DOT PHMSA Public Quarterly Report

Date of Report: 7th Quarterly Report Ending June 30, 2024
Contract Number: 693JK32210004POTA
Prepared for: USDOT PHMSA
Project Title: Advancing Hydrogen Leak Detection and Quantification Technologies Compatible with Hydrogen Blends
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For quarterly period ending: June 30, 2024

1: Items Completed During this Quarterly Period:

Error! Reference source not found. The 7th Quarterly Status Report was accomplished during this quarter of work and was drawn from Attachment #3, Technical and Deliverable Payable Milestone Schedule (in the contract) from the sixth payable milestones. These items were completed during this reporting period and are the corresponding items included on our next invoice.

2: Items Not-Completed During this Quarterly Period:
Laboratory Testing and Sensor Development activities have not been completed yet but are progressing well and will be integrated into future quarterly reports as work continues to be accomplished.

3: Project Technical Status:

ACTIVITY: LABORATORY TESTING

Item Title: Complete laboratory testing
Item Number: 10
Task Number: 4

Laboratory Testing has not been completed due to delays in the lab setup and the procurement of devices/sensors, gas mixtures, and their related connections. However, there has been good progress for both the sensor testing being conducted at SENSIT Technologies. In regard to the sensor testing, as discussed previously in the Evaluation Framework, the individual sensors being tested will be focused on four types:

1. Current state-of-the-art flammable gas detection sensors
2. Air toxic H2S and CO detection sensors

3. Oxygen detection sensors (both galvanic and electrochemical)
4. Hydrogen specific gas detection sensors

Table 1 below contains all the sensors that will be included divided by type and subcategorized by design:

Table 1. Descriptions and Pictures for Sensors used in Laboratory Testing

Flammable Sensors		
Metal Oxide Semiconductor	Figaro 2611: semiconductor gas sensor with high sensitivity to methane gas	
	FIS SB11A00: semiconductor gas sensor for methane and other hydrocarbons	
Pellistor-Catalytic	Alphasense CH-A3: Standard catalytic sensor	
	DDS GS+701: Standard catalytic sensor	
	SGX VQ548MP: Micro-Electrical-Mechanical Systems (MEMS) catalytic sensor	
Thermal Conductivity	Nevada Nano MPS: (MEMS) thermal conductivity type sensor	
NDIR	Cubic SJH: Nondispersive infrared (NDIR)	
	Winsen MH-440D: Nondispersive infrared (NDIR)	
Air Toxic Sensors		
Electrochemical	Alphasense H2S-AH: Electrochemical H2S	
	DDS GS+4H2S: Electrochemical H2S	
	Alphasense CO-AF: Electrochemical CO	

	DDS GS+4COF: Electrochemical CO	
	Alphasense CO-AX: Electrochemical CO low H2 Cross Sensitivity	
	DDS GS+4CO2H: Electrochemical CO low H2 Cross Sensitivity	
Oxygen Sensors		
Galvanic	Alphasense O2-A3: Lead-based galvanic O2	
	DDS S+4OX3: Lead-based galvanic O2	
Electrochemical	Alphasense LFO2-A4: Lead-free electrochemical O2	
	DDS S+4OXLFP: Lead-free electrochemical O2	
Hydrogen Specific		
Metal Oxide Semiconductor	FIS SB-19-03: Hydrogen MOS	
	Figaro 2616: Hydrogen MOS	
Electrochemical	Alphasense H2-AF: Electrochemical hydrogen	
	DDS GS+4H2: Electrochemical hydrogen	
Pellistor-Catalytic	SGX VQ21TSB: Hydrogen enhanced catalytic	

The lab setup for sensor testing, which includes an array of flow controllers, and a multi-gas testing fixture has been finalized for sensor testing. Results have nearly been finalized with most of the sensors still only needing failure testing based on hydrogen concentrations.

For the instrument testing, GTI Energy has been conducting a variety of tests at each of the gas mixtures listed below in Table 2.

