

HyCOMP

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Deliverable Report

WP7

Dissemination workshop

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1. Executive summary

1.1 Summary of deliverable content and initial objectives

This deliverable aims at presenting the organization of the HyCOMP final dissemination workshop: objectives, people invited, participants, etc. It serves also as the minutes of the workshop: questions raised, comments made, and answers brought.

At the end a list of possible topics requiring further research is given.

1.2 Partners involved

Air Liquide was the Task Leader (T7.6) for the organization of the final dissemination workshop, with the help of Armines, BAM, Faber, Hexagon, CCS and JRC-IE.

All partners were present at this dissemination workshop, except CCS.

1.3 Relation with others WPs / Tasks

This task is the final step of the HyCOMP project by disseminating project experimental results and recommendations to the international community of experts in the design and testing of composite pressure vessels. Each WP leader was directly involved in this event in presenting the results of their WP. Presentations have been prepared with the help of task leaders. By consequent, this task was directly related to all other tasks of the project.

2. Introduction

2.1 Objective of the dissemination workshop

The objective of this dissemination workshop was to present HyCOMP experimental results and outcomes, mainly recommendations, to experts in the field of composite pressure vessels for the storage of hydrogen (manufacturers, end users, test laboratories, OEMs, etc).

The purpose was to obtain feedbacks on the work carried out in HyCOMP and the recommendations coming from the project. It was intended as well to get some propositions for topics needing further research efforts.

2.2 Choice of the event

As the final objective is to implement recommendations in current standards, it was of interest to convince experts involved in ISO groups, with HyCOMP outcomes. Two ISO Technical Committees dealing with topics close to HyCOMP scope have been identified:

- TC58 Gas cylinders (all gases, not only hydrogen),
- TC197 Hydrogen technologies (all technologies in the Hydrogen Energy field, not only composite pressure vessels).

This workshop has been organized in junction with meetings of ISO TC58 / SC3 / WG24 (Factors of safety for composite cylinders) and WG35 (Refillable permanently mounted composite tubes for transportation), in order to get the highest number of participants as possible (minimization of travel costs). Following agenda was proposed:

- March 5th: HyCOMP dissemination workshop
- March 6th: ISO TC58 / SC3 / WG24 meeting
- March 7th: ISO TC58 / SC3 / WG35 meeting

2.3 Participants

Invitation to the workshop has been diffused to registered members of TC58 and TC197 through their respective secretary. Several reminders for registration to the workshop were sent. Invitation has also been largely diffused to relevant people (partners' contacts) even if they were not involved in TC58 and TC197.

A personal invitation has been sent as well to several OEMs by Hexagon (as task leader of T7.2: Automotive Advisory Group), as agreed with the project officer. Among them, we can quote: Volkswagen, Opel/GM, Honda... Only Opel/GM replied positively to the invitation, for a participation by teleconference. This illustrates the difficulties we faced during the project to liaise with the Automotive Industry, in spite of the efforts made to involve them in HyCOMP.

In total, 18 people from the HyCOMP consortium were present at this event (see attendance list). Each organization was represented, except CCS Global Group.

As external audience, 22 people attended this workshop, among which 4 people attended by teleconference.

It must be mentioned as well that a person from the US Department of Energy (Dr. Charles James) answered positively to the invitation, but was forced to cancel his participation few days before. Nevertheless, workshop presentations have been sent afterwards.

Hervé Barthélémy, Air Liquide, was appointed as the chairman of this workshop.

2.4 Agenda

The following agenda was proposed for this workshop.

