

FINAL PUBLISHABLE REPORT

CONTRACT N°: COOP-CT-2003-017331

PROJECT N°: FP6-017331

ACRONYM: TARE-IT

TITLE OF PROJECT: *A Novel Tare Identification and Corrosion Detection System to Improve Filling Accuracy, Productivity and Safety for SME LPG, Butane & Propane Gas Vendors*

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- 2 Arrow Technical Services Ltd
- 3 QUANTEL SA
- 4 OPTEL Spółka z o.o
- 5 Cylindric Denmark A/S

OTHER ENTERPRISE / END USER CONTRACTORS:

- 6 Kosan Crisplant A/S

RTD PERFORMER CONTRACTORS:

- 7 Danish Innovation Institute A/S
- 8 The Welding Institute Ltd

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ABSTRACT

A Consortium of European SMEs has completed a Cooperative SME Project to investigate and design/invent a high performance Ultrasonic Scanning prototypical rig for the Liquefied Natural Gas refilling centres and industries. The Project has investigated and designed the problems associated with using ultrasonic sensors to detect residual weight automatically in a re-filling process plant by successfully designing and building some algorithms and mechanical inventories.

The proposed CRAFT research project, **Tare-IT**, aims to develop a novel, proactive and cost effective ultrasonic based, simultaneous tare identification and corrosion leak detection system for pressure cylinders during filling. This will provide the more than 7,500 SME filling and test stations with an alternative technology to cost effectively and safely perform accurate tare identification while simultaneously performing corrosion leak detection in pressure cylinders during refilling. Accurate tare identification will help reduce the €1.2bn waste problem among the SMEs, while simultaneously increasing productivity and the frequency of corrosion leak detection, thereby significantly increasing the safety of pressure cylinders.

The technical work over the whole period of the project: 1st July 2005 to the 31st December 2007 is spread over the tasks in following Work Packages:

- WP1 – Scientific Characterisation of Pressure Cylinder Defects
- WP2 – Development of Corrosion Leak Detection and Fill Level Modules
- WP3 – Development of Data Analysis Software for Tare Identification
- WP4 – Integration and Industrial trials

The managerial work packages and task spanned all through the life span of the project. These packages included work packages 6 and 7 which are consortium management and project management respectively. The consortium was managed by every member of the consortium with the co-ordinator doing most of the work and communication between the consortium and the European commission.

There have been some generally well attended technical meeting, consortium and telephone meetings throughout the duration of the project.

In terms of the tasks completed by the consortium; the technical challenges has been completed although not all of it gave the expected results. Nevertheless, results and techniques got and learnt respectively during the project has been wholly beneficiary to the consortium.



OVERVIEW

The overall objective of our work is to develop a novel tare identification and corrosion detection system to improve filling accuracy, productivity and safety for SME LPG, Butane & Propane Gas Vendors

The principle objective of this project is to develop a novel proactive and cost effective, simultaneous, tare identification and corrosion leak detection system for pressure cylinders during filling by developing a novel non-contact Non-Destructive Testing (NDT) hybrid Laser EMAT/Air coupled Ultrasonic testing system and that has the ability to:

- Provide hybrid Laser EMAT/Air coupled Ultrasonic testing system capable of performing simultaneous tare identification and corrosion leak detection in steel and composite pressure cylinders
- This was changed to doing the same but using piezoelectric ultrasonic transducers and a data capture system.
- Provides tare determination in steel and composite materials with an accuracy of 5% of total tare weight.
- Provides sufficiently accurate data analysis to enable tare determination and corrosion leak detection of pressure cylinders in less than 30 seconds.
- Provides a continuous testing ability, which meets safety requirements for pressure cylinder safety standards.
- Provides continuous testing ability, which can be, electronically and mechanically interfaced with existing industry standard filling systems and handling equipment.
- Has a total cost of less than €80,000 per unit to the SME filling and test station.

