during work shifts. Note that vibration exposure, based on intensity and duration, is converted into a point system according to the table below:

- 100 points corresponds to 8 hours of working with a tool with 2.5 m/s2:

  Take action to reduce exposure. 1 in 10 develop HAVS in 12 years at this level.

- 400 points corresponds to 8 hours of working with a tool with 5 m/s2:

  Do not work above this level. 1 in 10 develop HAVS in 6 years at this level.



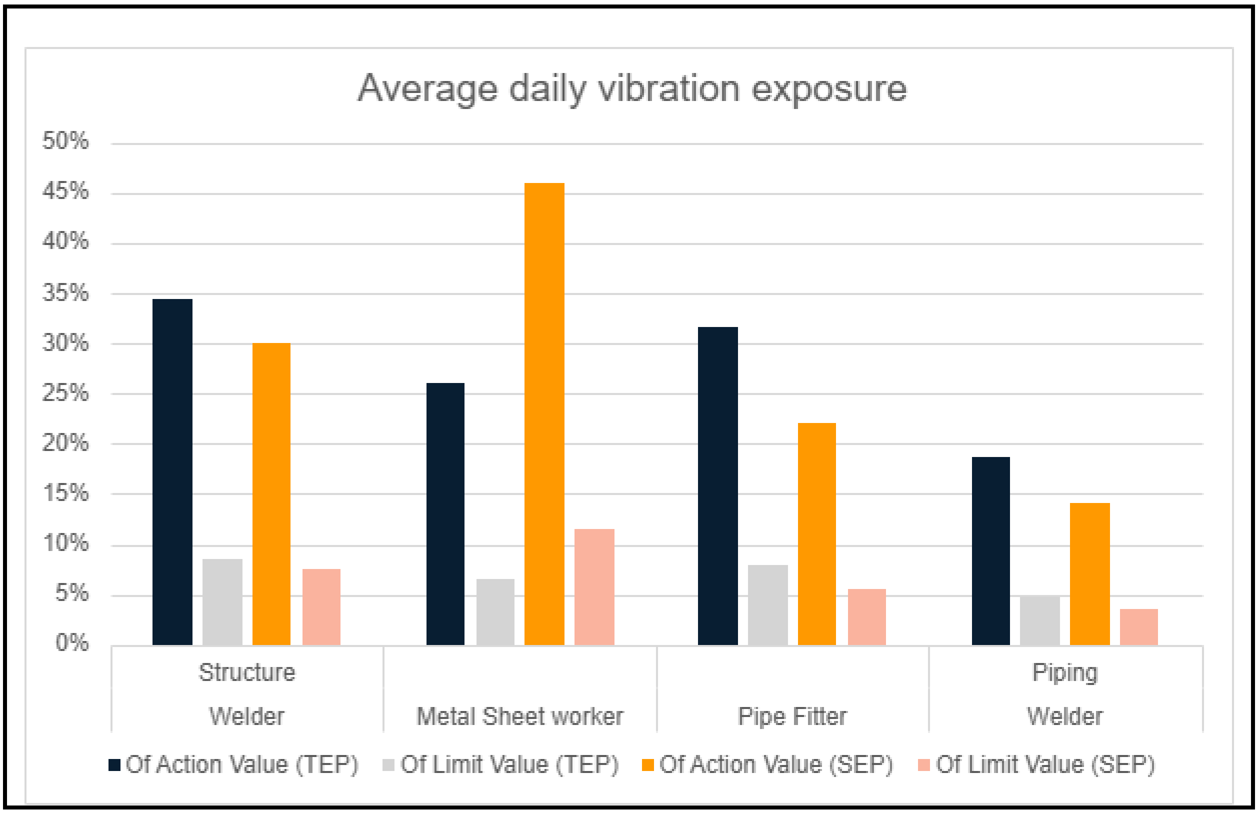
Vibration magnitude m/s²	15 m	30 m	1 h	2 h	3 h	4 h	5 h	6 h	8 h	10 h
40	800									
30	450	900								
25	315	625	1250							
20	200	400	800							
19	180	360	720	1450						
18	160	325	650	1300						
17	145	290	580	1150						
16	130	255	510	1000						
15	115	225	450	900	1350					
14	98	195	390	785	1200					
13	85	170	340	675	1000	1350				
12	72	145	290	575	865	1150	1450			
11	61	120	240	485	725	970	1200	1450		
10	50	100	200	400	600	800	1000	1200		
9	41	81	160	325	485	650	810	970	1300	
8	32	64	130	255	385	510	640	770	1000	1200
7	25	49	98	195	295	390	490	590	785	865
6	18	36	72	145	215	290	360	430	575	720
5.5	15	30	61	120	180	240	305	365	485	605
5	13	25	50	100	150	200	250	300	400	500
4.5	10	20	41	81	120	160	205	245	325	405
4	8	16	32	64	96	130	160	190	255	320
3.5	6	12	25	49	74	98	125	145	195	245
3	5	9	18	36	54	72	90	110	145	180
2.5	3	6	13	25	38	50	63	75	100	125
2	2	4	8	16	24	32	40	48	64	80
1.5	1	2	5	9	14	18	23	27	36	45
1	1	1	2	4	6	8	10	12	16	20

R-link calculates exposure points based on

- Tool Exposure Points (TEP) which is pre-determined expected vibration magnitude multiplied by trigger time points.
- Sensed Exposure Points (SEP) which is real use sensed vibration magnitude multiply by trigger time of tool use.

R-Link constantly senses vibration. It determines if the nature of the vibration is from a tool to decide that a tool trigger has been pulled. If an operator forgets to tag a tool after sign-out, the R-Link will display and store SEP points as TEP points without tool identity. Once a tool tag is read during a shift, TEP and SEP points are created independently. The trigger time and the last read tag vibration are used to calculate TEP points. If the operator forgets to tag the next tool, the TEP points will be based on the last tag read.

The figures below demonstrate the average HAV exposure data as a percentage of action (100 TEP exposure points) and limit values (400 TEP exposure points). The overall HAV exposure of participants remains below the action values, which is a positive outcome.



The table below summarizes the average exposure points and tool usage information, categorized by roles and disciplines. This data provides valuable insights into hand tool usage across groups, supporting further improvement efforts.

However, it is important to note potential sources of inaccuracy in the measurements, such as incorrect use of tags for tool identification, improper fastening of the watch, and variations in tool handling and grip technique, all of which can influence the recorded data.

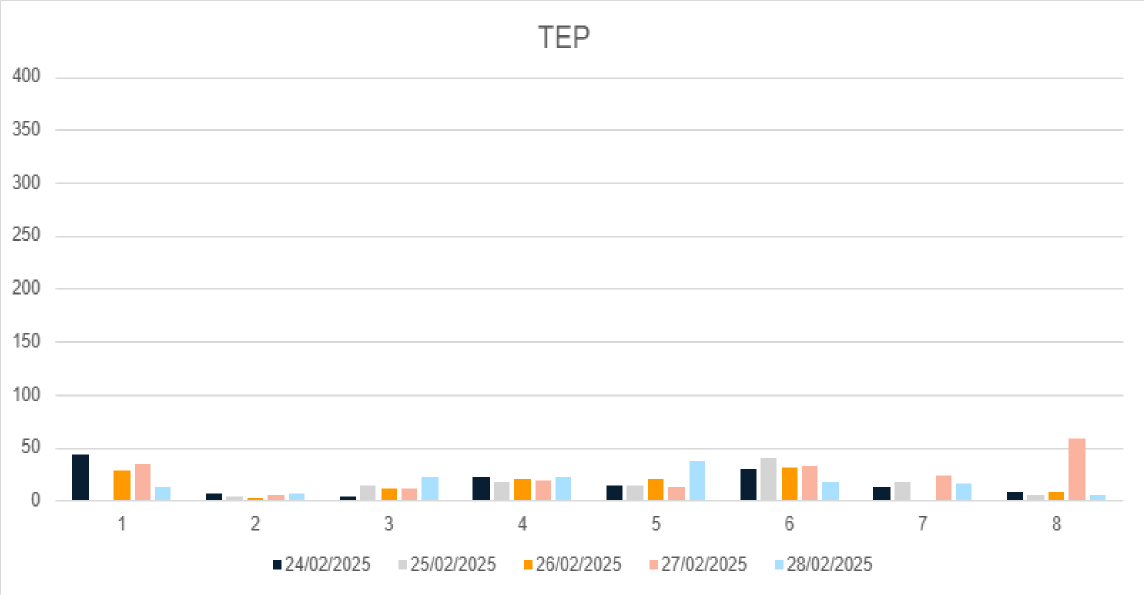
According to Reactec experts, examining SEP points is of high importance. Assuming the acceleration measurements are highly accurate, SEP points reflect the actual exposure level. In contrast, TEP points are solely based on the nominal vibration levels reported by the tool providers. However, factors such as tool aging, misuse, or variations in grip can cause the sensed vibration on the hand to be higher than the values reported by the equipment providers. Therefore, SEP points provide a more realistic assessment of the exposure level.

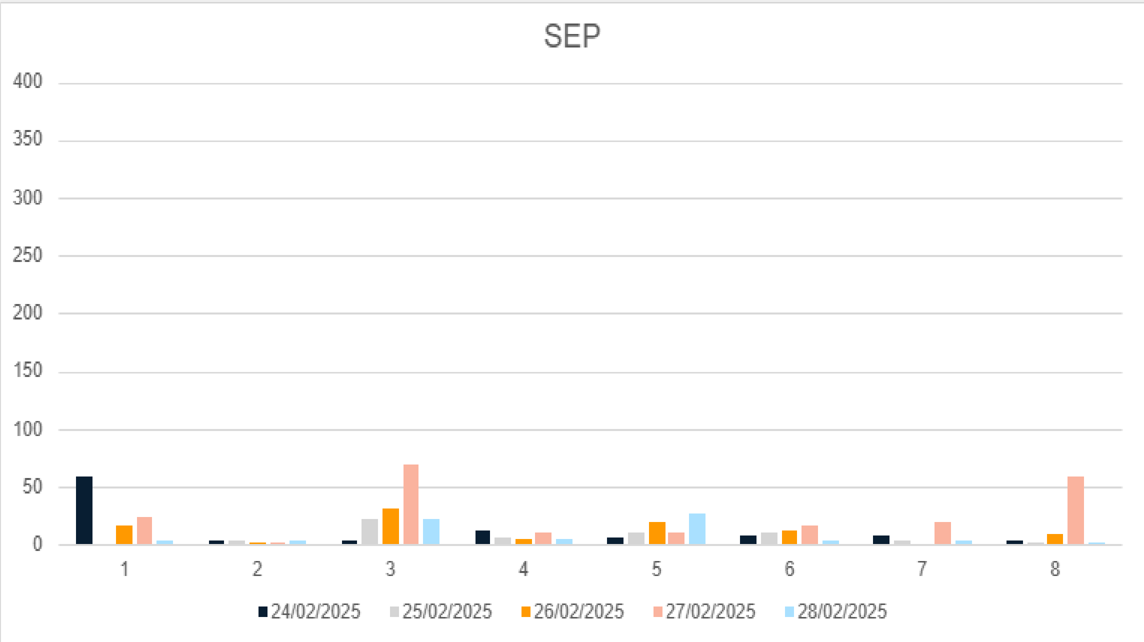
Roles	Discipline	Usage Time (Minutes)	Number of times used	Average usage time per session	TEP	SEP	Exposure points per minute	Of action value (TEP)	Of limit value (TEP)	Of actio n value (SEP)	Of limit value (SEP)

Welder	**Structure**	57.2	10.8	5.3	34.3	30.02	0.60	34%	8.6%	30%	8%
Metal Sheet Worker	**Structure**	43.6	13.5	3.2	26.0	45.98	0.60	26%	6.5%	46%	11%
Pipe Fitter	**Pipe**	45.9	10.5	4.4	31.6	21.88	0.69	32%	7.9%	22%	6%
Welder	**Pipe**	25.3	11.3	2.2	18.7	14.33	0.74	19%	4.7%	14%	4%

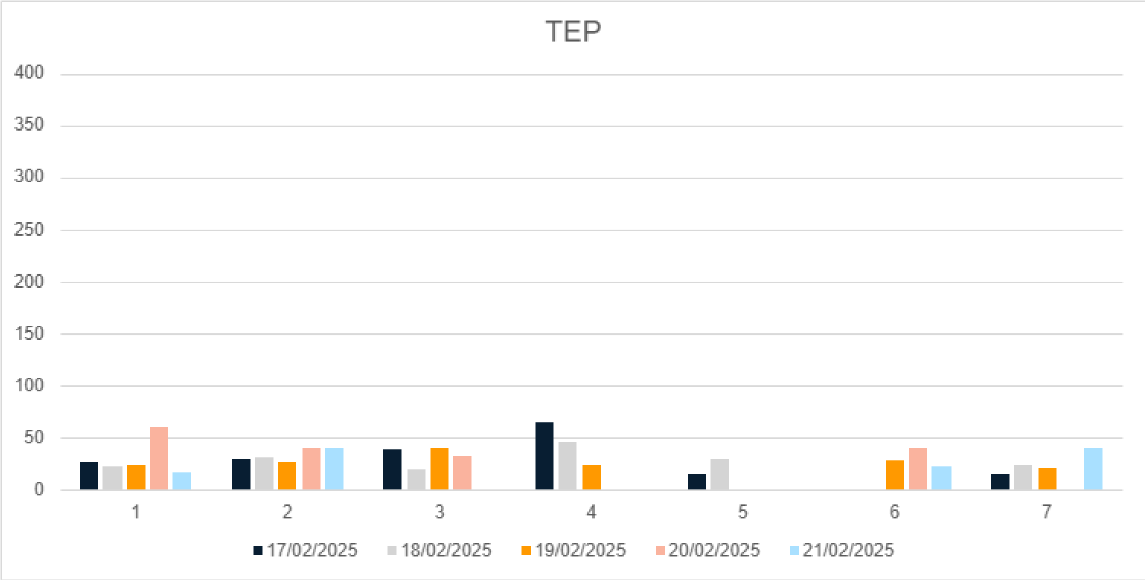
Furthermore, the plots below illustrate the TEP exposure points of individuals for each test week, confirming that HAV exposure points remain below the action values.

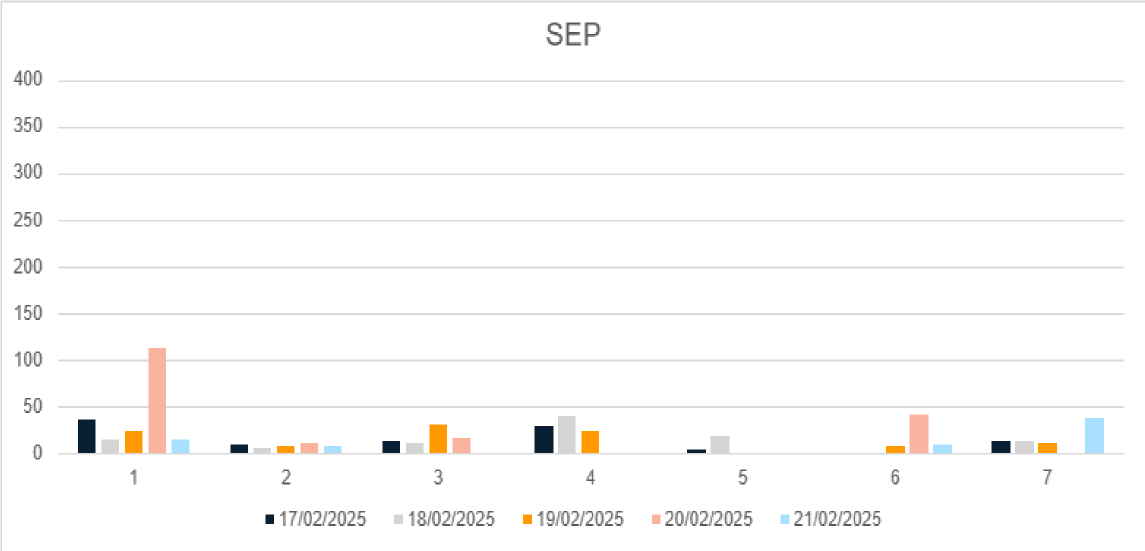
Welder – Piping – Week 9



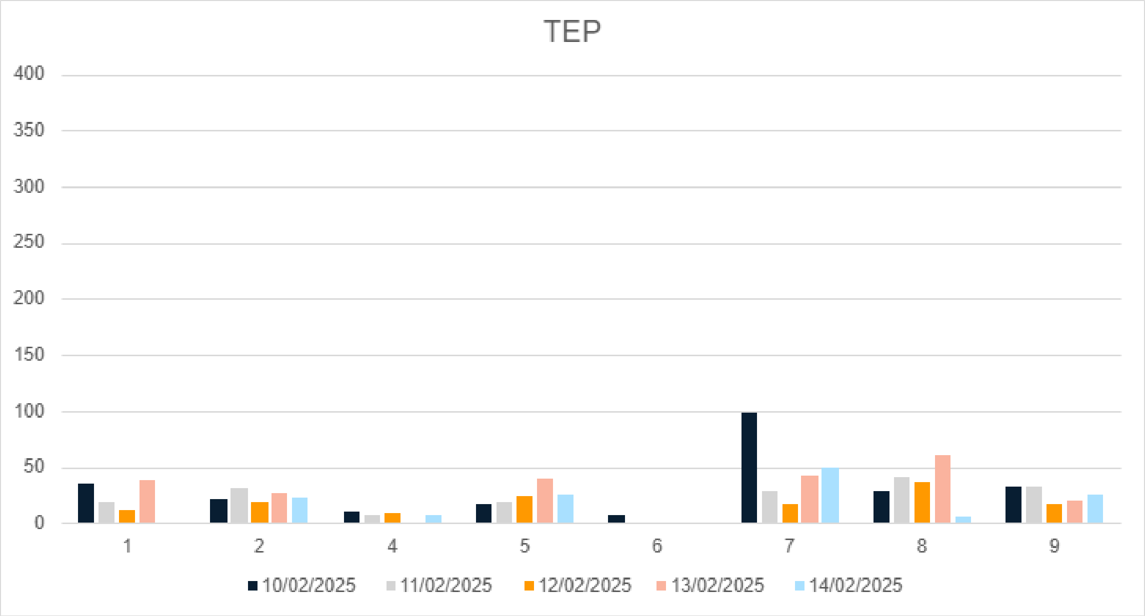


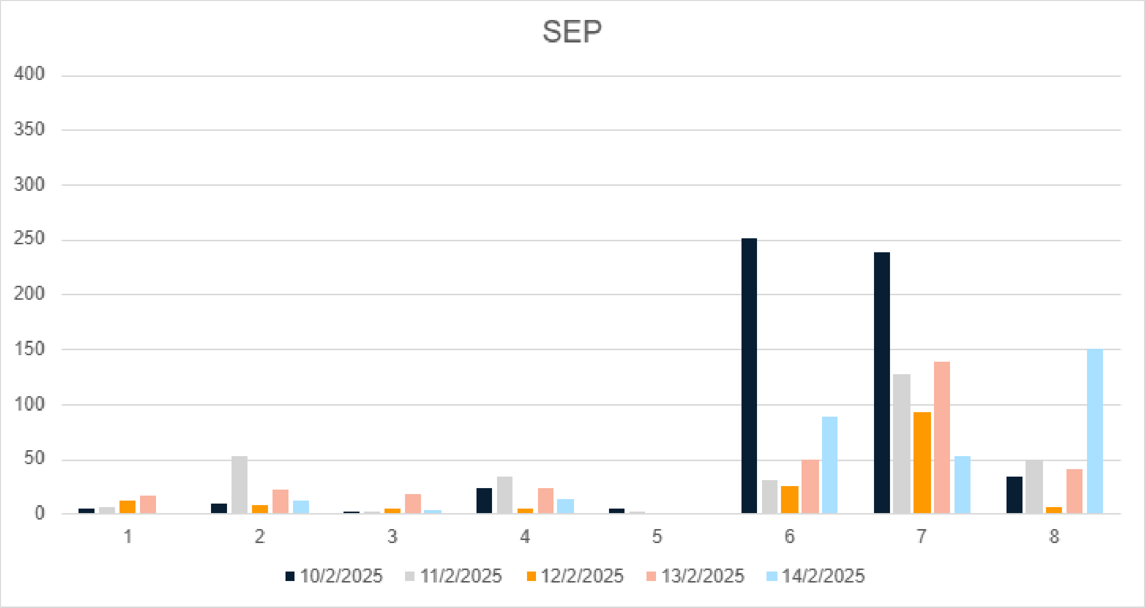
Pipe Fitter – Week 8



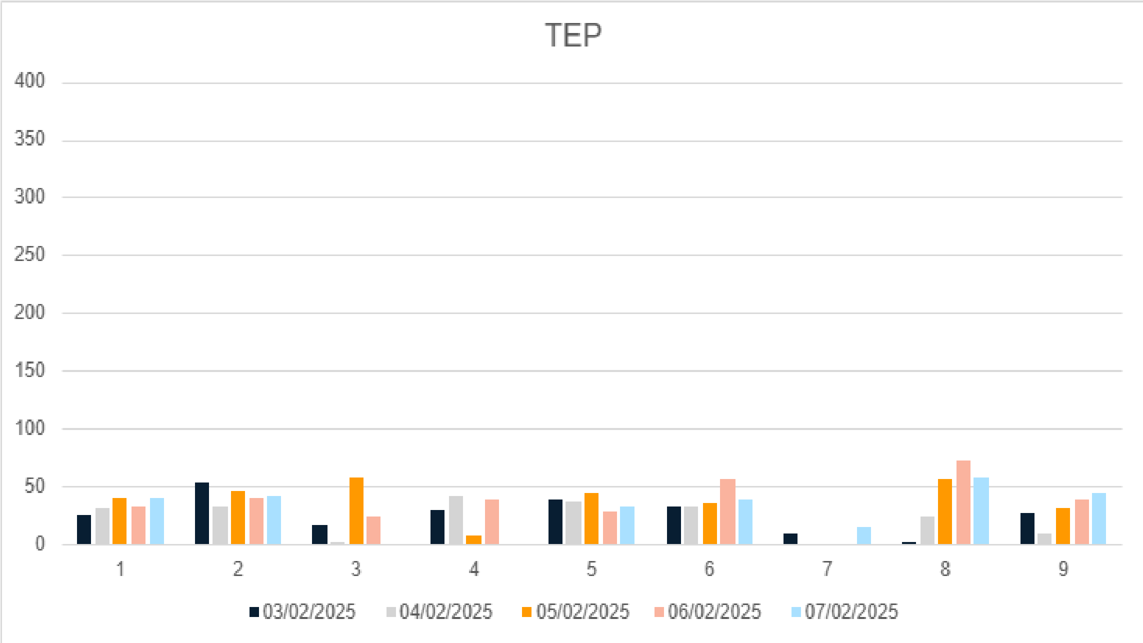


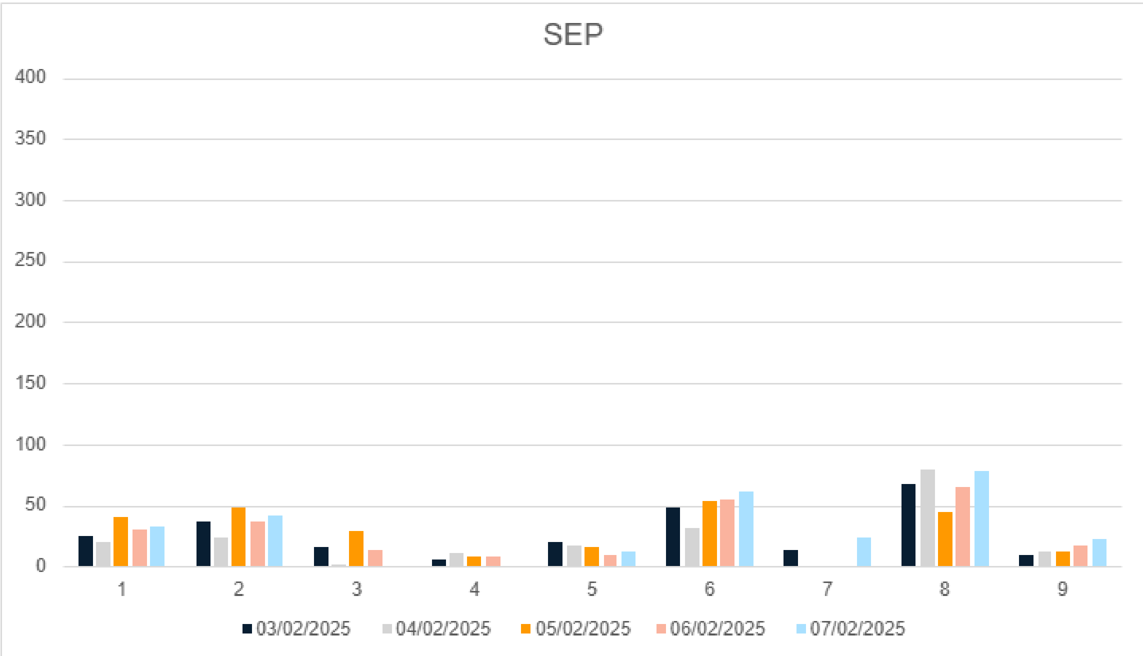
Metal Sheet Worker – Week 7





Welder – Structure – Week 6





Dust Exposure Data

Particulate matter exposure data was measured using a Trolex sensor, with a sampling rate set to 10 seconds. Short-term exposure level (STEL) was measured over a defined period of 15 minutes, and time-weighted average (TWA) was measured over a period of 480 minutes (average over 8 hours), with a threshold of 1 mg/m^3.