Time	Topic	Speaker
9h30 – 9h45	Welcome	H. Barthélémy, <i>Air Liquide</i>
9h45 – 10h15	Project presentation	C. Devilliers, <i>Air Liquide</i>
10h15 – 10h55	Damage accumulation in the composite wrapping: impact, rate and measurement (30 min presentation + 10 min questions)	K. Chou, <i>Armines</i>
10h55 – 11h15	<i>Break</i>	
11h15 – 11h55	Fatigue failure of cylinders (30 min presentation + 10 min questions)	G. Mair, <i>BAM</i>
11h55 – 12h30	Characterization of service life (20 min presentation + 10 min questions)	P. Heggem, <i>Hexagon</i>
12h45 – 14h00	<i>Lunch and coffee</i>	

14h00 – 14h40	Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics (30 min presentation + 10 min questions)	A. Agnoletti, <i>Faber</i>
14h40 – 15h20	Design requirements and testing procedures (30 min presentation + 10 min questions)	C. Devilliers, <i>Air Liquide</i>
15h20 – 15h30	<i>Break</i>	
15h30 – 17h00	Q&A session, discussions	All

An introduction was given by Hervé Barthélémy. He presented in few words project objectives, expected outcomes, etc. A short overview of the organization of TC58 (Gas cylinders) and TC197 (Hydrogen technologies) has also been presented. Among these two Technical Committees, Hervé Barthélémy mentioned the different Working Groups that are directly in link with HyCOMP topic.

Right after, Clémence Devilliers, explained in more details the HyCOMP project: general overview (duration, budget, and consortium), the context, its objectives, and the expected outcomes. No particular questions from the audience.

Then, results of each work package have been exposed by the WP leaders. For each work package, 30 min were given for the presentation and 10 min for questions. We will review in the following parts, the different questions raised by the audience.

3. Questions & answers sessions

3.1 WP2: Damage accumulation in the composite wrapping (Armines)

Mark Trudgeon, Luxfer:

First underlined the amount of work carried out. His question concerns the tests done between 84 to 96% of UTS and the result of iSF given at 75%: How do we get value at 75%?

Answer: The value obtained at 75% is based on extrapolation with the master curve given by the tests at higher stress and the numerical approach. The test would take too long at lower stress and the scatter increases as the load decreases.

Roy Irani, Gas Packaged Solutions:

Ask to remind the materials that were used for specimens.

Comment from C. Devilliers: Remind that the iSF is the bottom line and does not correspond to the safety factor that shall be applied directly at a cylinder scale.

Anthony Bunsell, Armines, launch a discussion on the effect of time (different loading rates) to underline that the tendency given by the model has been observed on cylinders by BAM (slow burst test concept). It is the opportunity to underline the accuracy of the model that has been developed.

Roy Irani noticed that the effect of loading rate on fibre break cluster formation is quite similar with dislocation clustering in metal materials. A Bunsell reminds that the rupture mechanisms remains different.

3.2 WP3: Degradation of composite cylinders under cyclic and static loads (BAM)

Greg Webster, CSA Group:

Scatter increases with time of test. So what is the relevance of slow burst test (SBT) that will induce increase of scatter?

Answer: Purpose of SBT is to compare initial and aged cylinders. The study of the increase of scatter is then a kind of diagnosis.

Stefan Behrning, TUEV Rheinland Group:

As a test laboratory, we are interested in the new criteria to apply with new aging/test procedures (i.e. 85% of nominal burst pressure)?

Answer: At that stage, there is no known answer. G Mair recommends keeping the same criteria and continuing to investigate probabilistic approach in parallel.

Are you concerned by safety of cylinder when they reached 15 years in service?

Answer: For transportable, as unlimited lifetime can be granted, there is a concern to have a safe cylinder after a long duration.

Comment Hervé Barthélémy, Air Liquide: No accident has been reported yet.

Mark Trudgeon, Luxfer:

Interesting results but different from Luxfer's results. The increase of burst pressure with pre-conditioning in temperature is surprising for type III Cylinders.

Answer: this tendency was indeed observed (slides showed again). The critical part of a type III composite cylinder remains the metallic liner.

Comment from Hervé Barthélémy, Air Liquide: the difficulty to use WP3 results is that there is an indication of importance of scatter rather than minimal acceptable properties. That last requirement is more easy to use in RCS.

3.3 WP5: Characterization of service life (HEX)

Roy Irani, Gas Packaged Solutions:

What is the guarantee on commercial serie production that a cylinder is representative of type approval?