After the commencement of the project, the Consortium discussed and set a list of priorities that the project needed to achieve:

1. Investigate steel cylinders (99% of the market according to partners' input)
2. Tare of cylinders
3. Detection of gas leak on cylinders
4. Corrosion inspection
5. Investigate composite cylinders

This priorities list reflects contrasts between technologies investigated for the project (ultrasonic) vs. project's objectives vs. partners' requirements.

For example, gas leak and corrosion might be possible to inspect on the cylinders' wall but this would mean a complete scanning of the cylinder which could take several minutes and will not be acceptable for an in-line industrial filling process.

Technical Objectives

The **scientific objectives** of our work are to:

- Generation of scientific knowledge that provides an enhanced understanding of defects found in steel and composite pressure cylinders and the properties of materials and defects on ultrasonic waves characteristics with change in frequency, signal amplitude, propagation time delay and phase change in relation to corrosion and cracks.
- Generation of scientific knowledge that enables the development wave characteristics and the requirement from sensors to generate defect and tare related ultrasonic sensor mathematical model.

The **technological objectives** of our work are to:

Produce a prototype system able to:

- Provide hybrid Laser EMAT/Air coupled Ultrasonic testing system capable of performing simultaneous tare identification and corrosion leak detection in steel and composite pressure cylinders
- Provides tare determination in steel and composite materials with an accuracy of 5% of total tare weight.
- Provides sufficiently accurate data analysis to enable tare determination and corrosion leak detection of pressure cylinders in less than 30 seconds.
- Provides a continuous testing ability, which meets safety requirements for pressure cylinder safety standards.
- Provides continuous testing ability, which can be, electronically and mechanically interfaced with existing industry standard filling systems and handling equipment.
- Has a total cost of less than €80,000 per unit to the SME filling and test station.

Economic Objectives

The proposed technology development targets the more than 7,500 EU SME gas filling and test stations, and the principle objective of this project is to develop a novel, proactive and cost effective ultrasonic based, simultaneous tare identification and corrosion leak detection system for pressure cylinders during filling. This will provide the more than 7,500 SME filling and test stations with an alternative technology to cost effectively and safely perform accurate tare identification while simultaneously performing corrosion leak detection in pressure cylinders during refilling. Accurate tare identification will help reduce the €1.2bn waste problem among the SMEs, while simultaneously increasing productivity and the frequency of corrosion leak detection, thereby significantly increasing the safety of pressure cylinders.

Innovation-Related Objectives to Enable Exploitation

The European Industrial Gases Association (EIGA), World LP Gas Forum (WLPGF) and World LP Gas Association (WLPGA) who will form part of the “End User Interest Group”. Specific tasks in the work programme are set aside for the dissemination of knowledge of this project into the 7,500 potential customers (Task 5.3 Dissemination of knowledge and Task 5.5 Development of exploitation strategy, see page 53).

The proposed market is too large for the consortium to exploit on their own; therefore in order to achieve the mentioned economic and societal benefits there is a need to actively promote the technology within the sector and across the different EU regions. Therefore a range of innovation-related activities have been planned to disseminate the through licenses for the system and licenses through the IPR and training. It is intended that the consortium will perform the following innovation related activities:

- To formulate the project results into a protectable form and apply for patent protection for each of the sub-components of the TARE-IT system by month 18 of the project
- To transfer knowledge from the R&D performers to the SME participants through 4 technology transfer events and interactions including 5 secondments and placements of 4 staff.
- Through our planned dissemination activities, we will engage, through the national trade associations in our End User Interest Group (specifically EIGA, WLPGF and WLPGA) with up to 100 filling and retest stations and process plants, in order to proliferate the technology.
- By demonstrating the best practice that is enabled through our developed technological solutions and enhanced understanding of the science behind both tare identification and corrosion and leak detection, and by demonstrating the effectiveness of low-cost high-tech applications within the sector, we aim to stimulate a rapid upsurge of interest within the primary pressure cylinder sector by encouraging adoption of new knowledge based testing processes. To achieve this we will broadcast the benefits of the developed technology and knowledge beyond the consortium to pressure cylinder communities such as EIGA, CEFIC, and specifically:
 - 125 organisations contacted directly to promote the project results
 - 3 conferences and 2 major exhibitions each with at least 50 and in excess of 2,000 attendees respectively.
 - 40 organisations will be stimulated to apply or use the results in their filling operations
 - 25 organisations will engage in detailed knowledge or technology transfer, 3 years post-project completion
 - 5 European organisations will be facilitated to adopt the results as licensees in the generation of new products, 3 years post project completion