Note that in week 8, we experimented with a low STEL threshold. This activated alarms for many participants, making the experience difficult and interfering with their work activities, leading them to put the sensor away. Consequently, after one day of testing with the lower threshold, we decided to revert to the default values. However, determining a proper and feasible threshold and period, as well as interpreting PM measurements and translating them into total dust levels, remains an open question to be explored in the next phases of the project.

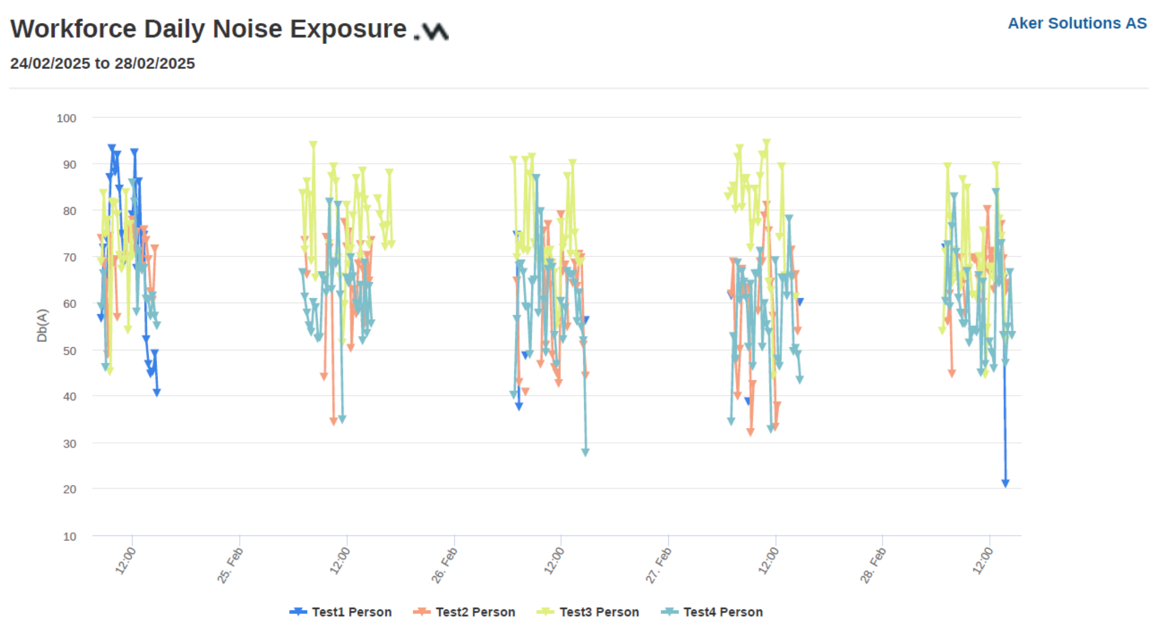
Note that in this data collection, the purpose of these measurements was to explore the feasibility of introducing a sensor worn on the clothes for the participants.

Additionally, according to the recorded data, there are multiple days where only vibration data was recorded, with no dust measurements. However, participants claimed that they used the dust sensor. This suggests there may be syncing issues between the R-link and Trolex sensor, which have already been reported by our team to the sensor providers.

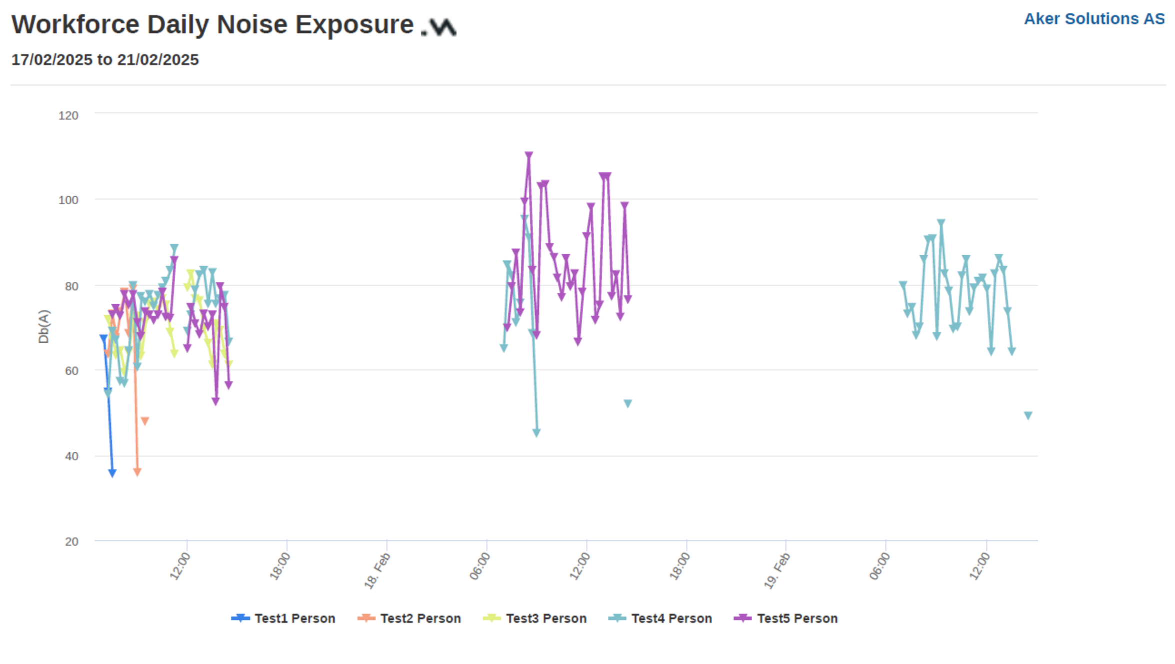
Noise Exposure Data

Noise exposure levels were measured using a Minuendo sensor. However, we only had five sensors, so only five participants each week tested the noise sensor. The figures below (extracted from Reactec analytics platform) show the highest noise measurements in ear categorized by groups and disciplines.

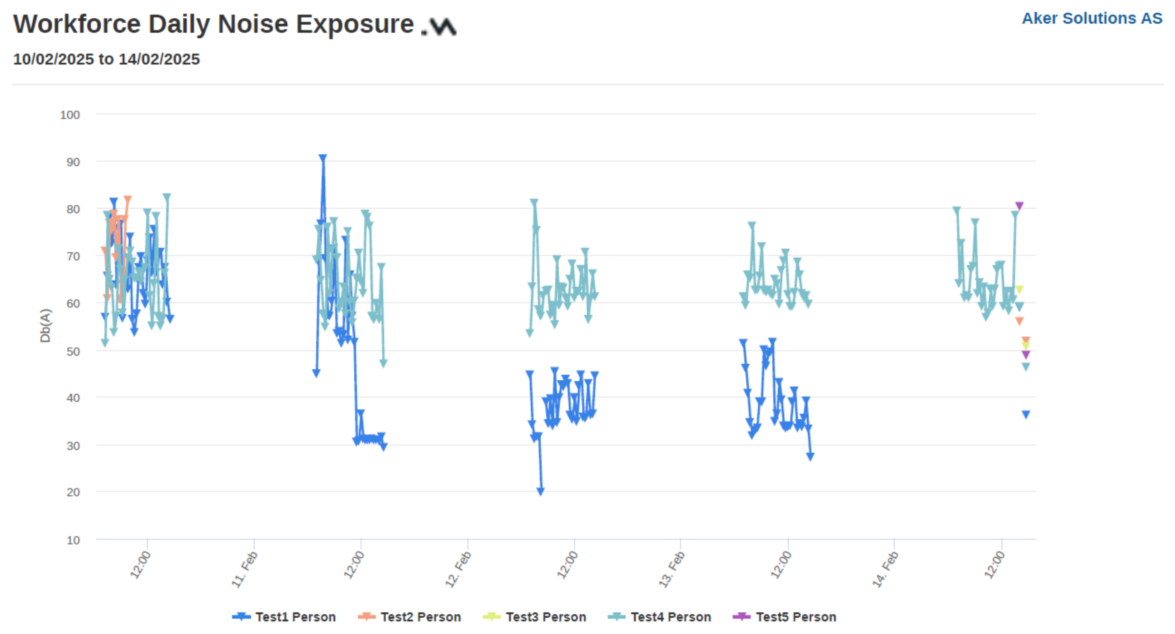
Welder- Piping- Week 9



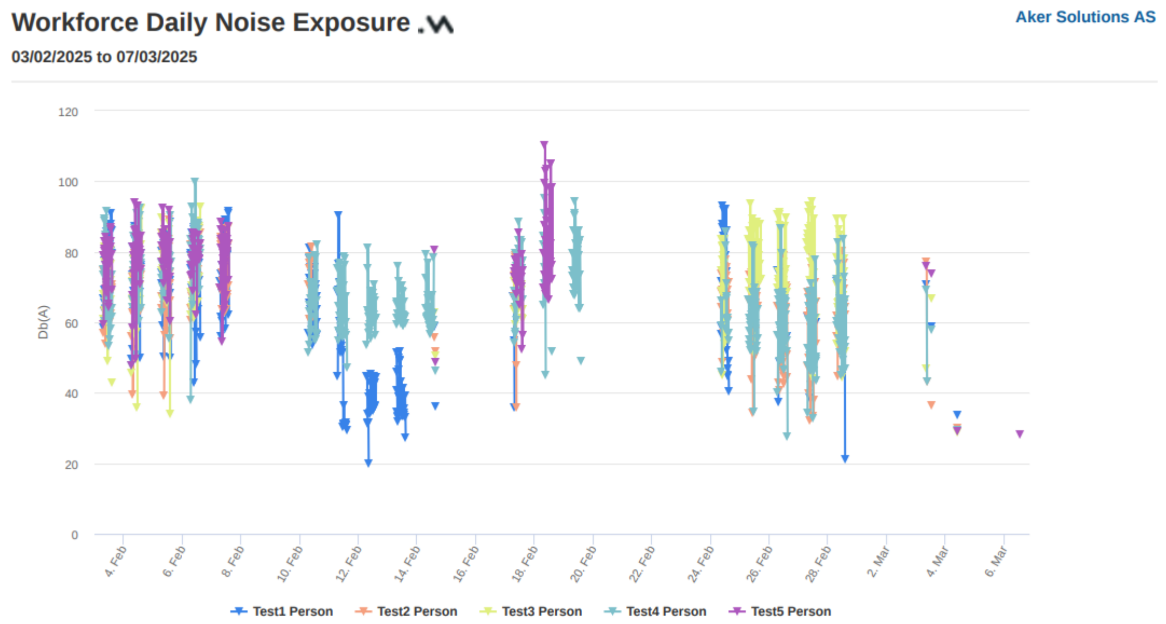
Pipe Fitters - Week 8



Metal Sheet Workers - Week 7

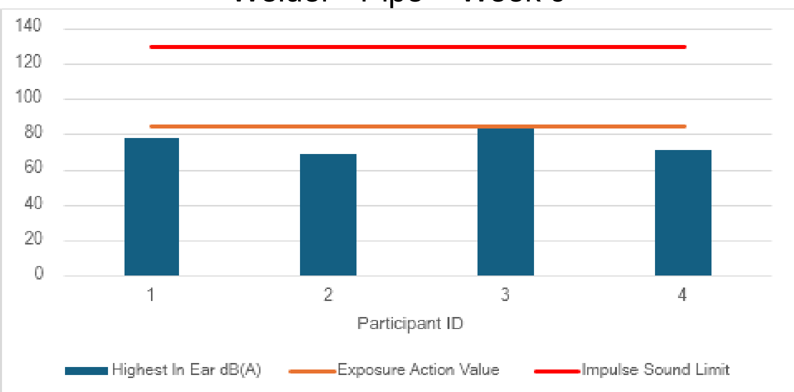


Welder- Structure - Week 6

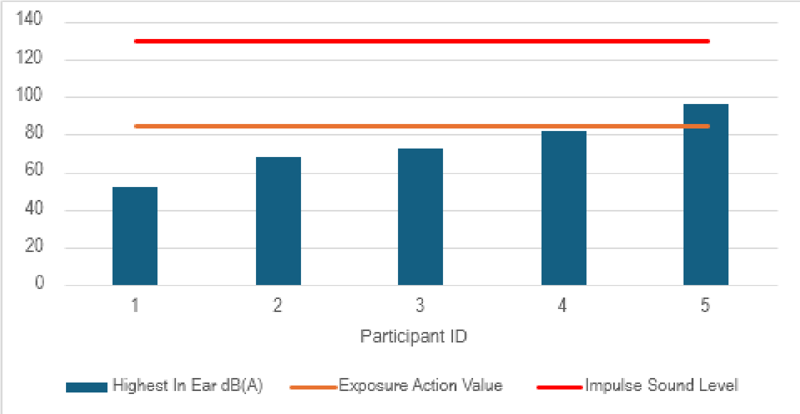


The following plots also present the average daily exposure measured for each participant within each test group.

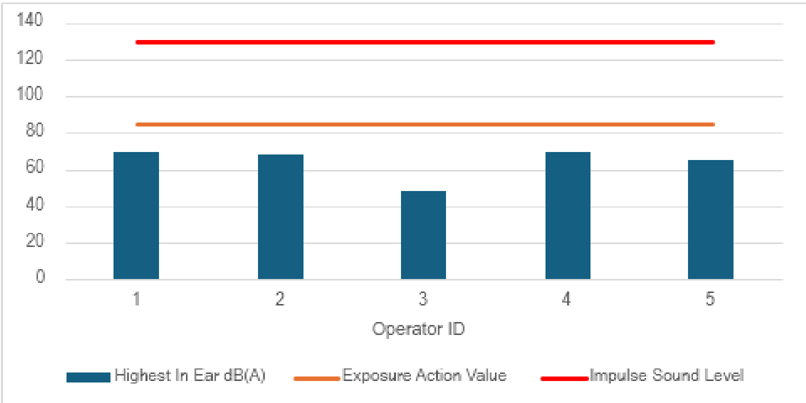
Welder - Pipe – Week 9



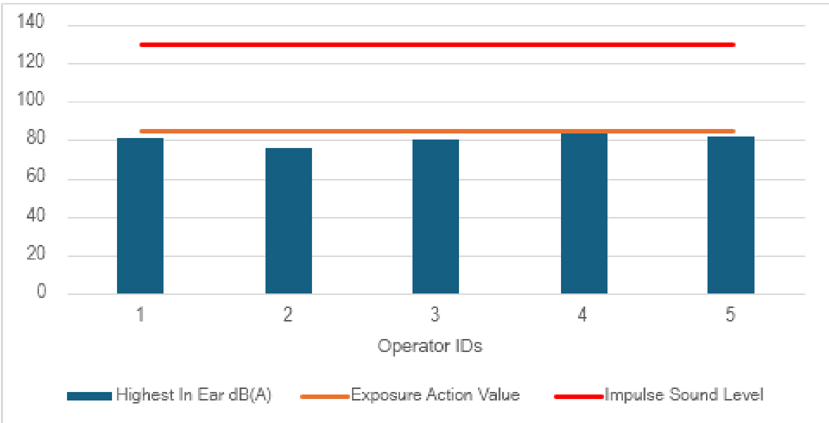
Pipe Fitters – Week 8



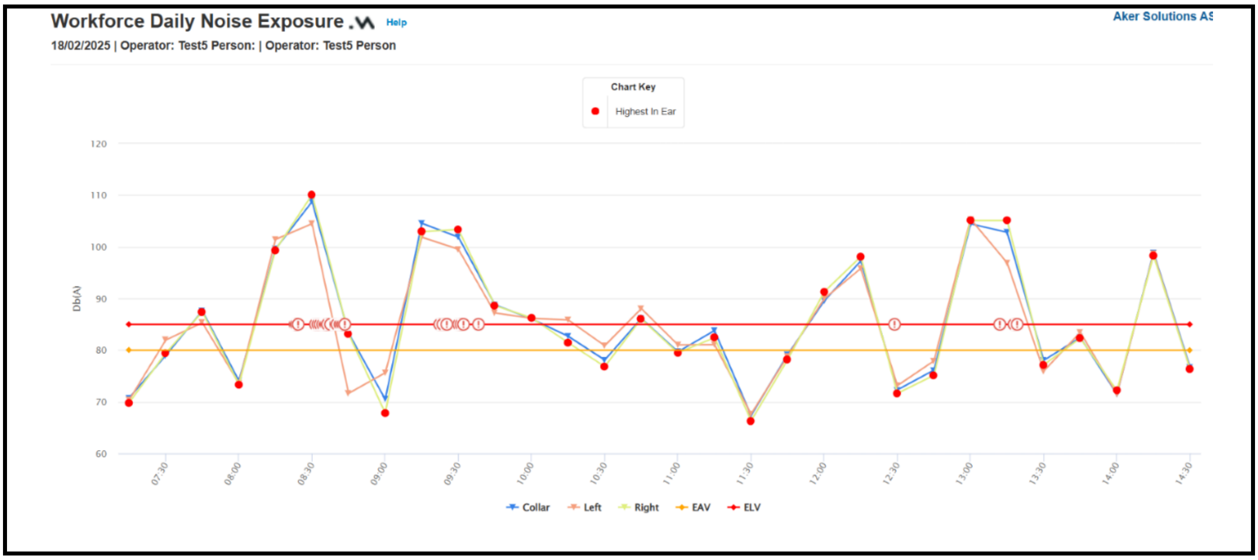
Metal Sheet Workers – Week 7



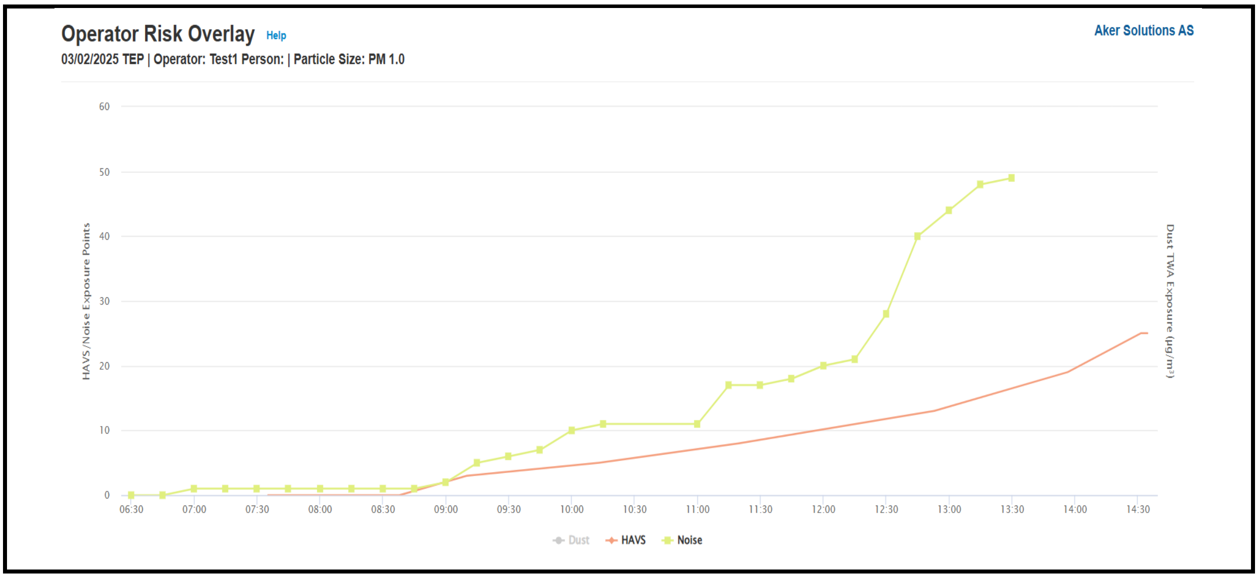
Welder – Structure – Week 6



Here is also an example of the noise measurements in Week 8, during which the participant was exposed to high levels of noise and received multiple alarms. However, unfortunately, the receipt of alarms or taking any action was not reflected in the questionnaires. We assume that either the alarms were ignored, or the earplugs were not worn properly, causing the alarms to be missed.

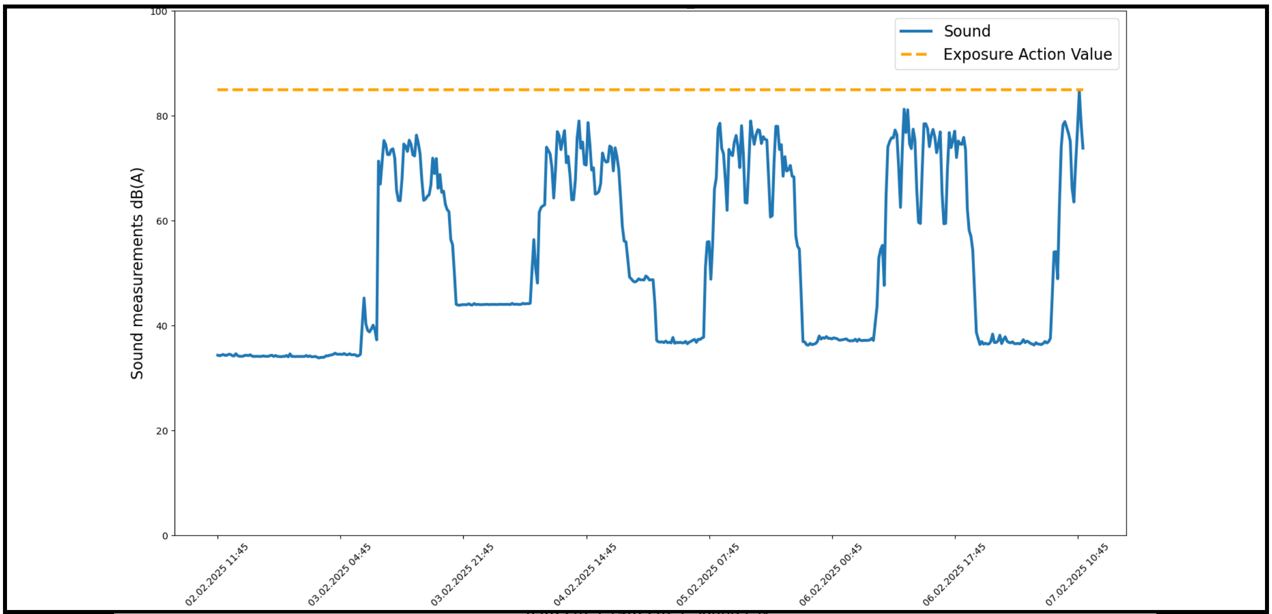


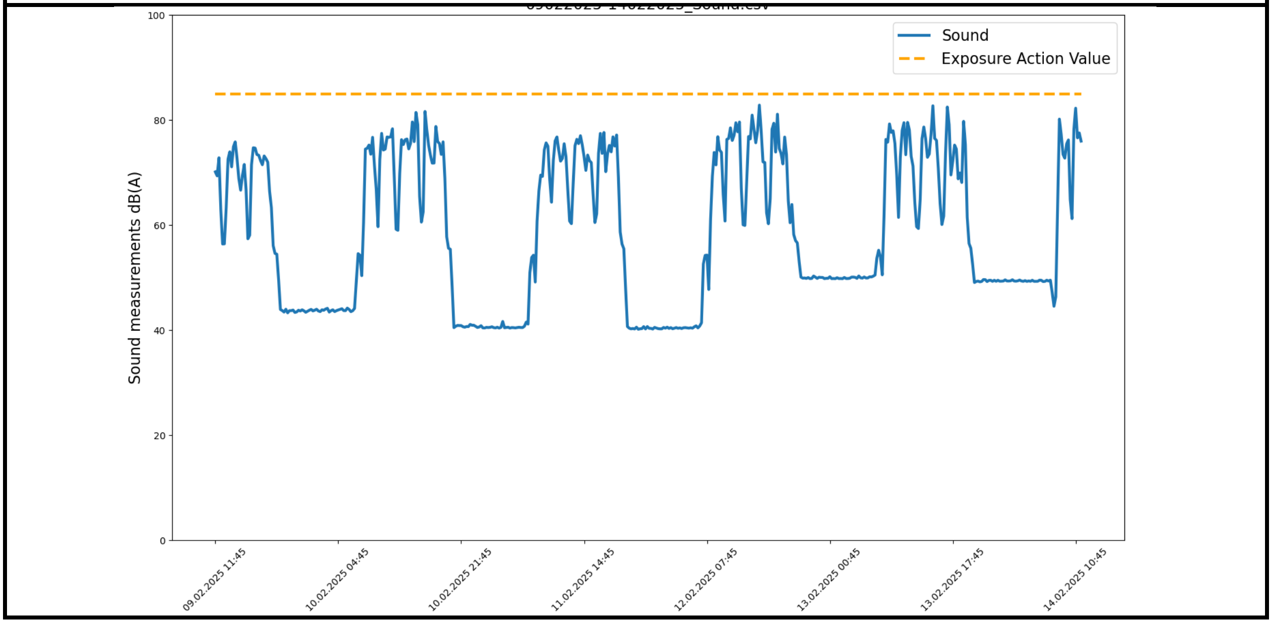
Another example of the exposure levels for a participant on the first day of the phase II experiment is shown below. As the figure shows, there is a positive correlation between noise, and vibration points. As the vibration points increase, noise exposures also rise. By investigating these correlations more thoroughly in future analyses, we can gain valuable insight into specific tasks, machinery, or areas within the yard that are associated with higher risk profiles. This knowledge can inform targeted interventions such as adjusting work practices to reduce simultaneous exposure to multiple hazards.