Answer: see WP4 presentation right after. This is indeed an important point of focus as we are talking of composites cylinders ramp-up.

Marc Trudgeon, Luxfer:

What is the size of on-board storage for vehicles?

Answer: 4 to 5 kg of H₂ for 500 km vehicle autonomy

Comment from Per Heggem, Hexagon: Some work has been performed in Hycomp WP3 on shallow cycles for extended cycle lifetime. It was not possible to determine the failure mode. Cylinders exhibited good cycling performance.

Comment Hervé Barthélémy, Air Liquide: The conclusion of WP5 could also be that the safety factor could be defined with the MAWP rather than the TP.

This is an important and general recommendation of the project.

3.4 WP4: Manufacturing quality assurance (Faber)

Romary Daval, Luxfer:

When you selected the parameter you wanted to assess, why not chose the % of resin in the composite?

Answer: it has been listed but not selected as a major parameter by the consortium

Roy Irani, Gas Packaged Solutions:

Why different pressurization rate for burst test on Type 3 (3 bar/s) and on Type 4 (1.5 bar/s)

Answer: Two different test labs, not significant difference compared to pressurization rate of Slow Burst Test.

Mark Trudgeon, Luxfer:

Can you show deviation of performance for curing at RT (defect MF3)?

Answer: Description of the slides concerned. Note that 5 Type 3 cylinders were tested, they overlap in two populations that seems to represent two stages of curing (some seem to have cured at RT, and some not).

Craig Webster, CSA Group:

Did you look to the correlation between defects and volumetric expansion?

Answer: No. This is already a reference test. It is present in the EC RE 79 and ISO standard. We wanted to propose something additional, in particular in addition to the control of process parameters.

Anthony Bunsell, Armines:

Is the AE reproducible for this purpose?

Answer: The method needs additional development as it depends on many parameters and the test conditions have to be further defined.

Comment Georg Mair: one relevant parameter is the confidence level on each parameter to calibrate the selectivity of the method. The reference curve must be based the highest possible number of “good cylinders” to increase the level of confidence.

Comment Anthony Bunsell: Comparison with the work of Marvin Hampston of Livermore Lab (now Denver University): AE for Quality Manufacturing Assurance gives a blind evaluation. It does not tell you why you discard the cylinder.

Comment Hervé Barthélémy, Air Liquide: Conclusions on the influence of manufacturing process parameters can be quiet optimistic, as big deviation of process parameters produces small deviation of cylinder performance (robust technologies).

Answer: there is still a need to cross several tests in addition to the control of process parameters as each test cannot cover every parameter.

3.5 WP6: Design requirements and testing procedures (AL)

Type approval:

Comment by Romary Daval, Luxfer: The sustained load test has been removed from the last version of ISO 11119 (except for glass & aramid fiber). The rationale is that a positive effect was observed on burst performance after sustained load and that carbon fibres do not age.

Georg Mair remind that the final traditional burst test is not appropriate to evaluate the performance of Type 3 cylinders and that a cycling test shall be proposed.

Comment Hervé Barthélémy, Air Liquide: A burst test remains important to evaluate compliance with the required safety factor.

Comment Mathilde Weber, Air Liquide: A recommendation on a minimal required value of Tg (glass transition temperature) seems relevant as the sustained load test has been suppressed from ISO 11119-3.

Comment by Mark Trudgeon, Luxfer: The sustained load has been suppressed because cylinders manufactured with a coefficient of 3 have shown no failure, based on manufacturers' feedbacks.

Comment Anthony Bunsell, Armines: This is true for carbon fiber only. Glass fibers fail because of stress corrosion (they don't fail under vacuum).

Inspection in service:

Roy Irani, Gas Packaged Solutions and representatives of Luxfer expressed their disagreement to support Acoustic Emission for periodic inspection due to the cost issue (handicap for composites cylinder ramp-up).