PROJECT RESULTS

Deliverable	Task	Partners Involved	Objective	Achievement During Reporting Period
D1	1.1	Quantel Optel DiITI TWI	Detailed defect specifications and spreadsheet test results	<ol style="list-style-type: none"> 1. Priority list and system specifications defined 2. Implementation of the tare calculation defined 3. Preliminary software simulations performed
D2	1.2	Norgaard Arrow Quantel Optel Kosan DiITI TWI	Ultrasonic sensor mathematical models. Sensor operational specifications with concept design drawings and control architecture	<ol style="list-style-type: none"> 1. First system design defined 2. Software simulations based on design performed
D3	1.3	Norgaard Arrow Quantel Optel Kosan DiITI	Feasibility and technological risk review meeting, Risk assessment report, Standards conformity report, Modification Plan	<ol style="list-style-type: none"> 1. Preliminary Ultrasonic's experiments performed with EMAT 2. List of risks identified
D4	2.1	Quantel Kosan TWI	A laser including for fibre-coupled generation of ultrasonic pulses on metal and composite cylinders	<ol style="list-style-type: none"> 1. Laser manufactured 2. Laser with fibre-couple setup

Deliverable	Task	Partners Involved	Objective	Achievement During Reporting Period
D6	2.3	Quantel Optel DiTI TWI	Laboratory Setup	<ul style="list-style-type: none"> 4. Successful setup of laboratory at 2 locations: arrow Technical limited (Sheffield) and TWI Wales. 5. testing and clarification of transducers 6. Knowledge of data capture system needed acquired. 7. Preliminary software simulations performed
D7	2.4	Norgaard Arrow Quantel Optel Kosan DiTI TWI	Feasibility and technological risk review meeting. Risk assessment report.	<ul style="list-style-type: none"> 3. Preliminary Ultrasonic's experiments performed with piezoelectric ultrasound transducers 4. Risk of using Laser clarified. 5. Feasibility of the whole system was better known and the risk involved in achieving our goals stipulated.
D9	3.2	DiTI TWI Optel	Software for wall thickness measurements, Tare estimation and liquid gas fill level	<ul style="list-style-type: none"> 3. Mathematical model of determining the wall thickness was developed and tested using simulation software and MATLAB. 4. Tare estimation was developed mathematically and tested although it tends to fail for some very old steel cylinder 5. Due to faulty equipments and time the liquid gas fill level mathematical model was not properly tested.
D10	3.3	DiTI	GUI – Graphical User Interface	<ul style="list-style-type: none"> 3. Designed using MATLAB and Java.

ACKNOWLEDGEMENTS

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The partners would especially like to thank Mrs Josefina Lindblom, the project's Scientific Officer, for his help and guidance throughout the project.

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GENERAL PROJECT INFORMATION

Title: A Novel Tare Identification and Corrosion Detection System to Improve Filling Accuracy, Productivity and Safety for SME LPG, Butane & Propane Gas Vendors

Acronym: TAREIT

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4	Optel Spółka z o.o.	Optel	Poland
5	Cylindric Denmark A/S	Cylindric	Denmark
6	Kosan Crisplant A/S	Kosan	Denmark
7	Danish Innovation Institute A/S	DiTI	Denmark
8	The Welding Institute Ltd	TWI	UK