Stationary Sensor Data

In addition to wearable sensors, the Aeroguard sensor was tested. It was placed in the welding area for the first two weeks of phase II testing. Below, we present examples of sound measurements recorded during this period.





Conclusions from Phase II

In conclusion, utilizing wearable sensor technology and continuous monitoring, rather than spot checks, makes it feasible to gain a comprehensive overview of the environment, identify faulty devices, and understand the reasons behind pollution increases. By analysing the type of work and its correlations with exposure levels, we aim to draw meaningful insights. The initial two phases of data collection were limited, primarily to observe how participants respond to new technology and wearable sensors, as well as to gauge the range of exposures.

Analysing SUS scores and responses indicates that the vibration sensor was generally well tolerated, with most users adapting to it over time. However, the fact that some participants experienced mild discomfort or awareness highlights a potential area for ergonomic improvements to enhance long-term wearability.

The overall positive reception of dust sensor suggests it can be integrated effectively into daily operations without significantly affecting user comfort.

Based on participants feedback, the noise sensor did not meet the expected comfort and usability standards for extended wear. Given that worker comfort is a critical factor in the successful adoption of wearable technology, these results suggest that the noise sensor is not a suitable option for continued use. Its impact on user comfort and potential interference with daily tasks outweigh its intended benefits. As a result, we recommend discontinuing the use of the noise sensor.

GDPR Guidelines

In Q4-2024, an external law firm, Simonsen Vogt Wiig (SVW), was engaged to provide recommendations on ensuring GDPR compliance when using wearable sensors to measure exposure to hazardous factors. The memo from SVW is reported in Appendix - Memo from Simonsen Vogt Wiig about GDPR compliance of the proposed process and method. The memo was reviewed with the support of Aker Solutions' GDPR counselor, who suggested further investigations of the use cases and purposes. Although it seems feasible to establish a framework for implementing wearable sensors based on workers' consent, it remains uncertain if this approach would be fully backed by a legal basis. The main challenge to face is the access to personal data, i.e., associated exposure data to a single employee. The initial concept where the medical doctor and the line manager of yard workers could access this information shall be revised according to the GDPR guidelines to ensure compliance. Consequently, GDPR and data protection laws do not represent a showstopper for the solution envisioned by this project.

In analyzing the use of sensors, the legal firm identified four key purposes for processing personal data. Real-time limitation of health risk:

1. Sending notifications to workers to act when exposure reaches the set threshold.
2. Real-time intervention by leaders or MD: Allowing leaders or MD to intervene if workers do not act upon receiving notifications.
3. Analysis of aggregated data: Understanding exposure in the working environment and identifying possible mitigating measures.
4. Use of collected exposure data by MD: Using the data for diagnosis purposes and follow-up of workers.

The memo emphasized the importance of adhering to GDPR and the Norwegian Data Protection Act, as the use of sensors involves processing personal data. The memo discussed the legal basis for processing, suggesting legitimate interest for real-time notifications and interventions, and consent for using collected exposure data for health services.

The memo concluded that:

- Use case *3. Analysis of aggregated data: Understanding exposure in the working environment and identifying possible mitigating measures* can be implemented as long as anonymity of the workers is guaranteed. In this case, a legal basis can in principle be established considering the legitimate interest by Aker Solutions.
- Use cases 1., 2., 4., cannot be clearly backed up on a legal basis and deserve more investigation.

After reviewing the memo together with Aker Solutions' GDPR counselor, it was concluded that for use cases 1., 2., 4.,, it is possible to investigate if legitimate interest can be established through a detailed analysis of the relevant regulations from Arbeidstilsynet, focusing on the specific regulations pertaining to the working environment, data handling, and employer/employee rights and obligations.

In conclusion, further investigation into the implications and benefits of revisited use cases is needed. This, along with consultation with a GDPR counselor, should be examined in a larger project.

User stories and Data Platform

Through the analysis of commercially available sensors on the market, it is clear that each individual supplier, in its own way, tries to offer overlapping functionality, but locked in a separate format and without the opportunity to use sensors that the supplier itself does not offer.

Additionally, several key functional requirements are often missing, making it difficult to rely solely on a single supplier's data platform to achieve broader goals. In some cases, however, these platforms can provide complementary insights for occupational health professionals.

To achieve the desired outcome of implementing wearable sensors technology, a separate data platform should be developed that addresses the functional requirements of the users described in this chapter.

The data platform, along with its associated functional requirements and potential architecture, is described in a general manner to ensure its relevance across all industrial enterprises employing skilled workers exposed to occupational hygiene risks.

Personas and user stories

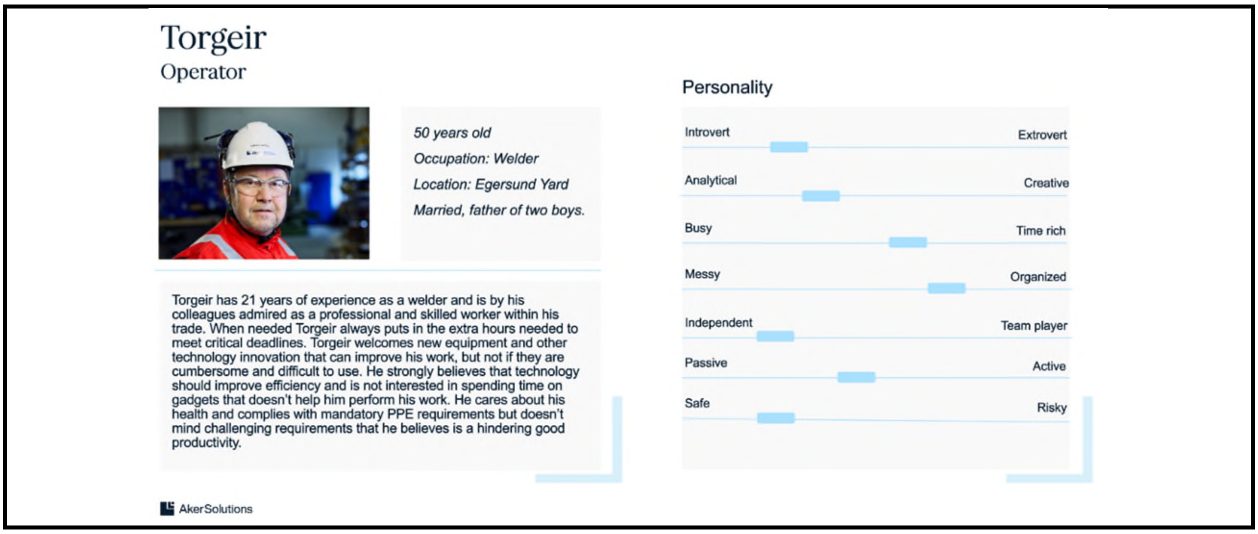
To describe the functionality of the data platform, user stories and persona descriptions are used.

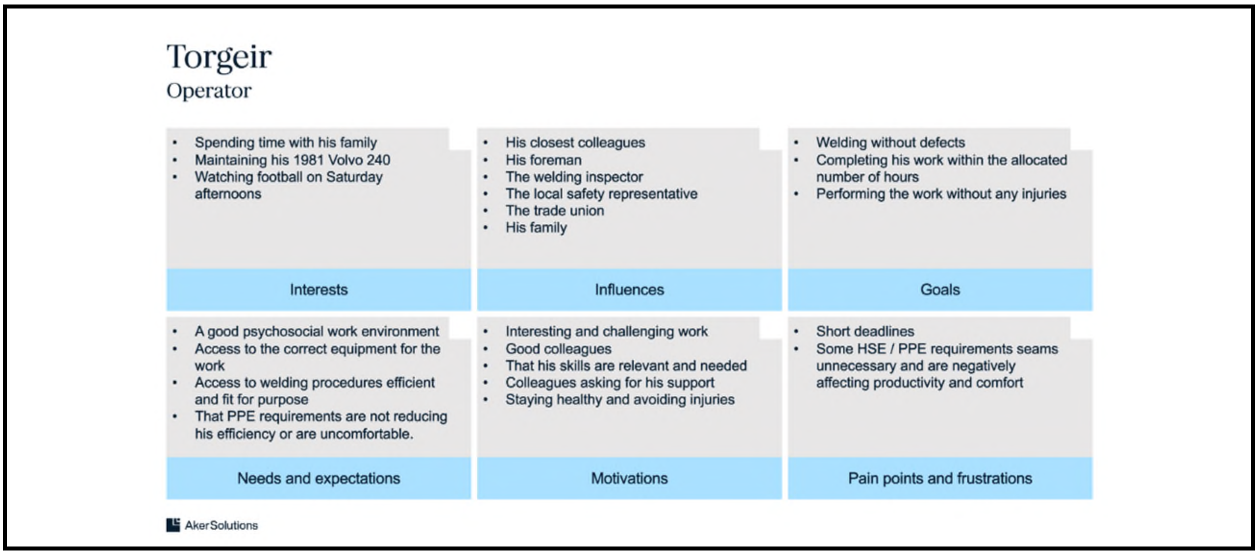
- A persona is a fictitious but realistic description of a typical user of the system. The description is based on user surveys, interviews and experiences and helps to understand the users' needs, goals and challenges.

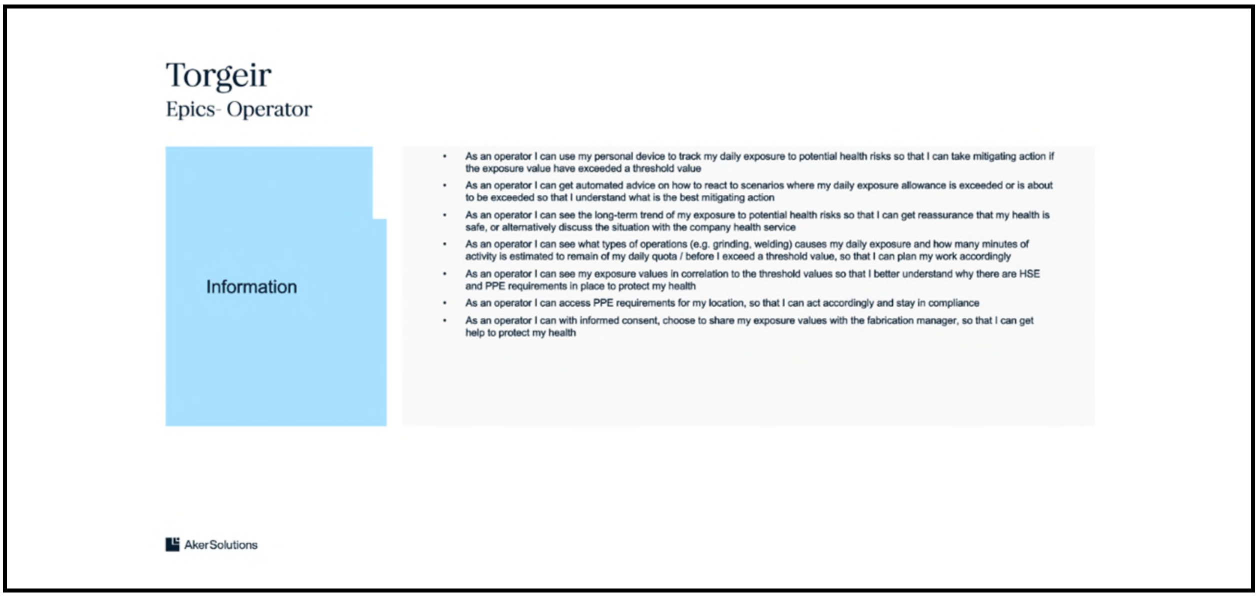
- User stories offer a straightforward and concise description of functionality from the user's perspective, helping to clarify what needs to be developed and why. At this stage, the user stories are high-level and not very detailed. Further refinement will be necessary before development work begins.

It is recommended that a future development project adopts an agile methodology with a strong emphasis on hypothesis testing. Rapid iterations, where real users provide feedback on functionality and user experience at an early stage, will help reduce the risk of developing data platforms in a low-value direction. This approach also allows for the continuous improvement of user stories in parallel with development, enabling requirements and priorities to be adapted along the way.

Operator







Fabrication manager

Øyvind

Fabrication manager

48 years old

Occupation: Fabrication manager

Location: Egersund Yard

Married, three kids (10, 13 and 20 years old)

Øyvind started his Aker Solutions career as a welder 20 years ago, an occupation he held for 5 years before he joined technical college for more education. He returned in a supervisor position and has held his current role as fabrication manager for the last 10 years. Øyvind cares about people and continuously seeks new ways to improve the performance of his team. He listens to his team members and take their feedback into consideration when attempting to find new smart solutions to improve productivity and HSE performance.

Personality

Introvert	Extrovert
Analytical	Creative
Busy	Time rich
Messy	Organized
Independent	Team player
Passive	Active
Safe	Risky

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Øyvind

Fabrication manager

Interests

- Coaches his youngest kids football team
- Reads technical magazines and articles
- Traveling and experiencing new countries and cultures

Influences

- Internal rules and regulations (including requirements from national work authority)
- Senior fabrication management
- Projects and their requirements
- His closest colleagues and team members
- His family and friends

Goals

- That all work within his area of responsibility is performed without injuries
- Delivering services of correct quality, productivity and at the correct time
- High work satisfaction within his team

Needs and expectations

- That the work his team receives is well defined and realistically planned
- That he can use his experience to influence planning and execution of work
- Access to skilled labor
- That provided tools and facilities meets his teams needs

Motivations

- That the role allows him to use his full experience and skill set – seeing that he can make a difference
- New projects with new problems to solve
- Using technology to improve his team's performance

Pain points and frustrations

- New administrative and technical requirements are restricting his team's performance
- Not given enough time to properly plan execution of the work

AkerSolutions

Øyvind

Epics – Fabrication manager (FM)

Information

- As a FM I can in real time understand my location(s) exposure to potential health risks, so that I together with HSE & MD can set the correct protective measures to prevent negative health effects in my team.
- As a FM I can understand which work operations trigger variations in exposure levels, so that I can use this information to improve work processes and tool usage in a way that exposure levels are reduced and potential negative health effects prevented.
- As a FM I can understand how exposure levels differ between production locations at the yard so that I can use this information to foster learning between locations, find actions and reduce potential negative health effects.
- As a FM I am notified when there is over exposure in my locations, so that I can inspect the location and intervene on any observable health risks.
- As a FM I can, if the operator has given his informed consent, identify if an operator exposure is exceeding a defined threshold value and no actions are taken by the operator, so that I can intervene to protect the operator's health.

Communication

- As a FM I can communicate to my team what is the correct PPE requirement for specific work tasks at specific locations so that PPE requirements are optimized, efficient and without health and safety risks.

Efficiency

- As a FM I can, if the worker has given an informed consent, based on workers exposure levels understand who is the best alternative to replace an operator in a specific task who has exceeded or is about to exceed a defined threshold level so that I can maintain productivity within the team.

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Medical Doctor

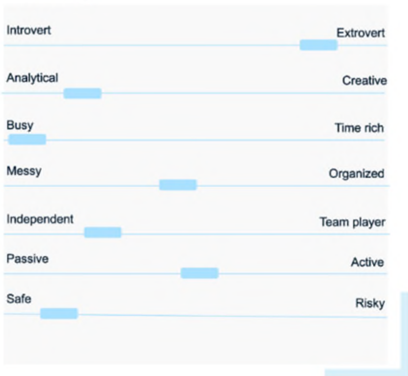
Lene

Medical doctor

43 years old
Occupation: Medical doctor, company health service
Location: Egersund Yard
Married, two children.

Lene recently joined the company health service as a medical doctor. She has previously worked at the local municipality medical office and is currently undergoing specialist training in occupational medicine. She genuinely cares about the health and wellbeing of her patients and works actively together with the rest of the BHT team implementing preventive measures to protect and improve the health of all employees.

Personality



AkerSolutions

Lene

Medical Doctor

Interests

- Keeping her small collection of German sports cars polished and ready for road trip
- Travelling and experiencing new cultures
- Keeping up with latest research within her profession

Influences

- Medical journals and publications
- Requirements from the national work authority
- BHT colleagues and peers within her profession

Goals

- Improving health conditions at the yard
- Efficiently treat patients bringing them back to their respective profession
- Participate in studies related the industrial work environment and publish the results

Needs and expectations

- Better data on the work environment from the location where she receives her patients
- Being able to work pro-actively regarding her patient's health – avoiding work related health problems rather than trying to cure them

Motivations

- Seeing health improvement among her group of patients
- Using her competence to identify the correct actions to reduce workers exposure to potential health risks and thus improving health conditions at the yard

Pain points and frustrations

- The patients experienced exposure to potential health risks are subjective and not necessarily not factual
- Patients cannot be given advice directly related to historical exposure and related health risks, only on a general manner related the patient's profession

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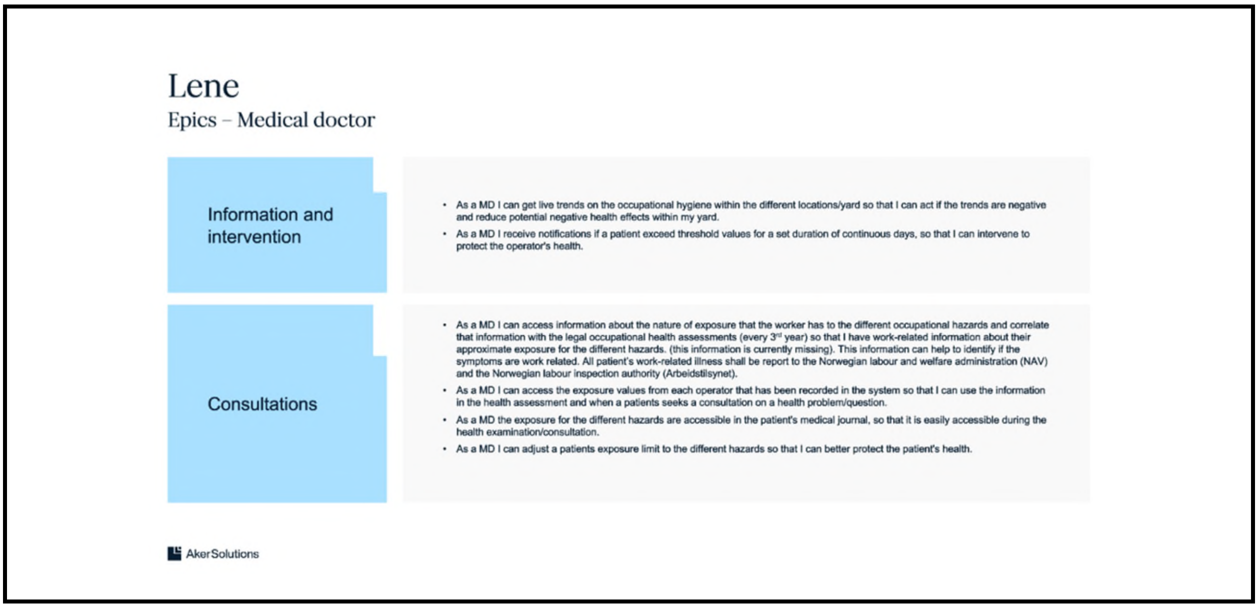
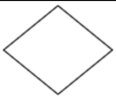


Data flow and process description

The flowchart shows the data platform's overall data flow and interaction between the roles. The table provides a symbol explanation for understanding flowcharts. Flowchart is available in the attachments.

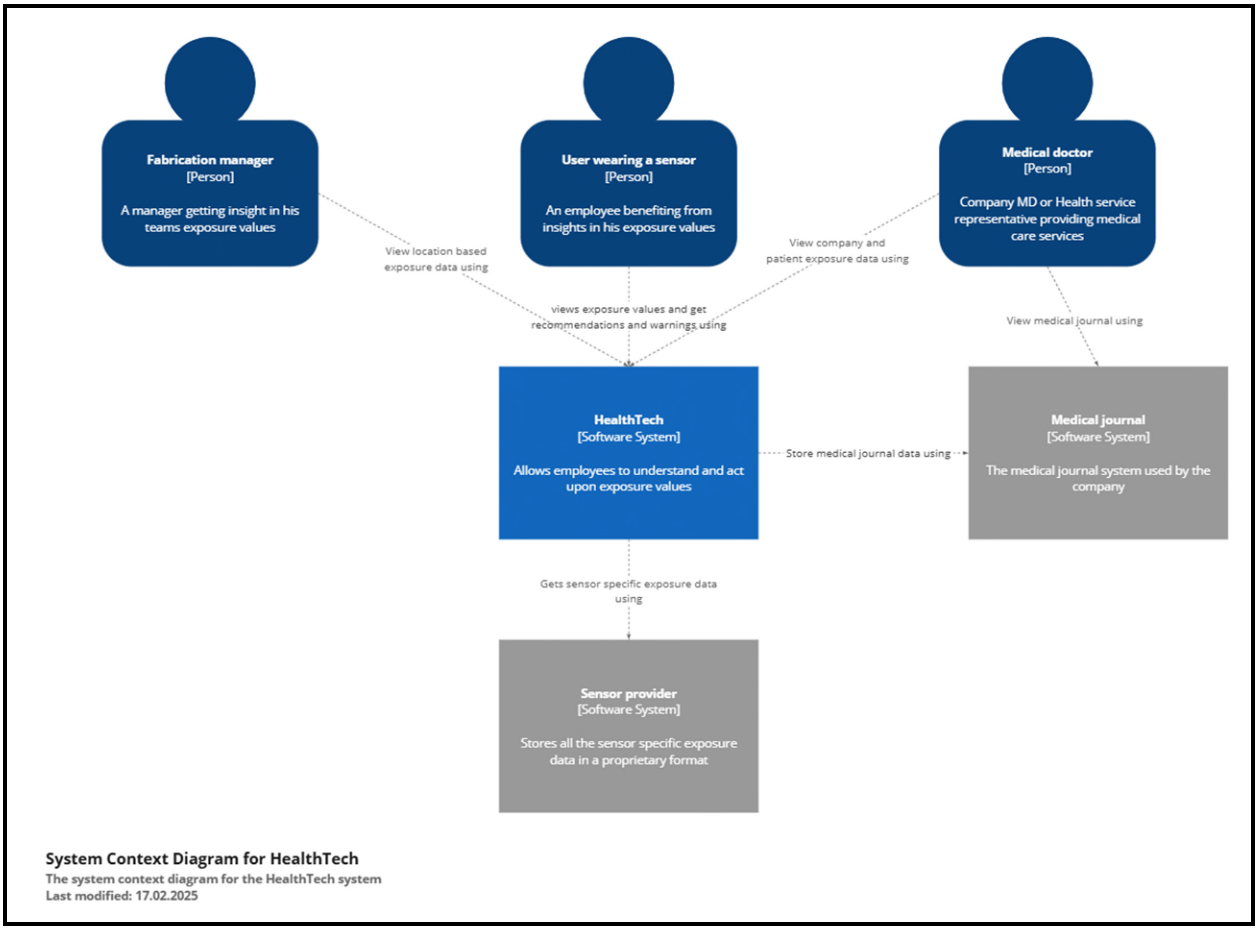
Symbol	Explanation
	A process that requires user interaction
	A user or system selection
	An automated process that doesn't require user interaction
	A user interface that makes information and alerts available
	Data storage. The storage is not necessarily done at or under the role that indicates a need for data storage.