Comment from Anthony Bunsell, Armines: There is of course need to have a simple technique. Further development is needed harmonize and simplify AE analysis, in order to get a very simple and cheap tool.

Design requirements:

Romary Daval, Luxfer: The minimal theoretical value demonstrated in WP2 does not take into account mechanical impacts (drops mainly). But drop test is a key test for the design of a cylinder.

Answer: This takes into account only intrinsic properties of materials at ambient temperature. Effects of other parameters (like temperature or impact for example) are covered by the performance-based tests required by standards. It could lead to additional safety margins in order to successfully pass the drop test for example.

Georg Mair, BAM:

What is the safety criterion at end of life? A final value of 1.8 would mean that 0.4 (=1.8 - 1.4) is set to cover manufacturing variability issues. Is it enough?

Answer: the factor 1.4 takes into account end of life with asymptotic behaviour. We then have to take into account temperature, impact, manufacturing variability, etc. in performance tests.

Comment Anthony Bunsell, Armines: the model is very conservative (severe load transfer distances, etc). Visual inspection is a real problem because it requires highly qualified people (so also expensive) and some damage can be non-visible (damage in volume for example).

Comment Craig Webster, CSA Group: Acoustic Emission has been studied extensively in the 90's on CNG vehicles. AE is promising, but very complex to implement and very expensive.

Comment Hervé Barthélémy, Air Liquide: it is true that visual inspection may need a specific development for some cylinders depending on the way their surface reveal impacts.

Comment Roy Irani, Gas Packaged Solutions: all NDT tests are more sensitive than a hydraulic proof test. This is what he observed when he introduced ultrasound test (US) on Type 1 cylinders. Over 4500 cylinders, 82 failed US but none the hydraulic proof test.

3.6 General questions / comments

Inspection in service:

Mark Trudgeon, Luxfer: AE is a promising technique but seems complicated from a practical and economical point of view. Digital Waves says that they have a technique accurate but the test is conducted in an isolated chamber. Mark cannot imagine the difficulty to do it on large cylinder and integrated in bus...

Comment Hervé Barthélémy, Air Liquide: Yes. Even if visual inspection requires a good understanding of defects and a good qualification of the operator, it has the advantage to be quick and cheap to carry out.

Comment Anthony Bunsell, Armines: Damage can be not visually evident (extend in the thickness of the composite).

Comment Patrick Breuer, Hexagon: In his previous company, they have done extensive impact tests on composite cylinders. The conclusion was that it was very difficult to detect damage done in the volume by visual inspection (simulation of car crash).

Design requirement:

Comment Georg Mair, BAM: Georg would limit the reduced safety factor to permanently mounted cylinders in a frame/structure. Is the hydraulic proof test still relevant?

Comment Hervé Barthélémy, Air Liquide: it is true that currently proof test does not lead to the discard of cylinders. Visual inspection is more relevant for inspection.

Test Approval:

Comment Georg Mair, BAM: What is the lifetime that has to be taken into account for transportable cylinders? What is the tool that can be used to assess end of life of cylinders in service?

Manufacturing Quality Assurance:

Comment Mark Trudgeon, Luxfer: A good rationale on safety factor has been demonstrated. He is not in favour of adding batch tests for the quality control like with Barcol test as process parameters can be well controlled by the manufacturers. Hervé Barthélémy tends to agree with Mark Trudgeon.

Answer from Alberto Agnoletti, Faber: Barcol is just an example. The recommendation is to say that the curing step is important. The control can be on the process parameters or on a dedicated test.

Comment Clémence Devilliers, Air Liquide: All of the recommendations are just propositions from HyCOMP. Of course, results have to be further discussed in ISO WG.

Comment Roy Irani, Gas Packaged Solutions: On Type 1 cylinders, a hardness test is done on each cylinder. An extra test such as Barcol test, which is very quick to perform and inexpensive, would bring more confidence in the technology to regulators.

Comment Georg Mair, BAM: There would be a need to harmonize standards between type approval and batch approval results: the batch approval criteria should not be the minimum required but the minimum obtained at type approval.