Table 2. Gas Mixtures Used for Laboratory Testing by Hydrogen Percentage

Hydrogen Percentage	Methane Concentration (ppm)	Hydrogen Concentration (ppm)
0%	10	0
	1,000	0
	5,000	0
	25,000	0
	100% Methane	0
5%	9.5	.5
	950	50
	4,750	250
	23,750	1,250
10%	9	10
	900	100
	4,500	500
	22,500	2,500
20%	8	2
	800	200
	4,000	1,000
	20,000	5,000

For each device and gas tested, 3-5 repeats are being run to ensure that there is consistency among the measurements. The quantities that are being measured include the initial concentration reading (which tends to vary by device), the time it takes for the device to reach 90% of the actual concentration (T90), the maximum concentration reading, the minimum concentration readings, and the time it takes to get back down to 10% of the maximum reading (T10). The setup for these laboratory tests includes a demand regulator attached to a gas cylinder extending to an electronic valve to allow venting to the atmosphere when not undergoing tests. A customized gas cell has also been procured for handheld laser testing which can be seen below in **Error! Reference source not found.**.

The team is still planning on examining some different variance analyses or an analysis of the covariance of a few different factors to help demonstrate hydrogen's effect on the devices and sensors.

Data analysis has also been expanded in recent weeks to encompass the nature of the devices and whether they are combustible gas indicators or methane-specific indicators.

The project team held an update meeting with TAP members on June 7th to communicate the progress that had been made on both laboratory and field testing. TAP members provided comments on the different types of CO and CO-H2 sensors that we have been testing as well as explanations for sensor behavior changes that the project team will take into consideration during our functional gap analysis.

ACTIVITY: SENSOR DEVELOPMENT

Item Title: Evaluate and determine functional gaps, begin proof of concept for sensor development
Item Number: 12
Task Number: 5

The project team has begun the sensor development deliverable by evaluating the current state-of-the-art sensors that have either garnered funding or been declared commercially available. This includes but is not limited to the six projects that were granted funding under Topic 2: Development and Validation of Sensor Technology for Monitoring and Measuring Hydrogen Losses in May 2023. The projects under Topic 2 have been awarded $8.6 million in total and seem to have all begun the initial stages of design and modeling for their preferred methods of hydrogen detection. The sensor development activity has not been completed yet as the laboratory testing of both sensors and devices is still ongoing, after which functional gaps that exist in the sensors and devices tested can be properly evaluated.

ACTIVITY: FIELD TESTING

Item Title: Determine field testing locations
Item Number: 14
Task Number: 6

The project team completed their first field testing trial in April at a sponsor's training facility. This first field test is far ahead of the initial schedule and was meant to help inform future field tests for hydrogen blends at 0%, 10%, 15%, and 20% hydrogen. There, 7 leaks were generated at aboveground leaks, belowground leaks, and appliances. A Hi-Flow sampler was used to help estimate leak rate beyond the capabilities of the sponsor's training facility with the number of indications and maximum concentrations being documented from each of the devices. Data analysis is still pending on this initial field test.

The second field trial is currently ongoing as of this quarterly report, with a preliminary data analysis expected to begin in the following quarter.

ACTIVITY: SEVENTH QUARTERLY STATUS REPORT

Item Title: Submit Seventh Quarterly Status Report

Item Number: 13
Task Number: 8

The seventh quarterly status report (this report) will be completed and submitted to PHMSA's PRIMIS server in both public and internal-facing formats

ACTIVITY: PROJECT MANAGEMENT

Item Title: N/A
Item Number: N/A
Task Number: 9

During this quarter, GTI conducted project scheduling, budgeting, establishment of data management strategies, preparation of reports, and organization of required meetings.

5: Project Schedule:

The project schedule is shown below in Table 3 with the submittal time of this quarterly report outlined in red.

Table 3. Project Schedule

Task	Description	1 - Q4 2022	2 - Q1 2023	3 - Q2 2023	4 - Q3 2023	5 - Q4 2023	6 - Q1 2024	7 - Q2 2024	8 - Q3 2024	9 - Q4 2024	10 - Q1 2025	11 - Q2 2025	12 - Q3 2025
1	Project Scoping and TAP												
2	Literature Review												
3	Develop Evaluation Framework												
4	Laboratory Tests												
5	Develop New Hydrogen Sensing Schemes												
6	Field Tests												
7	Statistical Analysis and Final Report												
8	Project Management												