System architecture

The C4 method has been used to describe a possible system architecture (https://c4model.com/). This method uses four levels (Context, Container, Component, and Code) to describe a system architecture with different levels of abstraction. As part of a pre-project, it would not be appropriate to describe the system architecture in more depth than a container diagram. Lower levels provide a technical implementation picture that the project is not currently mature enough to describe.

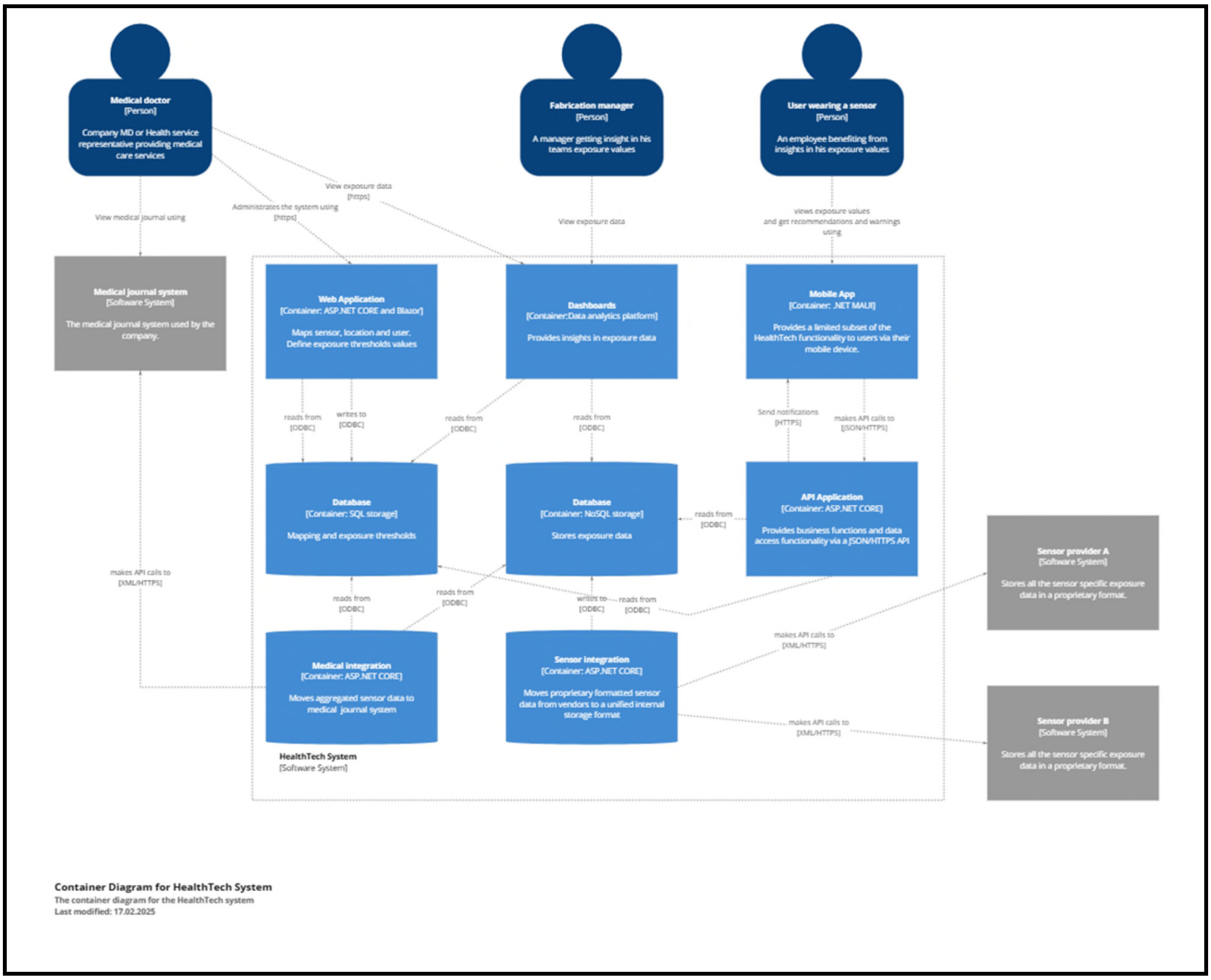
System Context Chart

System context diagram provides a visual representation of the system and how it interacts with external actors, such as users and other systems.



Container diagram

Container diagram shows how the system is divided into main components (containers), which can be applications, databases, microservices, etc.



Development group and roles

In a development project of this size and complexity, a typical development team will require the roles described below. However, these roles do not correspond 1:1 with the staffing needs in a crew plan, which will depend more heavily on the expertise of the available resources.

The team is set up with typical roles of a development team that follows an agile development methodology.

Role	Main Tasks
Product owner	A product owner in an agile development team is in charge of maximizing the value of the product being developed. The role acts as the link between the business side and the development team, ensuring that the team works on the most important tasks based on business goals and user needs.

	Considering the size of the project, it will be natural for the product owner to also act as a functional architect and together with representatives from the business side develop user stories to a level ready for development.
System architect	A System Architect oversees designing and planning technical systems and solutions that meet both business needs and technical requirements. This role involves creating an overall technical vision and architecture, as well as ensuring that the systems are scalable, secure, and sustainable in the long term. The system architect acts as the link between the development team, management, and other technical stakeholders to ensure that the solution aligns with both business goals and technological capabilities. In this project, the role also includes technical tasks related to the establishment and setup of technical infrastructure/cloud services.
Back-end developer	A back-end developer is responsible for the development and maintenance of the server-driven part of an application. This involves working with databases, server logic, APIs and integrations that allow the front-end to work seamlessly.
CI/CD developer	A CI/CD Developer (Continuous Integration / Continuous Deployment Developer) is responsible for developing and maintaining automated systems for continuous integration and deployment of the software. This role involves building, maintaining, and optimizing CI/CD pipelines to make software development more efficient, reliable, and scalable. The CI/CD developer works closely with both development teams and DevOps to ensure that changes to the code can be quickly tested and deployed to production without compromising quality. Considering the size of the project, it will be natural that these tasks are included in the role of the back-end developer.
Front-end developer	A front-end developer is responsible for developing and maintaining the user interface of an application or website. This involves transforming designs and interactions into working code, ensuring a good user experience and optimal performance.
UX designer	A UX Designer (User Experience Designer) is responsible for creating a positive user experience by designing intuitive, efficient, and user-friendly interfaces. The UX designer's main goal is to understand the needs of the users and ensure that the product meets those needs in a way that is also technically and commercially feasible.
Data analytics developer	A Data Analytics Developer is responsible for developing and implementing solutions that enable data to be collected, analyzed, and visualized. This role combines software development with data analytics

	to help organizations make informed decisions based on data-driven insights
Test manager	A test manager is in charge of leading the testing team and ensuring that the software being developed is of high quality. This role involves both technical insight and management, as the Test Lead will coordinate testing processes, plan tests, and ensure that the team performs thorough and effective tests throughout the development cycle.
Medical journal system developer	A developer for medical journal systems has cutting-edge expertise in the company's medical record system and can, on behalf of the system owner, make the necessary adjustments required to integrate the system with HealthTech.
Scrum master	A Scrum Master is a leadership role in an agile development team, with a focus on facilitating the Scrum process, helping the team achieve high performance, and ensuring that Scrum principles are followed. The Scrum Master acts as a mentor for the team, removing obstacles that can slow down development, and collaborates closely with both the team and product manager to ensure that the team can deliver value continuously. Considering the size of the project, it will be natural for the scrum master tasks to fall to an existing role in the team.

Development tasks

1. Detailing system architecture and securing sensitive personal information

A detailed description of the data platform's system architecture down to a component diagram containing technology selection, data flow, and the cloud services that need to be developed. It must be ensured that the solution is designed in a way that ensures the secure storage of personal data in accordance with identified requirements. All further development in the project must be in line with the principles contained in this description. The system architecture should include deliverables 2 through 11 in this description.

2. Scalability

The details of the system architecture must include a description of how the platform can be scaled so that it securely handles data from several companies and/or is duplicated to other companies that collaborate on the development. This includes scenarios where each company is the owner of its own data completely segregated from other companies.

3. Establishment of services, internal data model and storage

The system architecture is established in the company's infrastructure/cloud services and made ready for use. This includes mechanisms for anonymizing data and associating with an identifiable user in the right and controlled contexts. The data model must be designed in a general way so that it can receive sensor data from future sensor suppliers and facilitate implementing machine learning algorithms.

4. Integration with supplier data platform

Data from sensors is retrieved from the supplier's systems and stored in an internal data model in a normalized manner. The principles for handling sensitive personal information must be managed. To enable immediate action in the event of a breach of exposure limit values, the integration must be able to retrieve data in as close to real-time as possible.

5. User interface for linking person, location and sensor

A user interface must be developed where the link between the sensor, location and person is managed. In this interface, it should not be possible to read exposure data from sensors. The user interface is a web service accessible from a computer within the company's network.

6. User interface for defining exposure limit values

The occupational health service is given a user interface to adapt action and limit values for the respective types of exposure that the sensors cover. Personal limit values can also be defined for each type of exposure. The user interface is a web service accessible from a computer within the company's network.

7. User interface, personal data

Users of sensors are given a mobile interface to be able to follow their personal exposure from day to day. The information must be presented in an easy-to-understand manner and provide clear feedback if exposure approaches and exceeds permissible exposure limits. The information must be informative and provide concrete advice on how to handle the situation if exposure limits are exceeded. The mobile interface is being developed for iOS and Android devices and will be accessible via mobile network/Wi-Fi. The level of security shall be compatible with the processing of sensitive personal data.

8. User interface for data analysis - Occupational health service

The occupational health service gives a user interface to visualize and analyze exposure data. As healthcare professionals, data can be analyzed at an individual level, enabling the use of exposure data in patient consultations and preventive medical care. The user interface is a web service accessible from a computer within the company's network and with a level of security compatible with the processing of sensitive personal data.

9. Data Analysis User Interface - Fabrication Management

Fabrication management, such as area managers, department managers, and production management are given a user interface to visualize and analyze exposure data at their respective levels. This is done based on anonymized data. The user interface is a web service accessible from a computer within the company's network.

10. Alert services

To be able to intervene in potentially harmful activity/behavior, the occupational health service and fabrication management are informed if a user does not take action to reduce exposure risk. Notification is provided using the interface for data analysis. It shall be possible to set notification criteria specifically for each organizational unit, and fabrication management shall only be able to identify the user if permission to do so has in advance been granted by the user himself. The user interface for configuring notification limits and process is a web service accessible from a computer within the corporate network.

11. Customization and integration with company's medical record system

Aggregated exposure values for each user are transferred to the company's medical record system so that the information can be used effectively in medical consultation and diagnosis. Necessary adaptations in the medical record system may be necessary to be able to receive and use this information in a good way. Transferring exposure data to the medical record system also enables the data in the company's database to be anonymized to a greater extent without any link back to the individuals.

Data platform recommendations:

- To reduce risk in software development, development tasks 1-3 (mentioned above) should be carried out in a separate phase, leading to a better estimation basis for operating and development costs.
- The user stories can be further detailed and broken down into smaller stories to better describe the scope of the development work. This must be carefully weighed towards an agile development methodology and not become an attempt to derive all functionality before the most important hypotheses are tested on end users.
- The majority of business value is related to operators and their health benefits. In a development process, a lot of work will already have been put into the data platform before functionality is made available to operators. Continuous efforts should be made to prove the hypotheses underlying the operators' user histories and thus reduce the risk that early development efforts will have to be reversed and/or reworked.
- The development tasks (1-11) should be carried out according to priority in order to create the most value for end users as quickly as possible.

- To reduce investment costs, partnerships should be established between more stakeholders in the data platform. This includes both internal and potential external interested parties such as government and other industrial companies.
- It should be investigated whether already established commercial providers in this market are interested in further developing a partnership to realize the goals of the data platform.

Business case

The business case is calculated based on available resources in Aker Solutions' yard in Egersund, both in terms of activity and number of employees. The quantitative calculations reflect these variables and are based on the insights gained through the pre-project. The pre-project has been time-limited and does not provide the opportunity to show long-term effects of the use of sensors, so the revenue side of the business case will necessarily be hypotheses-based and must be further secured in subsequent project phases. The Business Case is articulated by discussing:

- Qualitative strategic advantages and benefits, i.e., Health benefits.
- Quantitative benefits, based on hypotheses subject to review and refinement in the project phase.
- Costs, based on the extrapolation of the costs and assumptions derived from this pre-project.

Strategic advantages

To monitor environmental conditions in the yards, the implementation of sensors offers several advantages. By integrating IT and OT solutions to collect daily operational data, we ensure a consistent flow of information, providing valuable insights into construction and fabrication processes. Wearable sensor technology facilitates extensive, structured data collection, enabling AI-driven analytics and informed decision-making regarding operational aspects, such as tool quality and usage.

The availability of structured and reliable data fosters strong industry relationships by demonstrating our commitment to employee health and workplace safety. This data allows us to document product fabrication compliance with health and safety regulations, enhancing Aker Solutions' reputation and that of our clients.

Health benefits

The health benefits of implementing wearable sensor technology on a full scale are described in the following sections.

Preventive health work

At Aker Solutions, the concept of "Always home safely" has been established as a vision and reminder that everyone works safely and takes responsibility for their own and their colleagues' health and well-being, while at the same time working to maintain good mental health and balance in life. The company believes this will:

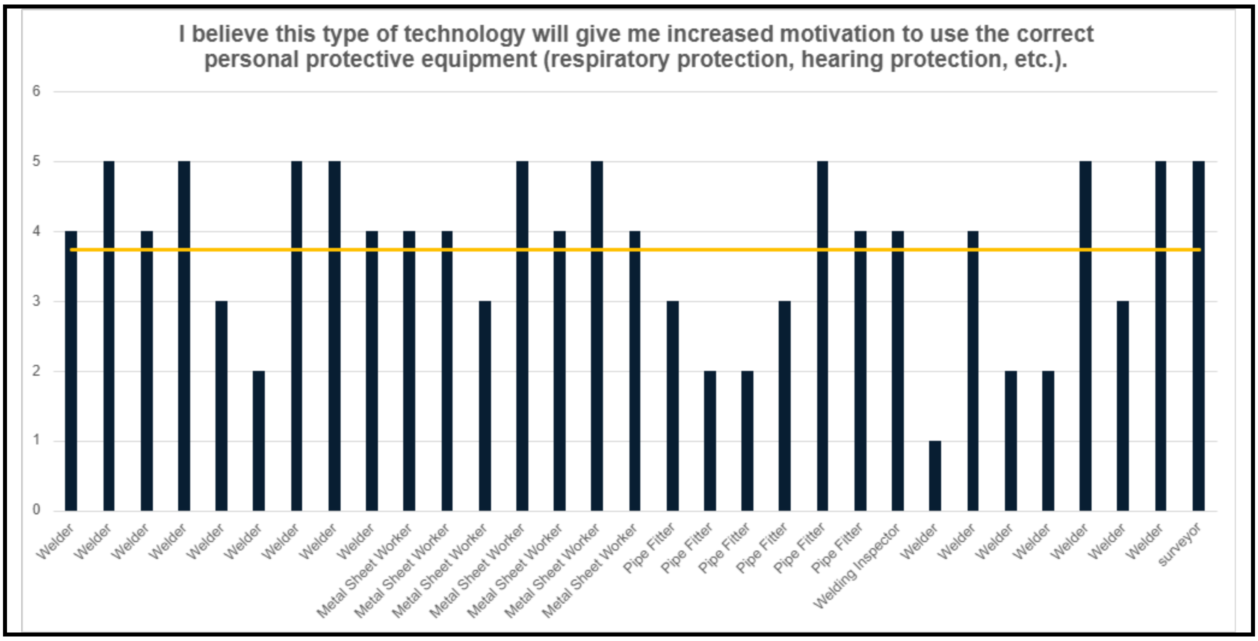
- Strengthen the HSSE culture in all Aker Solutions teams and projects.
- Create awareness, improvement and continuous focus on the importance of a safe and health-promoting operation.
- Help build a solid HSSE culture.
- Make "Always home safely" relevant to all employees by linking it to both safety and health in their daily work.

Through the HealthTech project, the company can enhance preventive health measures and further build on the vision of "***Always home safely***"—ensuring that employees maintain their health at work and return home healthy, day after day, week after week, year after year.

Personal health benefits are made possible through several mechanisms, all of which are preventive in nature and can have a positive impact mitigating the risk of employees developing health-related issues.

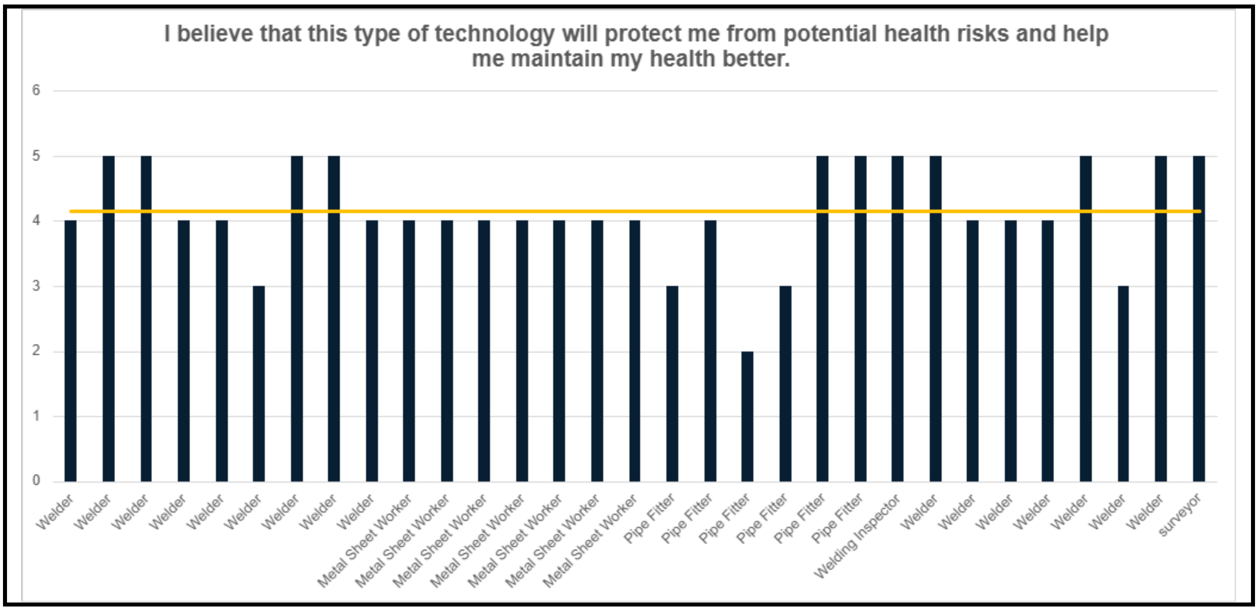
1. Exposure to occupational health risk factors is tracked in real time, enabling immediate personal measures to counteract risks that may negatively impact health. For example, employees can receive personal warnings when staying in areas where the noise level exceeds the limit for double hearing protection or receive information about use of handheld vibration tools and relevant exposure to vibration.
2. Occupational hygiene transitions from being general information about the working environment to a personal matter concerning one's own health. This awareness is made possible through personal feedback about individual exposure and the associated risk factors. As a result, employees can gain a better understanding, increased motivation, and improved compliance with requirements related to the use of personal protective equipment, emphasizing the importance of protecting oneself effectively.

   After testing wearable sensors for a week in phase II, the participants answered the following question: ***"I believe this type of technology will give me increased motivation to use the correct protective equipment (respiratory protection, hearing protection, etc.)"*** Scale from 1 - Strongly disagree to 5 - Strongly agree. The survey represents 31 out of 208 possible sensor users and gives a margin of error of 7.9% at confidence level 0.95. Average score **3.7.** Standard deviation **1.2.**



3. Action limits can be tailored to an individual's health and tolerance levels for exposure. This way, the work environment can be effectively adapted to the employee's health and work capacity. For instance, in consultation with the occupational health service, one might consider lowering dust tolerance limits if the employee has a known asthma diagnosis.
4. By gaining insight into their own exposure, employees can better understand their workday and how their tasks impact their health. This knowledge allows for more effective planning and organization of work to minimize health-damaging exposures. Similarly, this insight benefits the company by identifying which tasks or tools have the most significant negative health impact on employees. With this understanding, targeted measures can be implemented by both production management and the BHT/HSE departments. These measures, based on fact-based causal factors, ensure high-quality and effective interventions.

   Participants answered the following question: ***"I believe that this type of technology will protect me from potential health risks and help me maintain my health better."*** Scale from 1 - Strongly disagree to 5 - Strongly agree.



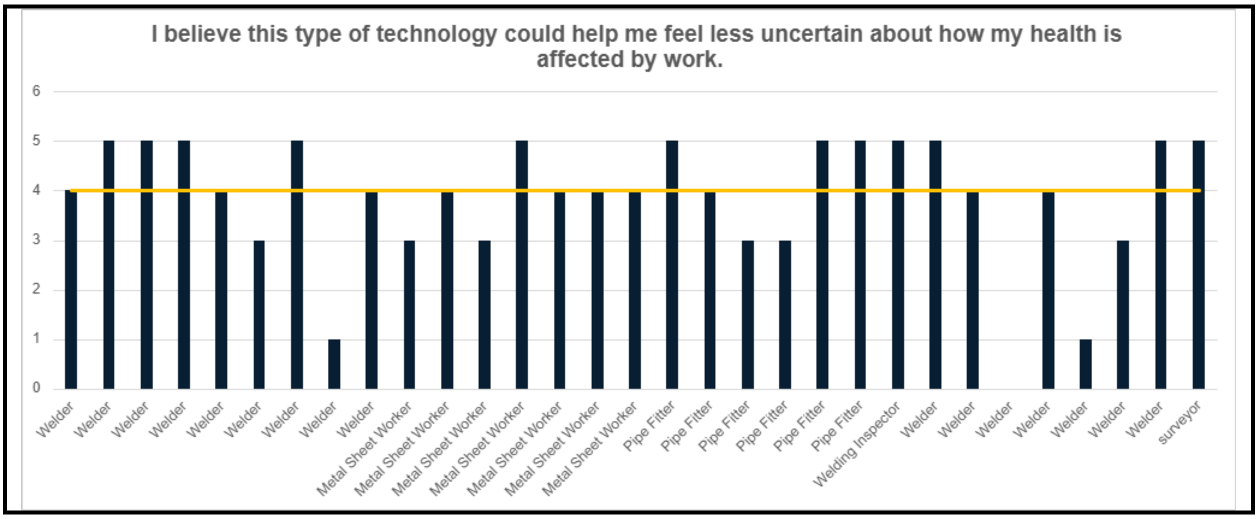
Average score **4.2.** Standard deviation **0.8.**

These mechanisms provide strong indications that employees can experience positive health effects, create healthier behaviors at work, and limit the development of work-related health problems. This can lead to a reduction in sickness absence. Additionally, the positive health effects significantly impact individuals, allowing them to maintain a good quality of life through preserved health.

Improved quality of life

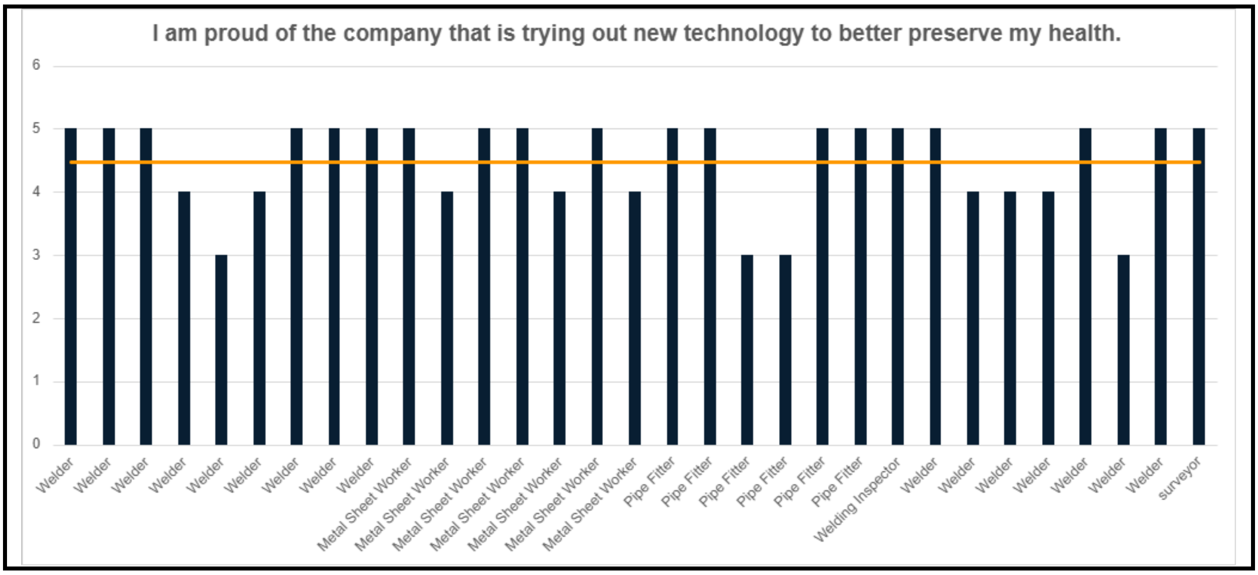
An employee's well-being at work can significantly impact their mental health. In addition to the physical health benefits provided by the HealthTech project, it can also offer mental health benefits through different mechanisms.

1. Employees can gain control over their work situation and understand how their health is impacted by their work, leading to an increased sense of security. This security reduces the perception of work as a risk to their health and provides predictability that employees without insight into personal exposure values would not otherwise have. After testing wearable sensors for a week, the participants answered the following question: ***"I believe this type of technology could help me feel less uncertain about how my health is affected by work."*** Scale from 1 - Strongly disagree to 5 - Strongly agree.



Average score **4.0**. Standard deviation **1.1**.

2. The employer's effort in establishment of projects like HealthTech and investment in employees' health can foster a sense of pride in individuals working for the company. This directly influences how employees enjoy their work and how they speak about the company to friends and family. Question: ***"I am proud of the company that is trying out new technology to better preserve my health"*** Scale from 1 - Strongly disagree to 5 - Strongly agree.



Average score **4.5**. Standard deviation **0.7**.

3. Each individual employee is given greater attention in matters concerning their health. This provides an opportunity to influence issues that are personally significant to them, fostering a sense of increased co-determination in how their health is managed.

In summary, these mechanisms can enhance well-being at work and decrease concerns related to work and health. Additionally, alongside the health benefits, they can help reduce the perceived strain of work, allowing employees to have more energy both at work and at home. This can directly improve their quality of life.

It is also known that better well-being at work can increase the threshold for staying at home in the event of illness with residual work capacity. NAV reports that only 5% of total sickness absence is due to absence without residual work capacity. By improving well-being and motivation, companies can reduce overall sick leave.

Quantitative benefits

Staffing and recruitment

Relevant in this context, the industry in Norway has two challenges where the interaction between work and life plays a central role:

- Norway has the world's highest sickness absence
- The retirement age from working life is early, and there are few signs of change.

The consequences of these factors directly impact the company's access to labor, a challenge that will worsen in the coming years. By 2031, the number of people over 65 will surpass the number of children and young people under 20 for the first time. By 2050, for each child less in the age group 1-5 (kindergarten), there will be 94 more seniors above 80 years (Statistics Norway).

In this demographic scenario, it is increasingly important to implement preventive health measures to ensure employees remain healthy and can stay at work longer. From a staffing and recruitment perspective, this approach will help the company:

- Retain experience-based knowledge within the company for longer, positively impacting efficiency and innovation.
- Reduce costs associated with recruitment and training new recruits.
- Maintain a reasonable level of self-staffing in the future where access to qualified labor is becoming more challenging.

The HealthTech project has the potential to significantly improve health and mitigate the challenges posed by work-related health issues and illnesses in staffing and recruitment contexts. Quantifying its impact is complex. For instance, retaining the expertise of a 62-year-old employee for an additional five years can greatly enhance efficiency. Similarly, maintaining consistent and accurate self-staffing, rather than relying on a larger number of temporary workers, can positively affect project delivery timelines and costs. These potential benefits of the HealthTech project need to be thoroughly investigated in a subsequent project phase to be effectively included in a business case.

Recruitment costs are quantifiable based on the number of dropouts that could have been avoided through improved health measures. Between 2010 and 2024, the company's yard in Egersund experienced a total of 52 health-related dropouts from the workforce, averaging 4 per year. The specific medical reasons for these dropouts are unknown, creating uncertainty about how many could have been prevented by the

HealthTech project. Additionally, HealthTech's impact will be delayed, as work-related illnesses leading to workforce dropout typically develop over time rather than immediately. For the business case, *we hypothesize that a 50% reduction in health-related dropouts can be achieved, with the effect increasing from year two onwards.*

Table 1. Numbers from Aker Solutions internal calculation of recruitment costs.

Cost	**Per employee**	**Year 1 (no reduction)**	**Year 2 (one employee)**	**Year 3 (two employees)**	**Total 3 years**
HR & recruitment costs	75 900	0	75 900	151 800	227 700
Training time and productivity loss (50% productivity over 3 months). Additional time foreman/colleagues. Internal training.	195 000	0	195 000	390 000	585 00
SUM	270 900	0	270 900	541 800	812 700

For the state of Norway, the same two challenges apply, but in a completely different magnitude.

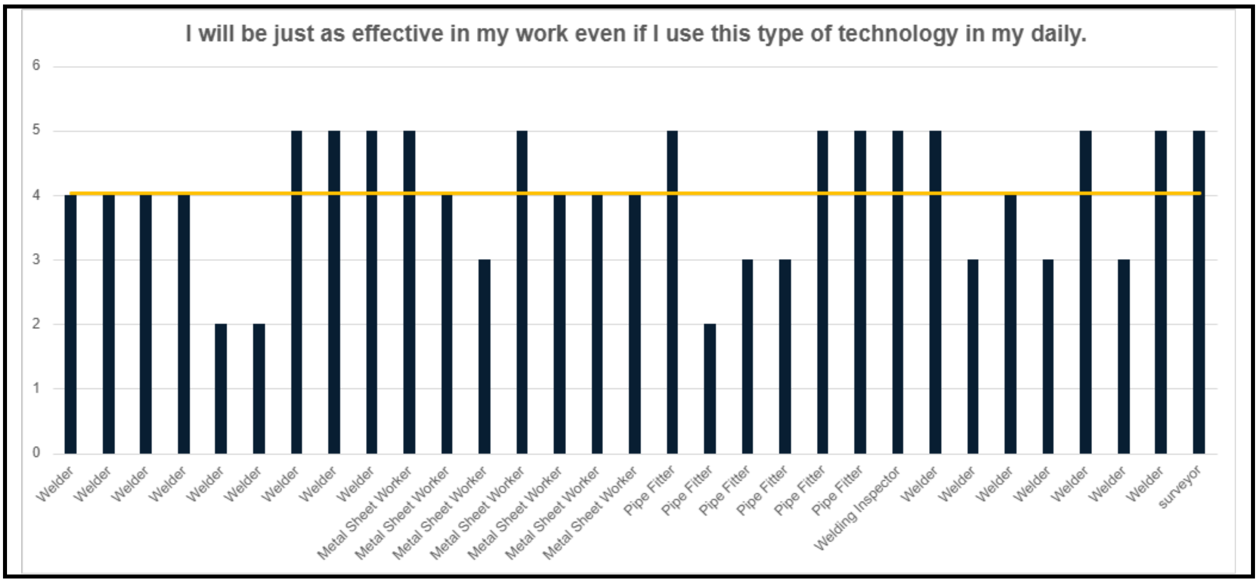
The individual's gain	*Gross disbursed*		*Tax*	*Net disbursed*		**The cost of the state**	
Disability benefit after a full- time job (66% of salary)	396 000	66 %	78 596	317 404		Disability benefit paid after tax	-317 404
Average annual salary	600 000		147 344	452 656		Reduced tax revenue	-68 748
Annual gain	204 000		68 748	135 252		Increased cost per year	**-386 152**
Number of years from drop-out to retirement	*22*			**2 975 544**		Increased cost until retirement	**-8 495 344**

From a societal perspective, NAV has calculated the socio-economic value of people working 1 year longer at NOK 40 billion (increased value creation). To illustrate this value, the importance of reduced dropout rates can be used (preventing a person from dropping out of working life due to health challenges). The example is based on an industrial worker with an annual salary of NOK 600,000 and a disability benefit from the age of 45 until the retirement age of 67. The tax figures are taken from the Tax Administration's tax calculator.

As the example shows, the government can avoid ~NOK 8.5 million in increased expenses for each employee the company keeps working from the age of 45. Increased expenditure related to health services in the event of illness/disability is not included in these figures.

Productivity

As part of the testing in the pre-project, the participants were asked to indicate the extent to which the use of sensors affected the efficiency of everyday work. The question "***I will be just as efficient in my work even if I use this type of technology in my everyday work***" gave an average score of **4** out of 5, and with a standard deviation of **1**, we can assume that with proper and sufficient training and follow-up in the start-up phase, sensors can be introduced without obvious productivity challenges. An individual's self-interest and focus on health are expected to influence their perception of sensors and productivity, whether positively or negatively. Effective health-oriented training has demonstrated good results in testing, helping to counteract the subjective feeling that sensors are a nuisance or not worth using. Testing data shows that an operator typically spends just a few minutes each morning equipping themselves with sensors, and only a negligible amount of time during the workday using them to understand their exposure and risk.



Testing has shown that users need to have a clear understanding of health risks and their work environment to appreciate how sensors can prevent work-related health problems. This means that sensors must be targeted at actual risks the employee faces. For example, it is counterproductive to equip an employee with a vibration sensor if they do not use vibrating hand tools.

The user survey also shows that sensor technology can have a motivating effect that can positively affect productivity. The question ***"I am proud of the company that is trying out new technology to be able to preserve my health better"*** is answered with an average score of **4.5** and a standard deviation of **0.7**.

With better insight into personal exposure, there will be a basis for reassessing perceived burdensome PPE requirements in favor of those that employees find easier to use in their daily work. This can positively impact both motivation and productivity in the long term.

The primary goal of HealthTech is to prevent work-related health problems. By addressing these health issues, productivity can be improved where it is currently hindered by health challenges. A healthy employee can work more efficiently and productively than one facing health challenges and associated limitations.

On the other hand, it is crucial to avoid deploying sensors in a manner that disrupts work or reduces productivity. Any uncertainties an individual may experience if a sensor indicates a risk must be managed with thorough training and clear guidelines on how to respond to these warnings in daily work. A comprehensive plan must be established for the roll-out and use of sensors to minimize the risk and consequences of unforeseen identification of exposure risks exceeding permitted limits.

Accurately quantifying the productivity effect based on the pre-project alone is challenging. However, the insights so far suggest that the positive productivity aspects may outweigh the negative ones, indicating that HealthTech could have a positive long-term productivity effect. As a preliminary estimate, to be verified in a later project phase, the following productivity and economic effects are considered based on 208 sensor users who deliver a total of 353,600 hours annually at a cost of NOK 650 per hour:

Effect	**Productivity impact**			**Time Effect**			**Cost effect**			**Total 3 years**
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	
Increased motivation	0,1%	0,1%	0,1%	354	354	354	229 840	229 840	229 840	689 520
Less burdensome PPE	0%	0,1%	0,1%	-	354	354	-	229 840	229 840	459 680
Better health	0%	0,1%	0,2%	-	354	707	-	229 840	459 680	689 520
Exposure alarm, rotation or stop/pause in work	-0,2%	-0,2%	-0,2%	-707	-707	-707	-459 680	-459 680	-459 680	-1 379 040
SUM							-229 840	229 840	459 680	459 680

Better health

The sensors tested in the pre-project targeted major health issues in the industry, including hearing loss, musculoskeletal disorders from vibrating hand tools, and respiratory problems due to dust and gas exposure. The potential of these sensors to improve health and reduce sickness absence is limited by the prevalence of these health issues and the extent to which they cause sickness absence. The pre-project lacks detailed data on these factors to determine the effect with certainty. Therefore, *the business case is largely hypotheses-based and must be verified in a later project phase.*

The cost savings estimation is based on confidential information; therefore, only a summary of the final estimated costs to implement the envisioned solutions is provided here. These estimates are derived by considering various hypotheses:

- probabilities for different work groups developing symptoms due to specific exposures.
- Occupational groups using vibrating hand tools may experience reduced sickness absence by decreasing work-related finger-arm ailments. A 50% probability is used initially to estimate the potential causal relationship, suggesting these ailments might be work-related and eventually diagnosed as such.
- *It is hypothesized that there is a 10%, 20% and 30% reduction in treatment over three years, respectively, for noise, respiratory and msk related ailments.*

Satisfaction and sick leave

The testing revealed a belief that technology can help individuals achieve better health, despite the mixed reception of the specific sensors tested. The initiative is well received and, with the right implementation, can enhance the focus on the connection between work and personal health. This, in turn, can increase satisfaction with both work and employer, thereby reducing sickness absence.

Increased satisfaction can influence an individual's assessment of their residual work ability, leading them to choose to come to work even if they do not feel 100% healthy. The pre-project has not attempted to quantify this effect, so the estimate for the business case will be hypothesis-based. Later phases of the project can aim to better understand this impact.

Given that increased satisfaction and better motivation to go to work with residual work capacity can reduce the general sickness absence by 0.5%, the reduced costs will correspond to NOK 910,000 annually for 208 sensor users. *The calculation is based on the SINTEF report from 2011, which calculated each week of sick leave to cost the company NOK 13,000 (inflation-adjusted to NOK 18,626) (https://www.sintef.no/prosjekter/2010/bedriftenes-kostnader-ved-sykefravar/).*

Costs

Investment costs – sensors

Investment costs are associated with purchasing sensors and the necessary infrastructure to use them. The number and types of sensors required will depend on the company's size, the tasks performed, and the types of exposure these activities entail. To account for these differences, investment costs are calculated per occupational group, along with an understanding of the types of exposure these groups face.

In this example, Aker Solutions' operations in Egersund are used as a starting point. The subtotals can be used to calculate investments in other companies.

It is assumed that the sensors communicate via Wi-Fi (either directly or through their own signal converter/gateway) and that this infrastructure is already established in the company's production premises. Therefore, costs for establishing a Wi-Fi infrastructure are not included in the investment costs.

Sensor	Exposure type	Cost per sensor* (NOK)	Comment
Reactec R-link	Vibration	6161	Vibration/Musculoskeletal
Trolex XD1+	Dust	13894	Dust

Minuendo	Noise	7062	Or another type of noise sensor
Not identified	Musculoskeletal disorders		Other musculoskeletal (neck, back

* Estimated with a minimum quantity of 10 sensors, including chargers and communication devices. Exchange rates as of 10.2.2025

The table below shows the distribution of sensors across working groups. To optimize sensor placement based on exposure risks, only relevant sensors are provided to each group. For example, a foreman is not exposed to vibrations and thus does not receive a vibration sensor. This approach avoids unnecessary equipment and saves on investment.

Table 2. Occupational groups and sensors distribution.

Occupational group	**Dust**	**Vibration/Musculoskeletal**	**Noise**	**Cost per occupational group (NOK)**
Welder		Yes	Yes	846 311
Metal sheet worker	Yes	Yes	Yes	1 220 297
Plumber	Yes	Yes	Yes	569 472
Forman	Yes		Yes	963 999
Scaffolder				0
Industrial Mechanic				0
Electrician				0
Welding Inspector			Yes	35 312
NDT Operator			Yes	28 250
Sandblasting				0
Industrial surveyor				0
SUM				**3 663 641**

AVG per employee				**17 614**

Investment costs – data platform

This section reports high-level estimates of the costs to develop, maintain and operate a data platform to handle all the data from the wearable sensors.

ID	Delivery	Hours (sum)
1	Detailing system architecture and securing sensitive personal information	43
2	Scalability	43
3	Establishment of services, internal data model, storage and connection to person	113
4	Integration with supplier data platform	187
5	User interface for linking person, location and sensor	241
6	User interface for defining limit values	241
7	User interface, personal data	1344
8	User interface for data analysis - Occupational health service	142
9	Data Analysis User Interface - Fabrication Management	142
10	Alert services for limit values	459
11	Customization and integration with your company's medical record system	359

	Total Hours	**3315**
	Total cost of 1500,- NOK per hour	**4 972 500**

Operating Costs

Sensors

Operating costs are estimated based on experience from testing and an outlined operating model with the following responsibilities.

No	Task	Responsible function	Annual cost per sensor user (hours)
1	Procurement of sensors. A fully negotiated framework agreement is assumed to form the basis for all purchases of examiners. Cost includes purchasing, invoice management and goods receipt.	Procurement	0,1
2	Setup/configuration. Primarily related to communication devices (Gateway).	On-premises IT	0,1
3	Training of users in sensors and the platform, including routines for use. Can be seen as part of basic HSE training. Cost also includes users and time spent on training.	HMS	1,1
4	1 line support for end users. Distribution of sensors. Registration of problems related to the software to the IT service desk. Handles a min/max stock of sensors. Equipping vibration tools with RFID tags for vibration.	Tool cage	0,5
5	2nd line support for handling technical issues and data communication. Escalation of failures to suppliers.	Local IT	0,1
6	Complaints, warranty and service.	Local IT	0,05
		SUM HOURS	**1,95**
		Total cost of 1000,- per hour per sensor	**1950**
		Total of 208 sensor users	**405 600**

Data Platform – Operation and Maintenance

After completing the development of the data platform, it is important to maintain continuous maintenance and development to ensure the platform remains relevant, secure, and effective in protecting workers in the industry. The main tasks in the operational phase will be to:

- Continuous improvement of data platform based on user feedback and learning.
- Remain compatible with users' mobile phones.
- Implement new sensors/suppliers in the platform.
- Safeguard data security requirements.
- Ensure uptime and solve operational challenges in line with company's requirements and expectations.
- Remain compliant with regulations and limit values from the Labor Inspection Authority.

Continuous maintenance and development are recommended to be managed by a developer/developer group with a minimum of one full-time capacity.

No	**Category**	**Content**	**Cost per year (NOK)**
1	Maintenance	Developer Services	1 700 000
2	Operating costs cloud services	Costs for technical services from cloud providers (databases and other technical infrastructure).	141 000
		Sum	**1 841 000**

Economic analysis

Sum Savings

This section summarizes the total cost savings according to the considerations and hypotheses listed in the sections above.

	Year 1 (NOK)	**Year 2 (NOK)**	**Year 3 (NOK)**	**Total 3 years (NOK)**
Total cost savings	811 677	1 673 774	2 306 030	4 791 481

Total non-recurring costs

The table below summarizes the total non-recurring costs.

Category	**Year 1 (NOK)**	**Year 2 (NOK)**	**Year 3 (NOK)**	**Total 3 years (NOK)**
Development of data platform	4 972 500*	0	0	4 972 500
Total non-recurring costs				**4 972 500**

* This cost will not increase even if the business case is expanded to all Aker Solutions yards.

Total recurring costs

The table below summarizes the total recurring costs.

Category	**Year 1 (NOK)**	**Year 2 (NOK)**	**Year 3 (NOK)**	**Total 3 years (NOK)**
Sensors	1 831 821**	1 831 821**	0	3 663 641
Operating costs	202 800	405 600	405 600	1 014 000
Maintain data platform	0	1 841 000	1 841 000	3 682 000
DaaS (Supplier)	211 000	422 000	422 000	1 055 000
Total costs	**2 245 621**	**4 500 421**	**2 668 600**	**9 414 641**

**Sensors are outlined here and rolled out in two stages.

Total costs

The table below summarizes the total cost.

	Year 1 (NOK)	**Year 2 (NOK)**	**Year 3 (NOK)**	**Total 3 years (NOK)**
Total costs	**7 218 121**	**4 500 421**	**2 668 600**	**14 387 141**

Summarized

In conclusion, the sum of the quantifiable costs and benefits is reported in the table below.

	Year 1 (NOK)	Year 2 (NOK)	Year 3 (NOK)	Total 3 years (NOK)
SUM (NOK)	**-6 406 444**	**-2 826 647**	**-362 570**	**-9 595 660**
Total without one-off costs (NOK)	**-1 433 944**	**-2 826 647**	**-362 570**	**-4 623 160**

Considering implementing sensors for all 208 potential users the resulting cost per user is:

Excluding one-off costs; Over three years; -22.226 or -7 408 per year

Including one-off costs; Over three years -46 132 or -15 377 per year

According to our hypothesis (*that a 50% reduction in health-related dropouts can be achieved, with the effect increasing from year two onwards*) and considering that all the workers in the various working groups, as described in Table 2, are provided with sensors, the business case results are negative.

In conclusion, the business case is negative. However, due to positive feedback from workers, there is a need to explore smarter solutions with fewer sensors that positively impact health. Additionally, further investigation into the market and availability of more affordable or alternative sensors is needed to improve the solution's economy.

Business case recommendation

- From a purely financial perspective, it can be difficult to justify spending ~NOK 9.6 million over three years. Although the benefits quantified in the business case are conservatively estimated, it is challenging to envision the final sum being financially positive in the short term. The personal health benefits and their impact on an individual's quality of life are difficult to quantify in monetary terms. Understanding how to balance these two aspects requires further exploration in a later project phase.
- The investment cost in sensors is high. From an implementation perspective, this can be challenged. For instance, can the same benefits be achieved with fewer sensors and a rolling deployment in the most vulnerable occupational

groups? These and similar questions should be addressed in a later project phase.

- The figures for work-related illness and sickness absence should be better understood to improve the quality of estimates regarding the potential financial gains for the company. For example, closer cooperation with NAV and/or the National Institute of Occupational Health can be sought to utilize national industry-related figures.
- The issues addressed by the HealthTech project are also relevant at the national level. It should be considered whether an attempt should be made to establish cooperation with the relevant authorities.
- Routines must be established for how operators should act when a sensor indicates exposure above the action level. This is important both to address the operator's uncertainty and to prevent loss of productivity.

Lessons learnt

1. ***Importance of Training and Familiarization:*** One key takeaway from test campaigns was the value of providing adequate training and orientation for participants before introducing them to the sensors. By offering a detailed explanation of how each sensor works, its purpose, and the data it collects, participants are more likely to feel comfortable and engaged with the testing process. Introducing the features of the sensors and demonstrating their functionality fosters curiosity and a positive attitude, helping participants view the sensors as tools for enhancing workplace safety rather than intrusive devices.

   We implemented this approach by conducting training sessions at the beginning of each test week in phase II, which significantly improved the acceptability of the sensors among users. Future test campaigns will continue to integrate dedicated training sessions to ensure participants are well-informed and confident in using the sensors.

2. **Adjusting Minuendo Earplugs for Comfort:** Properly fitting Minuendo earplugs is crucial to ensure user comfort during prolonged use. Users should be given time to try different ear hook and tip sizes and make adjustments before starting their shifts. This helps prevent discomfort and improves user acceptance and compliance. However, even though participants were allowed to try and fit the earplugs, many still found them uncomfortable. This highlights the need for further hardware improvements to enhance user acceptance and compliance.

   Additionally, having an earplug in combination with an earmuff proved to be simply uncomfortable for many users. Furthermore, according to the sensor vendor, the device should add 13dB attenuation if worn properly. However, the data showed that this was not the case, as the sensors did not provide the desired attenuation. This proves that even though the fitting of the earplugs was done for each user to choose a comfortable solution, the sensors were still not worn properly to be impactful. Therefore, we might need to explore other solutions for noise measurements to ensure better comfort and effectiveness.

3. **Tailored Sensor Allocation:** Preliminary data analysis revealed significant differences in exposure levels among different occupational groups. This suggests that equipping all workers with all sensors may not be necessary. Larger-scale data collection over extended periods is needed to further investigate these differences and identify specific roles or tasks that would benefit most from targeted monitoring, optimizing sensor usage and resource allocation.

4. **Clarifying the Role of Sensors:** It is essential to communicate that these sensors are intended as a prevention guide, not a diagnostic tool, and do not replace advanced hygiene assessments required by law. The data collected can assist medical teams in monitoring individuals who may have been overexposed and enable timely follow-up actions. Additionally, the sensors empower end-users to take immediate protective measures if they receive overexposure notifications, enhancing their ability to safeguard their health in real time. Despite our efforts to communicate and train participants to take action, we did not observe any response to activated alarms from participants. This indicates that more work and effort are needed from us to help them understand the importance of responding to these notifications.

5. **Data protection compliance:** The initial solutions investigated in this pre-project were aimed at delivering instant notifications to workers in case of overexposure to certain environmental factors (e.g., noise, dust, vibration) and notifying the medical doctor and workers' line manager about the lack of response from workers to overexposure notifications. However, these two use cases need to be revisited according to GDPR and data protection principles. It is unclear whether a legal basis for these two use cases can be established; therefore, further investigation on how to improve the current envisioned solutions is necessary. Any application that can be carried out using anonymized data can be supported by a legal basis. Specifically, the implementation of wearable sensors to obtain an "average" and continuous measurement of the noise level in one hall could be supported legally. Other similar use cases, where anonymous data can be utilized, should be investigated. For example, using wearable sensors to gain an overall understanding of exposure levels within a given hall, or employing arm wrist sensors to monitor the integrity of tools, such as tracking average vibration levels in ongoing processes in certain halls.

Conclusions

The **HealthTech** project has investigated the feasibility and effectiveness of using advanced sensor technology to monitor occupational hygiene risks in industrial environments, particularly within yards. The primary objective of this pre-project was to mitigate work-related illnesses by providing enhanced insights into personal and environmental exposures. Through systematic data collection and analysis, we addressed critical issues such as vibration, dust, and noise exposure, and got more insights into the implications, consequences, costs and benefits of an eventual implementation of wearable sensors.

By the end of the pre-project, we have achieved the following results:

1. **Assessment of Market Sensors**: We conducted a thorough evaluation of available sensors that provide insights into the health and hygiene conditions of shipyard workers. This assessment has enabled us to identify the most pertinent sensors for our needs. We purchased and tested these sensors and continuously tested and challenged their fit and relevance for the envisioned application.

2. **Test Campaigns**: We tested the sensors in two phases to evaluate the selected sensors' effectiveness and user experience. These tests have provided valuable preliminary recommendations on the sensors to be used for monitoring occupational hygiene conditions. The outcome of the test campaigns showed:

    - The positive reception of the dust sensor suggests it can be integrated effectively into daily operations. The employees that tested the wearable sensors responded positively to the outcome that these sensors could have on their health in the workplace.

3. **The sensors** that we tested shall be further investigated and eventually a more thorough investigation of the market shall be undertaken. Main reasons are: (i) not all the sensors are welcomed for their wearing comfort, e.g., the in-ear wearable sensors; (ii) measurements’ quality shall be further assessed to ensure that threshold levels for the various exposure factors are well considered and not either over- or underestimated.

4. **GDPR Compliance**: Consultations with Aker Solutions’ GDPR counselor and an external law firm have indicated the need to reassess our initial approach to ensure GDPR compliance. These discussions confirmed that certain use cases involve employees' personal data, necessitating careful consideration in defining the final solution to establish a legal basis. The dialogue with the

GDPR counselor is ongoing and will be further examined in a larger-scale project.

5. **Data Platform Discussions**: The analysis of commercially available sensors shows that each supplier offers overlapping functionalities but in proprietary formats, limiting interoperability. Key functional requirements are often missing, making it challenging to rely on a single supplier's data platform for broader goals. However, these platforms can still provide valuable insights for occupational health professionals.

   To effectively implement wearable sensor technology, a dedicated data platform should be developed to meet the outlined functional requirements. This platform is designed to be relevant across various industrial enterprises with workers exposed to occupational hygiene risks.

   The proposed data platform will use personas and user stories to describe its functionality, ensuring it meets user needs and goals. An agile methodology with rapid iterations and user feedback is recommended to refine user stories and align development with user needs.

   In summary, the proposed data platform aims to address the limitations of existing supplier-specific platforms by providing a comprehensive, scalable, and secure solution tailored to the needs of industrial enterprises and their workers.

6. **Business case:** The business case was developed using strong hypotheses, namely:
   - reduction in health-related dropouts of 50% across three years
   - residual workforce capacity savings according to findings in SINTEF 2011 report

   these hypotheses, together with the defined use case where the wearable sensors are distributed across all the occupational groups in the yard, lead to a negative business case if one looks only at the quantifiable benefits. It must be noticed that unquantifiable benefits, i.e., work morale and motivation, trust in the company and reputation of the company are not quantifiable but shall also be considered in the evaluation of the business case.

   Finally, the business case is prepared based on the preliminary findings of this pre-project and it shall be considered as a starting point to investigate alternative use of wearable sensors to make sure that investments conditions become more favorable while still ensuring good value outcome for the employees and the company.

7. **Next Steps and Collaboration**: We offered preliminary recommendations on the next steps, including internal work to implement the sensors for digitalizing occupational hygiene monitoring. Additionally, we explored the possibility of a

cross-industry project with Equinor, NTNU, and the inclusive working life industry program (IA- bransjeprogrammet) to define standards spanning across the value chain of projects handled by Aker Solutions.

In conclusion, the **HealthTech** project has successfully demonstrated the potential of advanced sensor technology to improve workplace safety and health conditions. The insights gained from this pre-project will guide the implementation of a larger project, ensuring effective management and compliance with health and safety regulations. The proactive approach to workplace well-being and environmental stewardship will contribute to a healthier and safer working environment for all employees.

Recommendations for the next phase

The lessons learnt and investigations done so far in the pre-project lead us to the following recommendations:

- *Further investigate sensor usability and comfort:* Conduct further testing and market evaluation to identify alternative noise sensors or hardware improvements, especially for in-ear solutions, which received lower usability scores.

- *Test Campaigns and Data Collection*: Design campaigns to test different applications with sensor rotations to minimize costs and ensure compliance with GDPR. The goal is to evaluate the effectiveness of using few sensors rotated among workers in various yard areas. It is also recommended to conduct tests in other yards beyond Egersund for broader feedback.

- *Preparing Promotion and Training Material*: Developing effective promotion and training materials is key to ensuring users are well-informed and confident in using new technologies. Therefore, we strongly recommend conducting training sessions and preparing promotional materials to help users understand how to use the technologies effectively.

- *Investigating Short-Term Exposure Limit of PM Measurements*: Setting feasible short-term exposure limits for particulate matter (PM) is crucial for in time intervention protecting workers' health. The recommendation involves analyzing PM measurements and collaborating with medical and occupational hygiene experts to establish safe exposure limits. This collaboration will help us develop guidelines that are both scientifically sound and practical for implementation in the workplace.

- *Stationary sensor*: The stationary sensor provides valuable information about environmental factors without GDPR issues and is easy to use for continuous monitoring of workplace conditions. Therefore, we recommend proceeding with testing the Aeroguard sensor and comparing its measurements with gold-standard sensors.

- *Data platform:* To reduce investment costs, partnerships should be established between more stakeholders in the data platform. This includes both internal and potential external interested parties such as government and other industrial companies. It should be investigated whether already established commercial providers in this market are interested in further developing a partnership to realize the goals of the data platform.

- *Business case:* The investment cost in sensors is high. From an implementation perspective, this can be reviewed. For example, can the same benefits be achieved with fewer sensors and a phased deployment in the most vulnerable occupational groups? The figures for work-related illness and sickness absence should be better understood to improve the quality of estimates regarding the potential financial gains for the company. For example, closer cooperation with NAV and/or the National Institute of Occupational Health can be sought to utilize national industry-related figures. The business case derived from this pre-project should be considered as an initial point to investigate the appropriate method for potential investment in wearable sensors rather than a definitive tool for making a final decision. This business case is based on general, preliminary hypotheses that need further refinement before a more consolidated business case can be developed for recommending a final decision.

- *GDPR and legal aspects:* This matter was primarily investigated according to initial use case for the sensors. However, this use case is already challenged by the business case and needs to be revisited. In addition, the original use case (i.e., share health data with the medical doctor and line managers) is also challenged by the GDPR compliance. We therefore recommend that in a larger scale project it is investigated:
    - Clarification of the purpose and legal basis: Aker Solutions needs to be very clear about the purpose of using personalized sensor data.
    - Assessment of Necessity of Personal Data: If the data is used only to trigger actions based on exposure levels, it needs to be clarified why personal data is necessary and how it will be used.

  If Aker Solutions wants to use personalized data without sharing it with the medical officer, it is advised to obtain external advice to determine if such data will be classified as sensitive personal data requiring consent.

- *Partnerships and collaborations:* it is recommended to continue partnerships and collaborations with NTNU for defining BSc and MSc projects and securing funding for a full-time PhD or research project focused on AI-driven exposure monitoring and musculoskeletal disorder prevention. Additionally, proposals should be prepared to leverage student resources from the computer science department for data platform design and prototyping. Efforts should also be made to collaborate with industry partners such as Aker BP, Equinor, and Skanska to validate the technology in real-world settings, gather comprehensive data, and practical feedback from users.

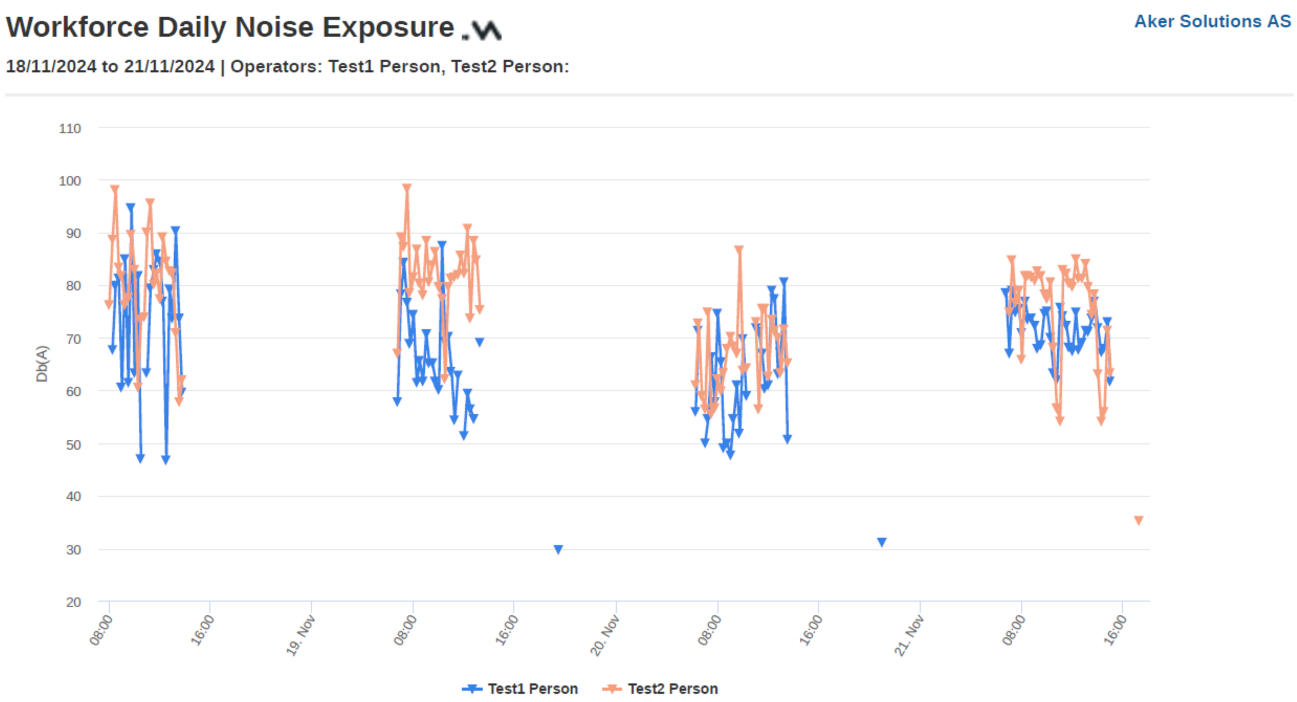
Appendix

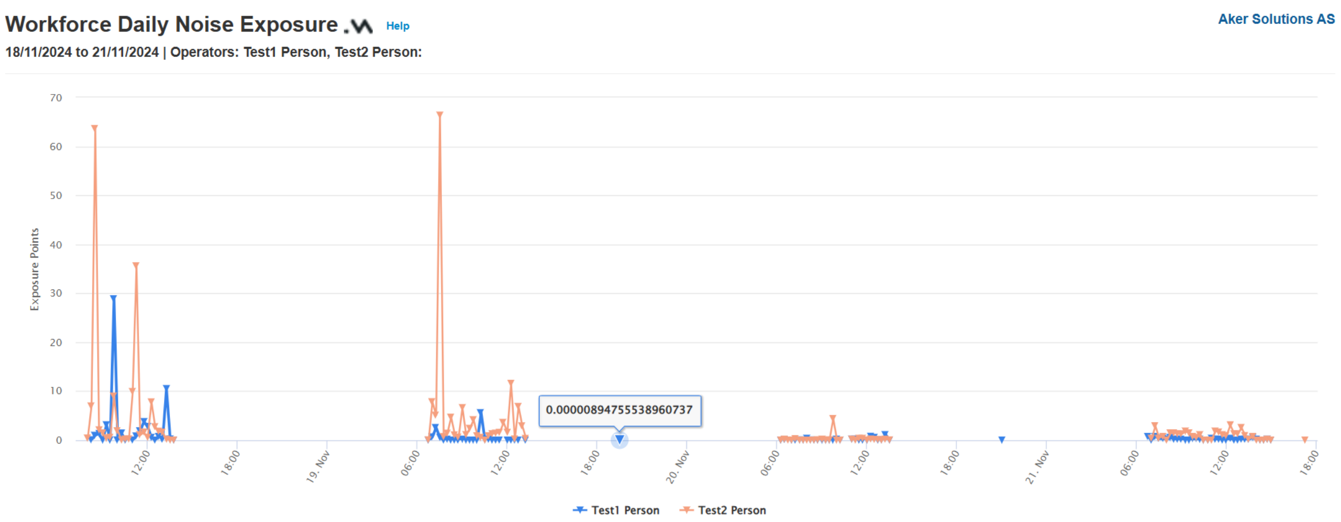
Sensors and Measurements from test campaign Data Collection – Phase I

The following plots, accessible through the Reactec analytics dashboard, are provided for reporting and resource management purposes.

Noise Exposure data

We present the noise exposure levels recorded during the four-day testing period, offering a detailed view of the participants' noise exposure throughout the experiment.





Operator Daily Noise Exposure Help

Aker Solutions AS

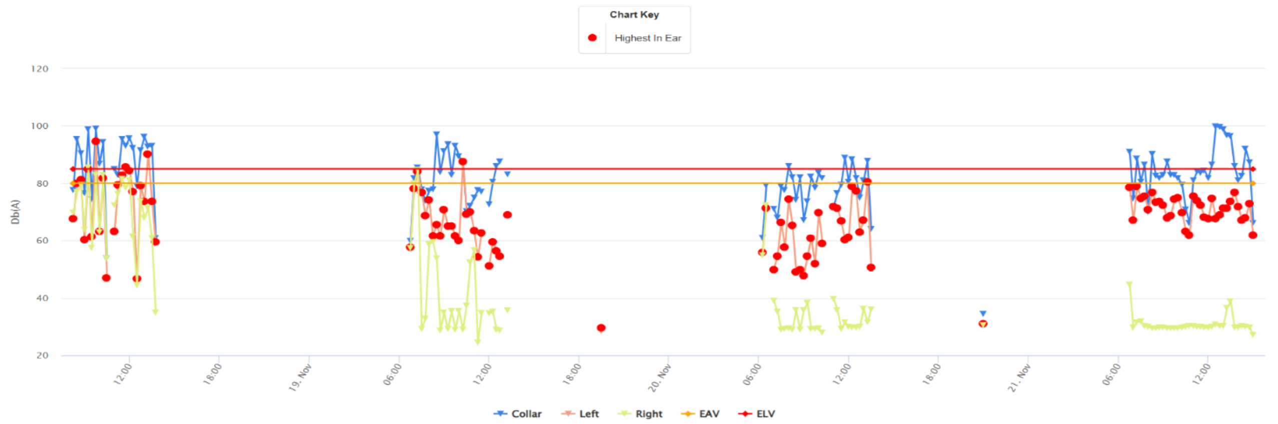
18/11/2024 to 21/11/2024

Date	Day	Group	Operator ID	Name	EAV	ELV	Highest in Ear Exposure Points	% of ELV	Left Exp dB (A)	Right Exp dB(A)	Ambient Exp dB(A)	View Details	Interventions
21/11/2024	Thu	P 1 Hallen	001	Test1 Person	32	100	7	7%	73.19	33.23	91.17	Details	+
21/11/2024	Thu	P 1 Hallen	002	Test2 Person	32	100	31	31%	79.67	76.23	99.01	Details	+
20/11/2024	Wed	P 1 Hallen	002	Test2 Person	32	100	7	7%	73.93	70.33	82.63	Details	+
20/11/2024	Wed	P 1 Hallen	001	Test1 Person	32	100	3	3%	71.11	58.01	81.95	Details	+
20/11/2024	Wed	P 1 Hallen	001	Test1 Person	32	100	0	0%	30.97	30.44	34.4	Details	+
19/11/2024	Tue	P 1 Hallen	001	Test1 Person	32	100	10	10%	76.16	71.9	87.61	Details	+
19/11/2024	Tue	P 1 Hallen	002	Test2 Person	32	100	136	136%	87.07	86.36	86.86	Details	+
19/11/2024	Tue	P 1 Hallen	001	Test1 Person	32	100	0	0%	28.32	29.57	28.71	Details	+
18/11/2024	Mon	P 1 Hallen	001	Test1 Person	32	100	57	57%	84.22	77.85	93.03	Details	+
18/11/2024	Mon	P 1 Hallen	002	Test2 Person	32	100	150	150%	87.45	88	93.23	Details	+

Workforce Daily Noise Exposure Help

Aker Solutions AS

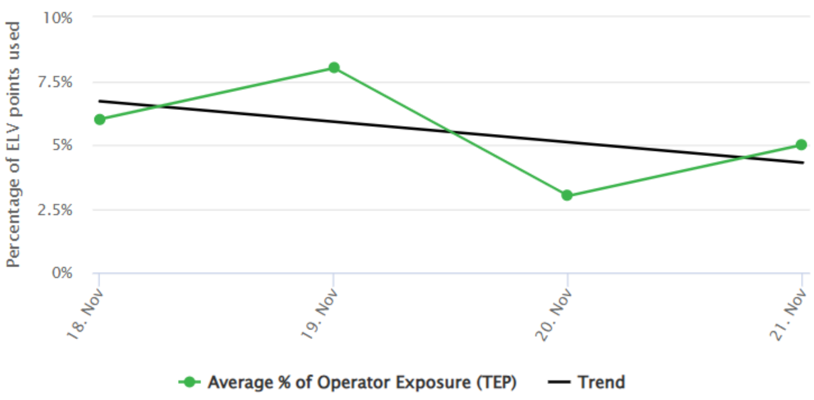
18/11/2024 to 21/11/2024 | Operator: Test1 Person: | Operator: Test1 Person



Vibration Exposure Data

We present the vibration exposure data, which includes two key measures: sensed vibration exposure levels (SEP) and tool exposure levels (TEP).

TEP

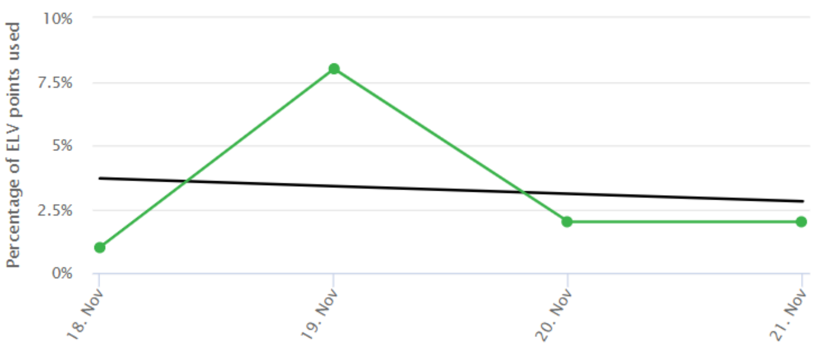


Total Operators: 4

Initial Average Exposure: 6%
Final Average Exposure: 5%

Exposure Trend: -2%

SEP



Total Operators: 4

Initial Average Exposure: 1%
Final Average Exposure: 2%

Exposure Trend: -1%

Operator Daily Exposure Help

18/11/2024 to 21/11/2024 SEP

Aker Solutions AS

Overridden	Date	Day	Group	Operator ID	Name	EAV A(8) m/s²	ELV A(8) m/s²	Total Exposure A(8) m/s²	% of ELV	Trigger Time (Hours)	View Details	Interventions
	19/11/2024	Tue	P 1 Hallen	002	Test2 Person	2.5	5.0	1.7	12%	1.0581	Details	+
	21/11/2024	Thu	P 1 Hallen	004	Test4 Person	2.5	5.0	1.2	6%	0.5589	Details	+
	19/11/2024	Tue	P 1 Hallen	001	Test1 Person	2.5	5.0	1.0	4%	0.5942	Details	+
	20/11/2024	Wed	P 1 Hallen	001	Test1 Person	2.5	5.0	0.8	2%	0.2897	Details	+
	20/11/2024	Wed	P 1 Hallen	002	Test2 Person	2.5	5.0	0.8	2%	0.4050	Details	+
	18/11/2024	Mon	P 1 Hallen	001	Test1 Person	2.5	5.0	0.5	1%	1.1167	Details	+
	18/11/2024	Mon	P 1 Hallen	002	Test2 Person	2.5	5.0	0.5	1%	0.1819	Details	+
	21/11/2024	Thu	P 1 Hallen	003	Test3 Person	2.5	5.0	0.5	1%	0.2631	Details	+
	20/11/2024	Wed	P 1 Hallen	002	Test2 Person	2.5	5.0	0.4	0%	0.0306	Details	+
	21/11/2024	Thu	P 1 Hallen	004	Test4 Person	2.5	5.0	0.0	0%	0.0056		+

The SUS questionnaire

Here is a copy of the questionnaire that was presented to the workers that participated in the test campaigns – Phase I & II.

Please answer the questions based on your experience	**Strongly Disagree**			**Strongly Agree**	
1. I think that I would like to use **Reactec Watch** frequently	1	2	3	4	5
2. I found **Reactec Watch** unnecessarily Complex	1	2	3	4	5
3. I thought **Reactec Watch** was easy to use	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use **Reactec Watch**	1	2	3	4	5
5. I found the various functions in **Reactec Watch** were well integrated	1	2	3	4	5
6. I thought there was too much inconsistency in **Reactec Watch**	1	2	3	4	5
7. I would imagine that most people would learn to use **Reactec Watch** very quickly	1	2	3	4	5
8. I found **Reactec Watch** very cumbersome to use	1	2	3	4	5
9. I felt very confident using **Reactec Watch**	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with **Reactec Watch**	1	2	3	4	5

How would you describe the general feeling of wearing the *Reactec Watch* for an extended period (8 hours)?

- ☐ I forgot I was wearing it
- ☐ I was slightly aware of it
- ☐ I was uncomfortable wearing it
- ☐ I felt anxious or stressed wearing it
- ☐ Other (please specify): ________________________________

Please answer the questions based on your experience	**Strongly Disagree**				**Strongly Agree**
1. I think that I would like to use **Dust Sensor** frequently	1	2	3	4	5
2. I found **Dust Sensor** unnecessarily Complex	1	2	3	4	5
3. I thought Dust **Sensor** was easy to use	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use Dust **Sensor**	1	2	3	4	5
5. I found the various functions in Dust **Sensor** were well integrated	1	2	3	4	5
6. I thought there was too much inconsistency in Dust **Sensor**	1	2	3	4	5
7. I would imagine that most people would learn to use Dust **Sensor** very quickly	1	2	3	4	5
8. I found Dust **Sensor** very cumbersome to use	1	2	3	4	5
9. I felt very confident using Dust **Sensor**	1	2	3	4	5

10. I needed to learn a lot of things before I could get going with Dust **Sensor**	1	2	3	4	5

How would you describe the general feeling of wearing the *__Dust sensor__* for an extended period (8 hours)?

- ☐ I forgot I was wearing it
- ☐ I was slightly aware of it
- ☐ I was uncomfortable wearing it
- ☐ I felt anxious or stressed wearing it
- ☐ Other (please specify): ______________________________

How would you describe the general feeling of wearing the *Noise sensor* for an extended period (8 hours)?

- ☐ I forgot I was wearing it

Please answer the questions based on your experience	Strongly Disagree				Strongly Agree
1. I think that I would like to use **Noise sensor** frequently	1	2	3	4	5
2. I found Noise **sensor** unnecessarily Complex	1	2	3	4	5
3. I thought Noise **sensor** was easy to use	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use **Noise sensor**	1	2	3	4	5
5. I found the various functions in **Noise sensor** were well integrated	1	2	3	4	5
6. I thought there was too much inconsistency in **Noise sensor**	1	2	3	4	5
7. I would imagine that most people would learn to use **Noise sensor** very quickly	1	2	3	4	5
8. I found **Noise sensor** very cumbersome to use	1	2	3	4	5
9. I felt very confident using **Noise sensor**	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with **Noise sensor**	1	2	3	4	5

- ☐ I was slightly aware of it
- ☐ I was uncomfortable wearing it
- ☐ I felt anxious or stressed wearing it
- ☐ Other (please specify): ______________________________

How do you rate your overall workday (8-hour working day)?

- ☐ Low activity

- ☐ Normal activity
- ☐ High activity

Did you experience/notice anything specific/abnormal within the workday?

- ☐ Yes
- ☐ No

If yes, please specify: ____

Please select your age range:

- ☐ 17-19
- ☐ 20-29
- ☐ 30-39
- ☐ 40-49
- ☐ 50-59
- ☐ 60-69
- ☐ 70 and above

The Daily questionnaires for Phase II

My test number: _______________ **DATE:** ______________________

1. **Did you encounter any technical problems (e.g., sensor malfunctions, battery issues) during your shift?**

If **yes**, please describe the issue.

2. **On a scale of 1 (Very Uncomfortable) to 5 (Very Comfortable), how would you rate the overall comfort of wearing the sensors today?**

1	2	3	4	5

3. **Did you feel the sensors interfered with your work tasks or PPE usage in any way?**

If **Yes**, please explain.

4. **How do you rate your overall workday (8-hour working day)?**

Low activity

Normal activity

High activity

5. **Did you experience/notice anything specific/abnormal within the workday?**

Yes

No

If yes, please specify: ____

6. **Did you receive any notifications or feedback from the sensors during your shift (e.g., alerts or recommendations)?**

No

If Yes, which sensor?

- ☐ Noise
- ☐ Dust
- ☐ Vibration

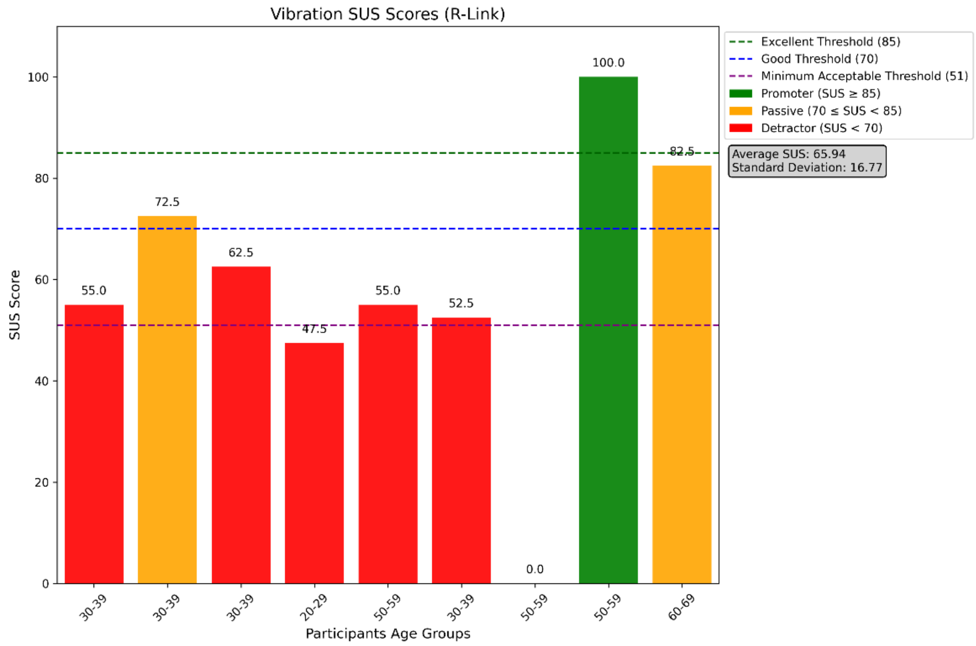
If Yes, how did you react to the notification?

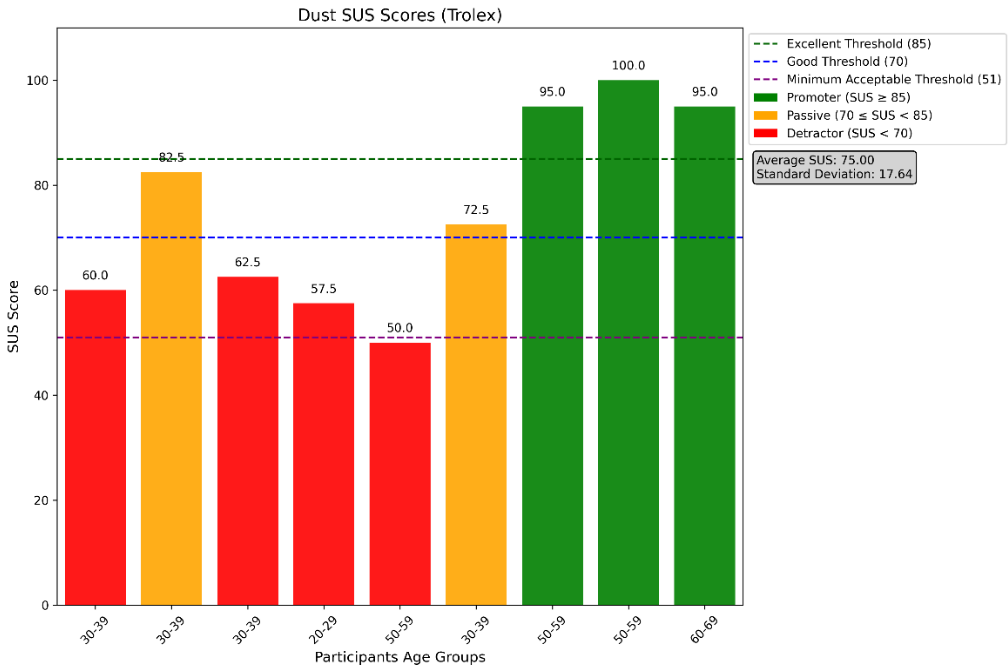
- I was busy so I Ignored it
- I forgot about it.
- I contacted my supervisor/foreman.
- I adjusted my behavior/actions immediately
- I planned to address it later
- Other (please specify): ___________________________

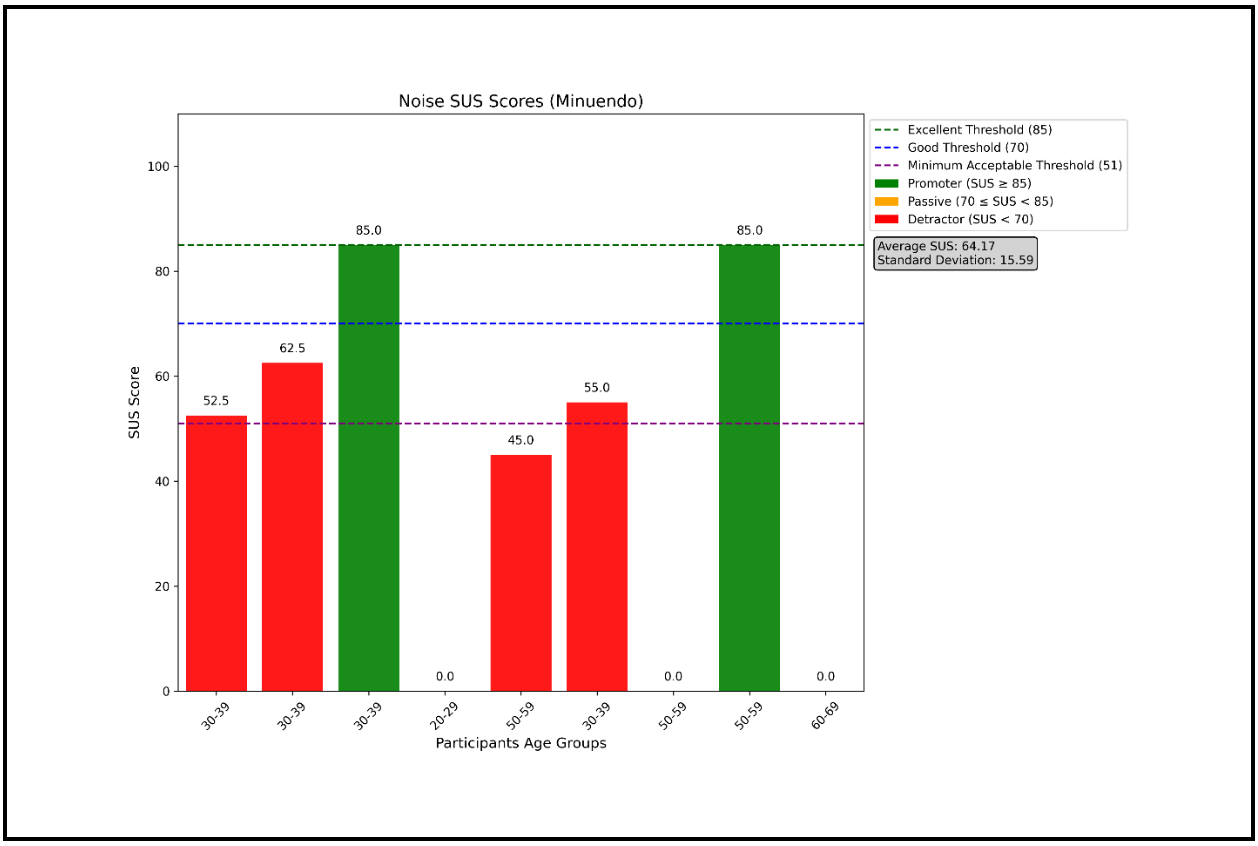
SUS Questionnaire Results from the second test campaign – Phase II

The following section presents individual SUS scores, with plots categorized by test groups for clearer comparison. Note that participants completed the questionnaire after one week of using the sensors.

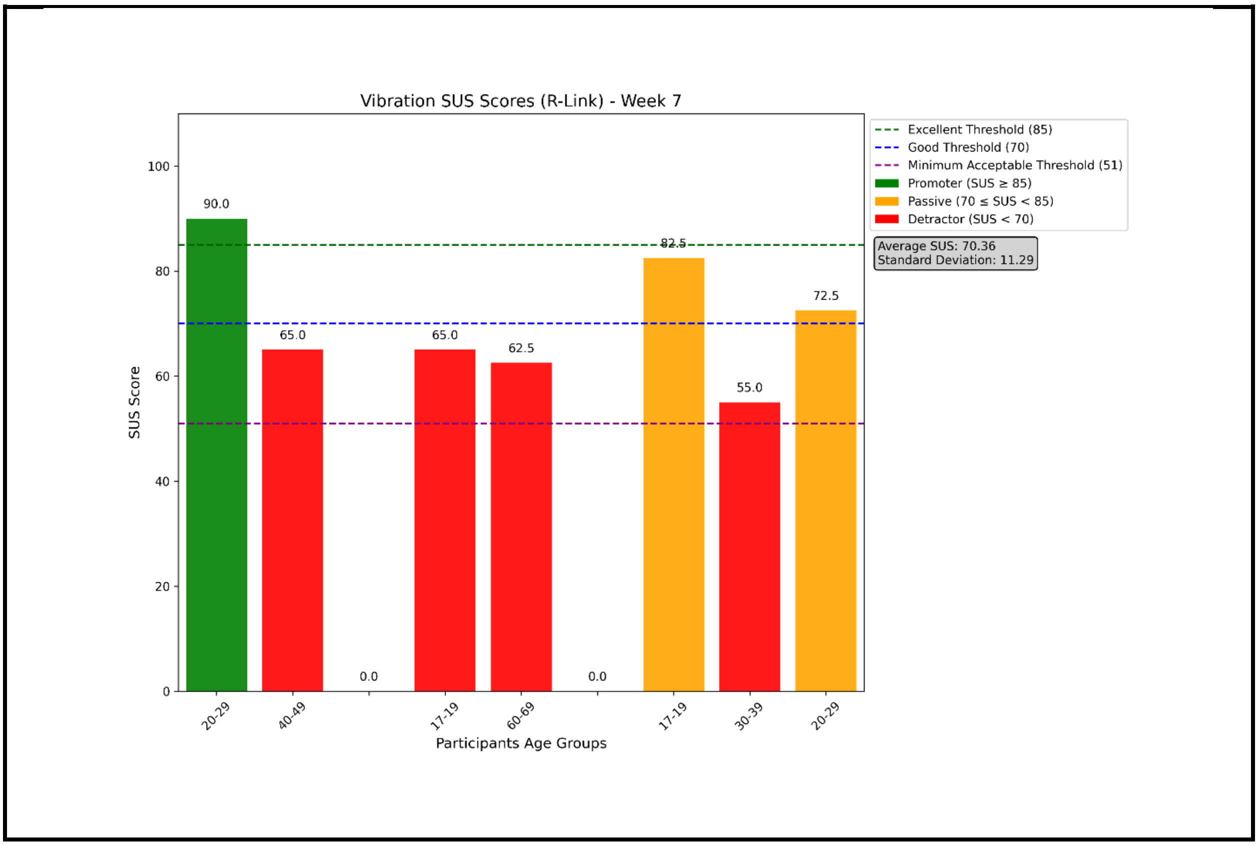
SUS Responses – Structural Welders – Week 6

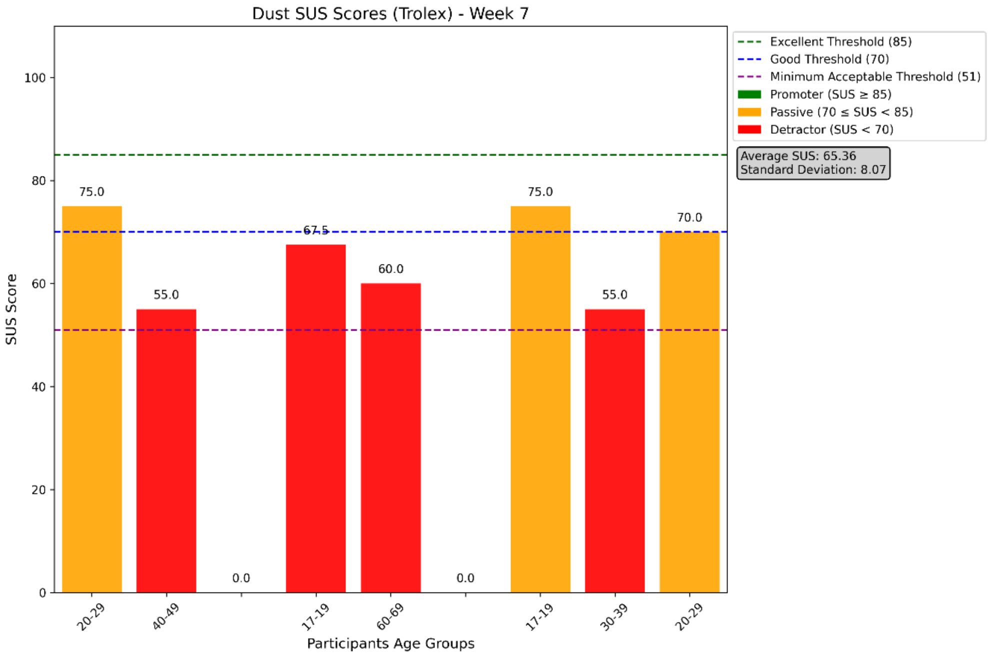


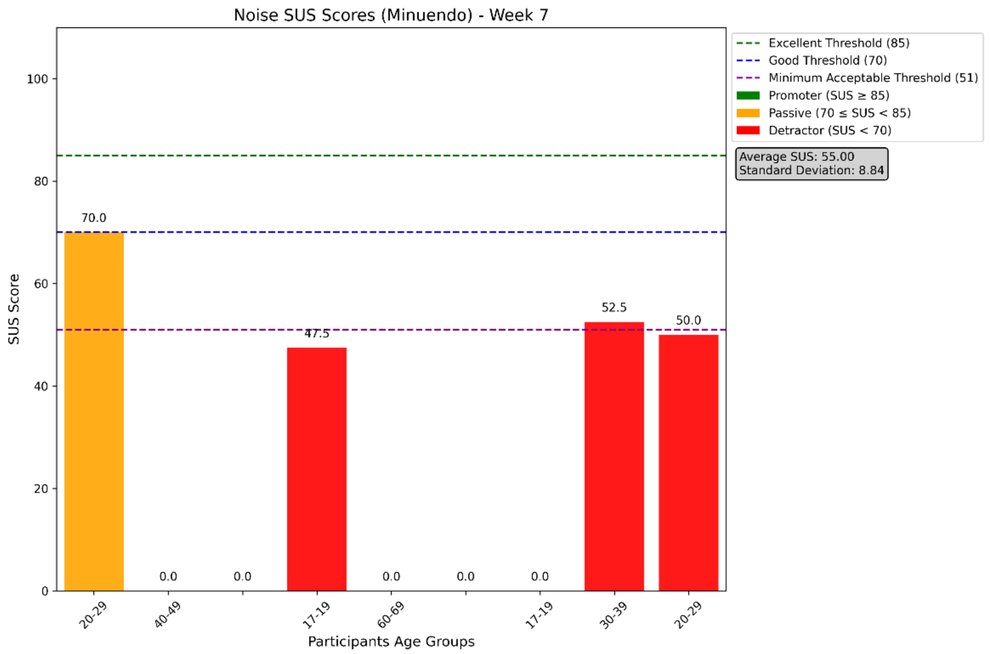




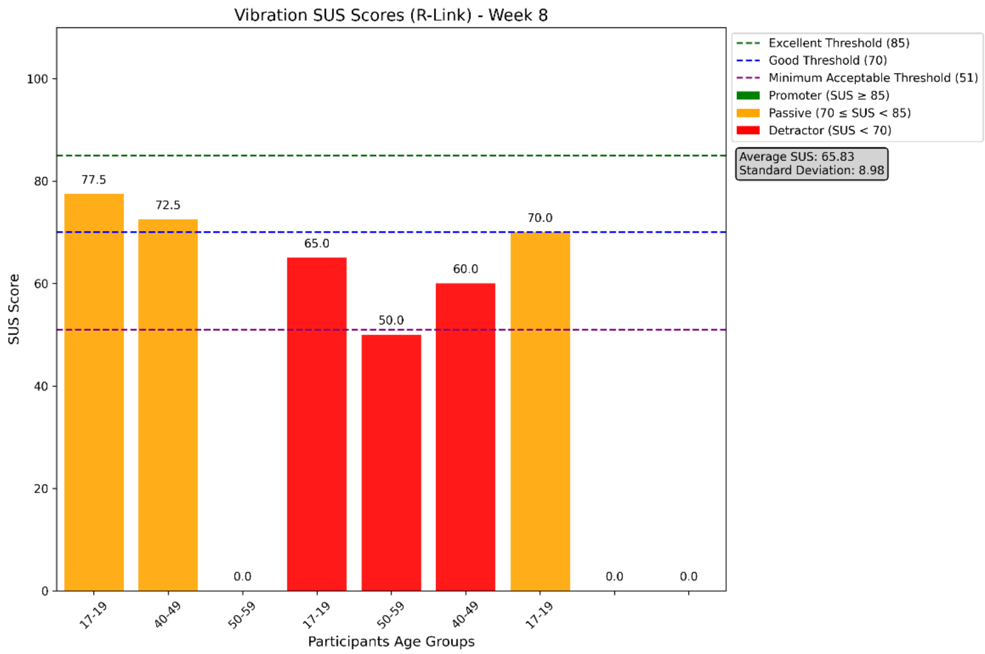
SUS Responses – Metal Sheet Workers – Week 7

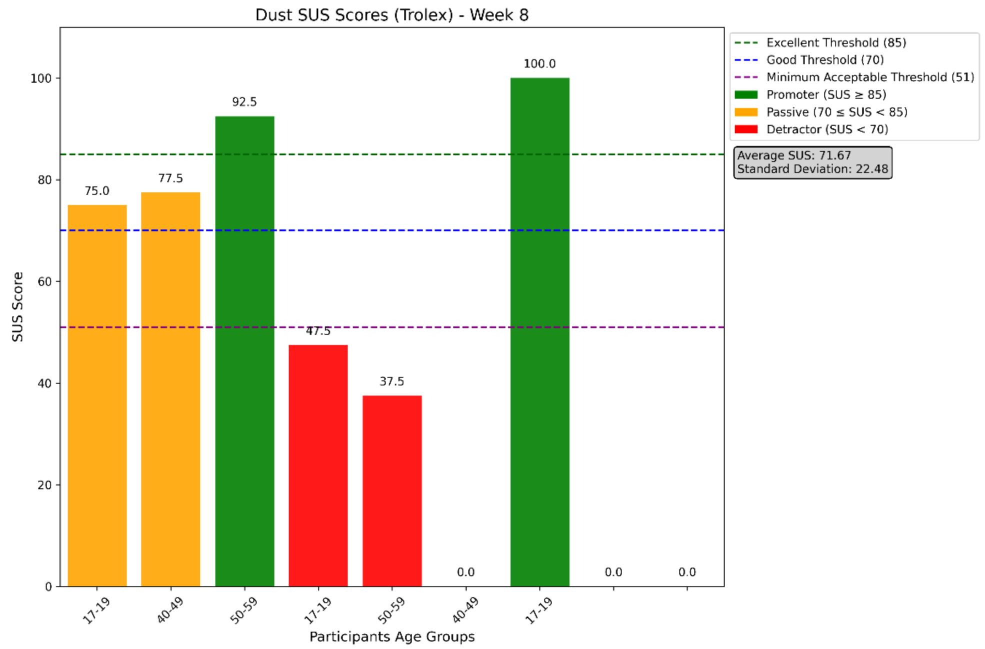


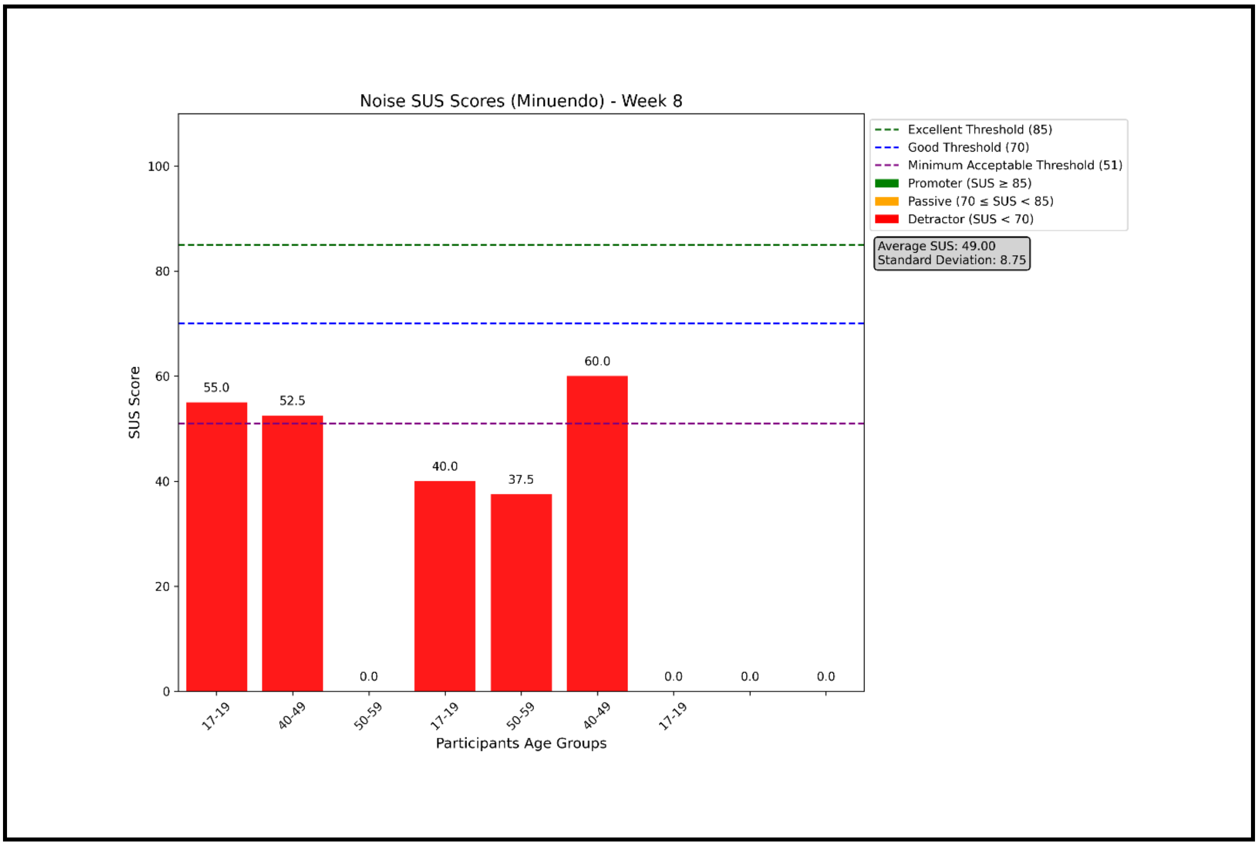

Dust SUS Scores (Trolex) - Week 7
Excellent Threshold (85)
Good Threshold (70)
Minimum Acceptable Threshold (51)
Promoter (SUS ≥ 85)
Passive (70 ≤ SUS < 85)
Detractor (SUS < 70)
Average SUS: 65.36
Standard Deviation: 8.07
SUS Score
0
20
40
60
80
100
75.0
55.0
0.0
67.5
60.0
0.0
75.0
55.0
70.0
20-29
40-49
17-19
60-69
17-19
30-39
20-29
Participants Age Groups


Noise SUS Scores (Minuendo) - Week 7
Excellent Threshold (85)
Good Threshold (70)
Minimum Acceptable Threshold (51)
Promoter (SUS ≥ 85)
Passive (70 ≤ SUS < 85)
Detractor (SUS < 70)
Average SUS: 55.00
Standard Deviation: 8.84
SUS Score
0
20
40
60
80
100
70.0
0.0
0.0
47.5
0.0
0.0
0.0
52.5
50.0
20-29
40-49
17-19
60-69
17-19
30-39
20-29
Participants Age Groups

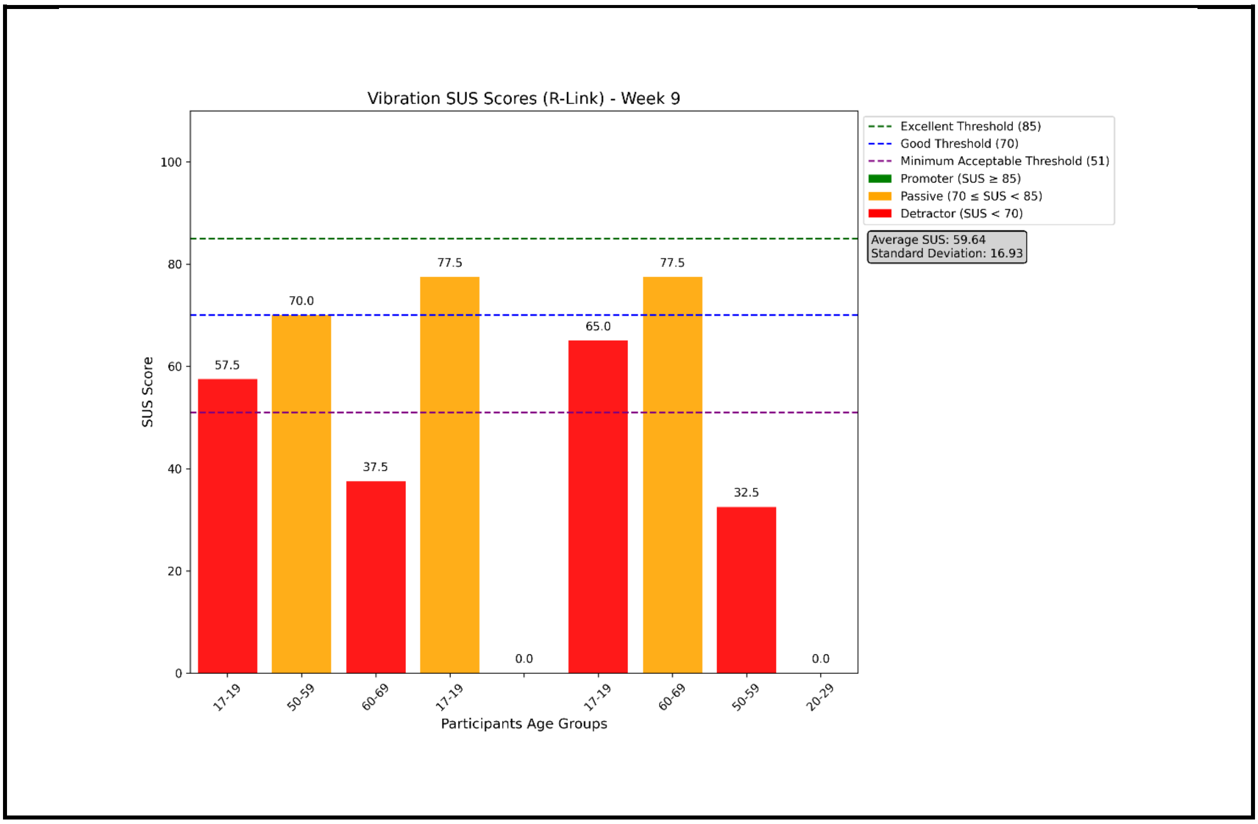
SUS Responses – Pipe Fitters – Week 8

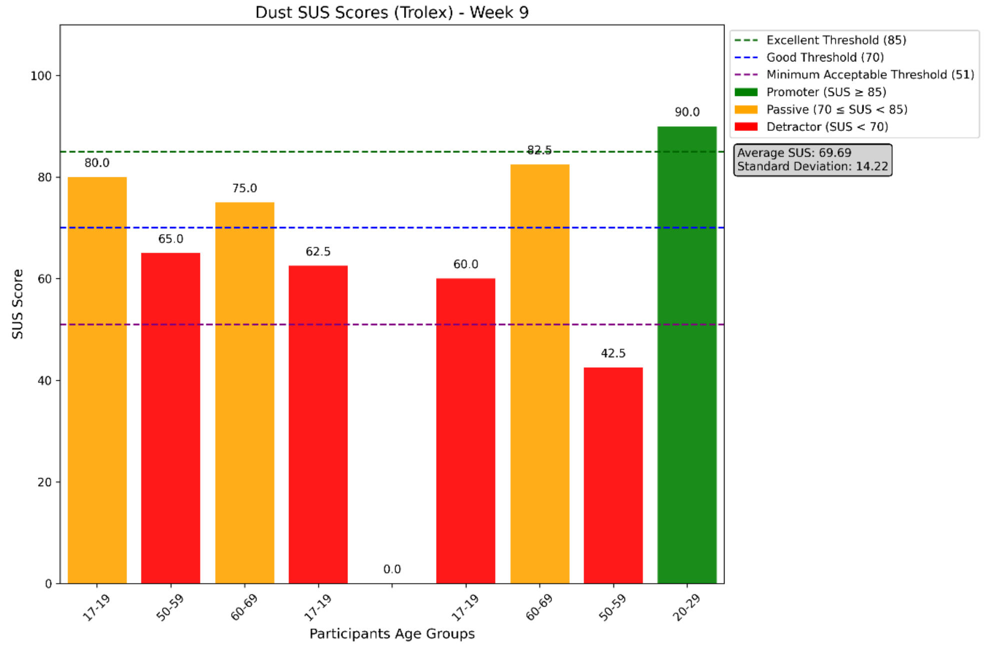


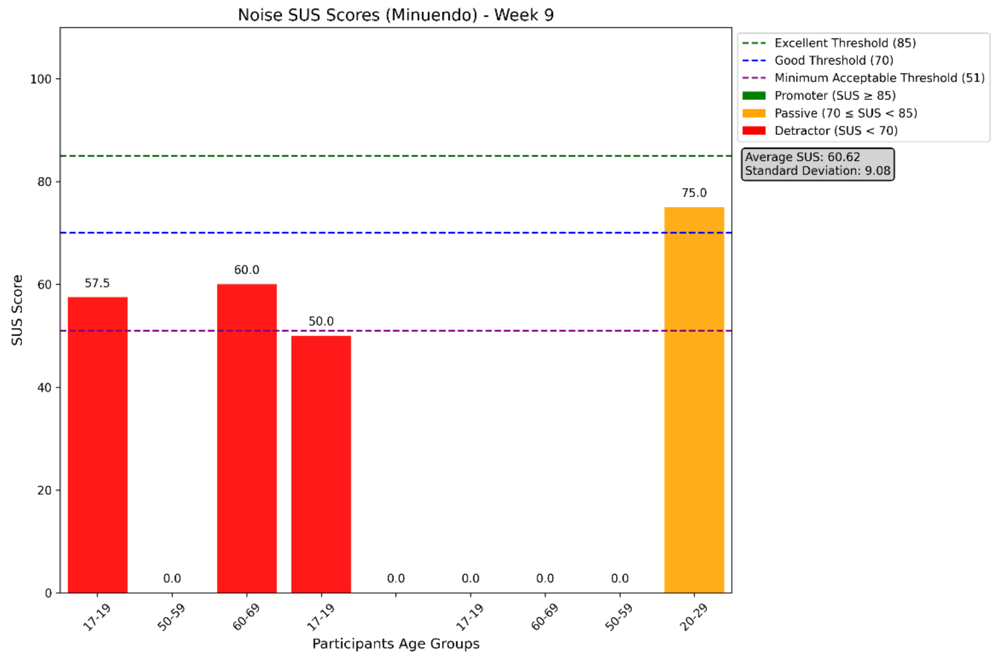




SUS Responses – Piping Welders – Week 9







Memo from Simonsen Vogtviig about GDPR compliance of the proposed process and method

Memo

To: Aker Solutions AS, att. Gry Braathen

From: Advokatfirmaet Simonsen Vogt Wiig AS

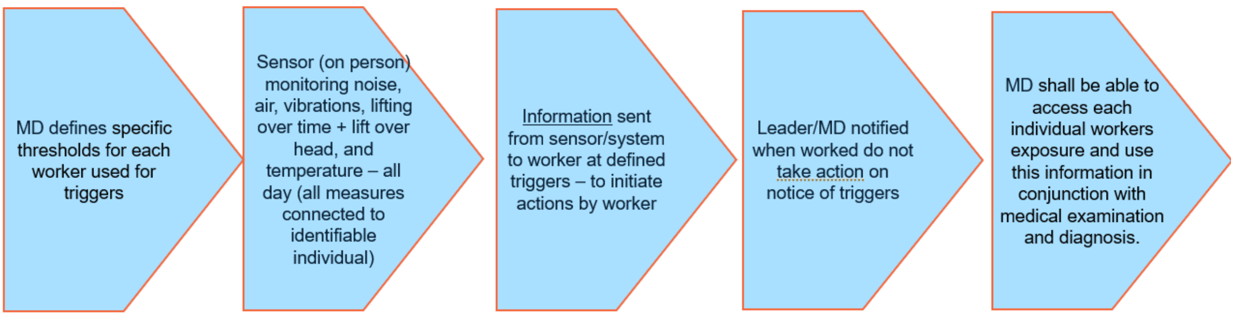
Lawyer in charge:	Our ref.:	Oslo
Thomas Olsen	68372509	9 January 2025

LEGAL IMPLICATIONS RELATED TO USE OF SENSORS IN THE WORKPLACE

Introduction

Aker Solutions AS ("AKSO") has asked Advokatfirmaet Simonsen Vogt Wiig AS ("SVW", "we") for assistance related to a project involving use of sensors in the workplace. This memo addresses, on a high level, challenges and mitigating measures related to data protection, the Working Environment Act Chapter 9 on control measures and other challenges identified.

AKSO has provided the following description:



Based on the description and additional information from AKSO, our understanding of the processing can be summarized as follows:

1. The Medical Doctor ("MD") defines specific thresholds for each worker used for triggering notifications to the worker. The thresholds are, inter alia, based on legal requirements to the working environment.[13]

2. The workers will throughout the shift wear arm wrist band with sensors which will monitor:

- Noise
- Air
- Vibrations
- Lifting (by use of sensors that gives information about motion of arms and upper body (position of arms, velocity and acceleration)
- Temperature

3. If the set thresholds are exceeded, information is sent to the worker to initiate actions by the worker. We understand that the actions would depend on the circumstances, e.g. leaving the area, stop machines or tasks, ensuring better ventilation etc.

4. The Leader/MD will be notified when workers do not take actions on notice of triggers. This will allow the leader and/or the medical doctor to intervene.

5. Information collected from the arm wrist band will also be recorded and made available to the local MD for future reference. The MD could use the data to follow up the employees and help correctly diagnose a potential work-related illness. For example, if an employee develops ear loss symptoms, the MD could check if an employee has received notifications related to noise and whether these have been acted upon.

Challenges related to the GDPR and the Personal Data Act

The use of sensors will involve processing personal data which AKSO leaders and MD can relate to identifiable workers. This means that the requirements of the EU General Data Protection Regulation ("GDPR") and the Norwegian Data Protection Act must be adhered to.

Roles and responsibilities

Our assessment is that AKSO, acting as employer for the workers, would be the controller determining the purposes and means for the processing related to the use of sensors.

---

[13] Forskrift om tiltaks- og grenseverdier (FOR-2011-12-06-1358), including Section 2-2 Limit values for noise and Attachment 1: List of limit values for pollutants in the working atmosphere, available at the Norwegian Labor Inspection Authority: https://www.arbeidstilsynet.no/regelverk/forskrifter/forskrift-om-tiltaks--og-grenseverdier/

The solution makes use of services (hardware and software) from US-based third-party providers:

- MakuSafe
- Modjoul

Our assessment is that MakuSafe and Modjoul will be considered as processors processing personal data on behalf of AKSO. Hence, there needs to be in place a GDPR Article 28 compliant data processing agreement between AKSO and the providers.

The MD is subject to obligations under Norwegian health legislation, in particular the Patient Records Act and the Health Personnel Act. Our assessment is therefore that the MD as a point of departure will be considered controller for processing of personal data related to data stored in the patient records. The MD must also respect confidentiality obligations following from the health legislation. The MD can as a main rule not share the worker's health data with others, not even AKSO as the worker's employer, without consent from the worker.

Purpose limitation principle

One of the key principles of the GDPR is the purpose limitation principle. The principle consists of two components. The first component is a requirement on the controller prior to the processing set out the purposes for the processing of the personal data, cf. GDPR Article 5(1)(b). The purposes shall be specified, explicit and legitimate.

The second component is that the personal data cannot later be used for new purposes that are incompatible with the initial purposes, unless AKSO obtains consent or can rely on a statutory authority (i.e. legal Act or Regulation). This means that intended or unintended broadening of the scope must be avoided. For example, a "function creep" towards using the sensors to measure the efficiency of the workers could be unlawful if this was not the initially specified purpose.

AKSO should therefore strive to identify all relevant purposes for processing personal data prior to introducing sensors in the workplace.

Based on the information received so far, our understanding is that it would be relevant to use the body sensors for the following purposes:

1. Real time limitation of health risk by sending notification to the worker to act when exposure reaches the set threshold.
2. The possibility of real time intervention by leader (or MD) if the worker does not act upon receiving a notification.
3. Analysis of aggregated data to get better understanding of the exposure in the working environment and possible mitigating measures. For example:

- If one worker has recorded high noise exposure, how has this noise affected other workers in the same area? What work process caused the noise and how can the company prevent it from affecting others?

- Workers in location A are in general experiencing higher vibration exposure than in location B. Based on this knowledge, would it be possible to introduce mitigating measures in location A?

4. Use of collected exposure data for the individual workers by the MD for diagnosis purposes and follow up of the workers (health care services).

For the sake of good order, we also mention that the current small-scale pre-project in collaboration with NTNU may be considered as a research project involving processing of personal data. However, since this memo focuses on the implications of a large-scale implementation, we have not elaborated on the legal aspects of carrying out the pilot/testing.

In summary, we recommend that AKSO takes great care in identifying and specifying the purposes to ensure that they cover all activities and that the purposes can be easily understood by all stakeholders (the leaders, MD and the workers).

Legal basis

Whether the data constitutes special categories of personal data

To be lawful, the processing of personal data must have a legal basis. An important question when determining the legal basis is whether the data concerns the worker's health and therefore would be considered special category personal data which requires a legal basis in both GDPR Article 6 and Article 9(2).

On the one hand, it could be argued that the sensors only collect information about the working environment, not about the worker him-/herself. Use of aggregated data which cannot be related to identifiable workers would not be considered special category personal data (and fully anonymized data would not be considered personal data).

However, if data is collected over time and can be related to the individual workers, we cannot rule out that the data may be considered as health data relating to the individual workers. This is particularly the case with regard to MD's use of the data for diagnostic purposes.

To summarize, we recommend carrying out a more thorough analysis when AKSO has determined the purposes of the processing, the data collected, access management, possibilities of identifying the individual etc.

Legal basis for purposes 1 and 2 (real time notification to workers and intervention by leaders)

We believe that purposes 1 and 2 have certain similarities so that their legal basis could be considered together.

As set out above, there is some uncertainty as to whether the data would be considered special category personal data.

If the personal data is not considered special category personal data (not health data), we believe that the most appropriate legal basis would be legitimate interest pursuant to GDPR Article 6(1)(f). This would require AKSO to carry out a documented balance of interest assessment which shows that AKSO's legitimate interest in carrying out the processing outweighs the interests of the workers. This assessment would have many similarities with the assessment that needs to be done to fulfil the conditions for control measures under the Working Environment Act, cf. section 0 below. Our immediate assessment is that it probably would be possible to establish a legal basis based on legitimate interests.

The workers would have a right to object (opt-out) on grounds relating to his or her particular situation, but AKSO can nevertheless carry out the processing if AKSO demonstrates compelling legitimate grounds for the processing which override the interest of that particular worker. This means in essence that AKSO must consider the objection, but that AKSO may be in the position to continue if it considers that its interests in carrying out the processing outweighs those of the worker.

If the data is considered special category data (data about health), AKSO would also need a legal basis in Article 9(2).

One possibility could be to use Article 9(2)(b) which concerns processing necessary for the purposes of carrying out AKSO's obligations in the field of employment in accordance with applicable law. It could be argued that the use of sensors is necessary to comply with "Forskrift om tiltaks- og grenseverdier". However, it is doubtful whether it is necessary to use body sensors to comply with these requirements. Also, we cannot see that the legal requirements set out specific thresholds for e.g. heavy lifting. It is therefore uncertain whether Article 9(2)(b) could be used as a legal basis.

Another alternative is to use consent as legal basis (Articles 6(1)(a) and 9(2)(a)). The challenge with using consent is the high threshold for consent being freely given. Due to the imbalance between the employer and employee, it could be difficult to fulfil this requirement. A prerequisite would at least be that use of the sensor is completely voluntary and that there are no downsides for the employee to not provide consent. A consent also needs to be specific and informed, meaning that the workers would need to be provided clear and concise information about the consequences of providing consent. The workers would have a right to withdraw consent at any time. AKSO should consider whether this involves any disadvantages which makes consent less favorable compared to the other legal bases.

Legal basis for purpose 3 (analysis of aggregated data)

Our understanding is that purpose 3 could be achieved using aggregated data, i.e. that this purpose could be achieved without identifying workers. If this assumption is correct, the data processed for this purpose would not be considered special category data personal data concerning health of identifiable workers.

This means that the legal basis could be legitimate interest (GDPR Article 6(1)(f)).

However, since the data is collected in relation to purpose 1 and 2, we believe that AKSO should consider whether the choice of legal basis for purpose 1 and 2 may impact the choice of legal basis for purpose 3. For example, if AKSO chooses to use consent for purposes 1 and 2, it may be relevant to obtain consent also for purpose 3. We believe that it would be possible to use consent for purposes 1 and 2, and legitimate interest for purpose 3. However, this would require AKSO to provide very clear information about purpose 3 and also about the possibility of objecting (opting-out) of purpose 3.

Legal basis for purpose 4 (use of collected exposure data by the MD for providing health services)

Our immediate assessment is that use of the data for this purpose would involve processing of special category data (health data). We believe that the relevant legal basis would be consent. The consent must be freely given, specific and informed, cf. above.

Data minimization

A principle closely related to the purpose limitation principle is data minimization, namely that personal data must be adequate, relevant and limited to what is *necessary* in relation to the purposes for which they are processed.

This means that AKSO must consider for each of the purposes which data are necessary to obtain the purposes.

Accuracy

AKSO should ensure that the sensors and the associated data are accurate, e.g. through testing and quality assurance over time. For example, relying heavily on sensors and notifications could jeopardize worker's health and safety if the sensors are not reliable.

Storage limitation

The storage limitation principle sets out that data should not be kept in a form which permits identification of data subjects for no longer than is necessary for the purposes for which the personal data are processed. This means that when the data is no longer necessary for a purpose, the data should either be deleted or anonymized.

Integrity and confidentiality

The data must also be processed in a manner that ensures appropriate security. AKSO should carry out an information risk assessment which also covers the technical and organizational measures provided by the third-party vendors.

Fulfilling data subject rights

AKSO must also ensure that the data subject can exercise their rights under GDPR Chapter III in connection with the use of sensors. We believe that the right to information and the right of access is particularly important.

- Right to information – the workers have a right to information about the data collected and how it is used. Communicating the purposes of the process and the worker's rights in a clear and consistent way is crucial. We understand that AKSO plans to inform all workers thoroughly before implementing use of the sensors. The processing should also be mentioned in the employee privacy notice.
- Right of access - the right of access essentially entails that the data subject has a right to obtain information about whether personal data about them are being processed and details of the processing, in addition to a copy of the personal data processed.

Data Protection Impact Assessment (DPIA) and documentation requirements

A Data Protection Impact Assessment (DPIA) is required if it is likely that the processing results in a high risk to the data subjects. It is not totally clear whether the threshold is met here. However, it seems that four of the criteria in the guidance from the data protection authorities is fulfilled, and is therefore a presumption of high risk:[14]

- Sensitive data (sensor data could involve health data)
- Data concerning vulnerable data subjects (employees)
- Innovative use or applying technological or organisational solutions (sensor technology)
- Data transfer across borders outside the EU/EEA

We therefore recommend carrying out a DPIA which describes the processing, assesses the necessity and proportionality of the processing, assesses the risks to the workers and identifies mitigating measures.

Furthermore, to ensure that AKSO can demonstrate compliance with the GDPR, the processing activities related to the sensors should be reflected in AKSO's key data protection documentation, including:

- Records of processing activities
- Privacy notice
- Necessary training and awareness for involved stakeholders (leaders, MD and workers).

Issues related to use of third-party providers

AKSO must ensure to enter into a data processing agreement with the two US-based third-party providers:

- MakuSafe
- Modjoul

[14] Article 29 Working Party, Guidelines on Data Protection Impact Assessment (DPIA) and determining whether processing is "likely to result in a high risk" for the purposes of Regulation 2016/679.

We assume that the providers do not need to know which worker the data relates to. This means that the providers as a point of departure are not able to identify the workers.

We understand that both providers may store data in the US. This means that there must be in place a legal basis for the transfer of personal data outside of the EEA, e.g. EU Standard Contractual Clauses. We don't see any particular challenges in complying with the data transfer rules. The commitments provided by the US in relation to the EU-US Data Privacy Framework apply also in cases where the data importer in the US has not self-certified according to the Data Privacy Framework. This means that additional measures to the EU Standard Contractual Clauses are not necessary.[15]

Requirements under the Working Environment Act

Introduction

Chapter 9 of the Working Environment Act (WEA) sets out requirements for introducing control measures in the undertaking. It could be discussed whether AKSO's intended use of sensors constitutes control measures. However, our immediate assessment is in any case that the introduction of sensors may have a certain impact on the workers and the working environment, so it would be advisable to adhere to the WEA's requirements. The provisions of Chapter 9 of the WEA apply in addition to the requirements under the Personal Data Act and the GDPR for processing of personal data, cf. WEA Section 9-1(2).

Conditions for control measures

The conditions for introducing control measures in the undertaking are according to WEA Section 9-1 that such measures are:

- objectively justified by circumstances relating to the undertaking;
- it does not involve undue strain on the employees.

Our assessment is that recording of sensor data is "objectively justified" ("saklig begrunnet") considering the importance for AKSO to comply and demonstrate compliance with legal requirements (forskrift om tiltaks- og grenseverdier) and its interest in protecting the health and wellbeing of the workers.

In our view, it is more questionable whether the use of sensors would involve "undue strain" ("uforholdsmessig belastning") on the workers, even though the employees are provided information, and it is voluntary to use it. We believe that many of the considerations that are made in relation to processing personal data will also be

[15] See https://www.datatilsynet.no/aktuelt/aktuelle-nyheter-2023/nye-regler-for-overforing-av-personopplysninger-til-usa/, under the heading "Hjelper de nye reglene meg om jeg vil overføre personopplysninger som ikke står på lista»?

relevant here, in particular related to the use of legitimate interest as legal basis and DPIA (cf. above).

Consultations, information and evaluation of control measures

The Working Environment Act also sets out requirements regarding the procedures that need to be followed when implementing control measures at the workplace.

Firstly, the employer is obliged to as early as possible to *discuss* needs, design, implementation and major changes to control measures in the undertaking with the employees' elected representatives (WEA Section 9-2(1)).

Secondly, before implementing such measures, the employer shall provide the affected employees with *information* concerning (Section 9-2(2)):

a) the purpose of the control measures,
b) practical consequences of the control measures, including how the control measures will be implemented,
c) the assumed duration of the control measures.

Finally, the employer shall, in cooperation with the employees' elected representatives, regularly *evaluate* the need for those control measures that are implemented (WEA Section 9-2(3)).

We recommend that these procedures are followed. The information that is required to be provided to employees under the WEA could be coordinated with information requirements under the GDPR (see above).

Data flow and process description - flowchart