Comment Hervé Barthélémy, Air Liquide: yes indeed you are right to insist on that point.

Comment Mark Trudgeon, Luxfer: what is the accuracy of Acoustic Emission for manufacturing quality control? Some parameters seemed to be missed or poorly detected.

Comment Alberto Agnoletti, Faber: The technique has shown the ability to detect some defects, not all. It has to be further developed. The number of defects detected depends on the confidence level: with a low confidence level, all defects can be detected. And inversely, with a very high confidence level, it is more difficult to detect defects.

Comment Georg Mair, BAM: the AE technique proposed is a tool to reduce scatter in production.

4. Recommendations for further R&D work

To conclude the day, it has been asked to participants to express the topics of research they have identified to optimize the design of composite pressure vessels and reduce its cost without compromising its degree of safety.

It has been reminded to participants the on-going projects or on the point to start:

- Hydrogen embrittlement of metallic liners (on-going FCH-JU funded project, Mathryce)
- Understanding of mechanical impacts on composite pressure vessels (damage produced and associated loss of cylinder performances, etc) and development of Non Destructive Techniques to detect critical damages during in-service inspection (FCH-JU funded project starting in April 2014, HyPactor)
- Fire behaviour of composite cylinders (on-going FCH-JU funded project, FireComp)

Concerning further research work needed to improve the understanding of composite pressure vessels behaviour, following topics have been proposed:

- Anthony Bunsell, Armines: further work on alternative NDT for periodic inspection and on the effect of porosity on cylinder performance (porosity specifications exist in aeronautic industry)
- Craig Webster, CSA group: improvement of carbon fiber properties at a reduced cost
- Georg Mair, BAM: further work on probabilistic assessment of cylinder performance and on the definition of an End-of-Life criterion (based on data from cylinders in service)
- Georg Mair (BAM), Roy Irani (Gas Packaged Solutions), Per Heggem (Hexagon): further work on fatigue performance of composite pressure vessels: effect of shallow cycles on composite cylinders cycling performance (for hydrogen and natural gas), definition of a relationship between cycle depth and lifetime. Demonstration of End-of-Life properties for small and large cycles + relevance of sustained load test for stationary application

A discussion started on this last topic. Pawel Gasior from WUT presented the results of Task 3.4 in HyCOMP where effect of cycle depth on Type 4 cylinders was studied. It seems that the deep cycled cylinders showed increased damage level in the composite wrapping as one cylinder burst at the end of the test (total 50 000 cycles + sustained load test at 80% of the burst pressure). The project did not succeed in AE data analysis. For the lower amplitude cycle depth, the cylinder survived sustained loads at 80% of BP and 50 000 cycles at PH without burst (test stopped).

Comment Anthony Bunsell, Armines: the model developed by Armines considers visco-elastic properties of the matrix (stress rupture). However the model has to be further developed to describe fatigue. Anthony wonders if failure mechanisms would be different (expect crack propagation in the matrix, more than fiber breaks).

All of the topics expressed above for further research projects were also mentioned in the evaluation forms (see scans of these forms in the following part).

Clémence Devilliers warmly thank all participants for their participation at this workshop, and for the discussions we had around HyCOMP results.

5. Evaluation forms

Dissemination Workshop on

“Design requirements and testing procedures for the safe storage of hydrogen in composite pressure vessels”

March 5th 2014 in Paris (AFNOR), France

Evaluation form

Name: *LANGLOIS Christophe*

Company: *COMPOSITES AQUITAINE*

1- How do you evaluate the general organization of that event?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Global organization	X				
Communication/ Announcement	X				
Agenda proposed (time allocated to presentations vs. discussions)	X				
Meeting room	X				
Lunch / refreshments	X				
Teleconference					X

2- How do you evaluate the quality of presentations?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Introduction		X			
AL - General presentation of the project		X			
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	X				
BAM - Fatigue failure of cylinders		X			
HEXAGON - Characterization of service life		X			

FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics		X			
AL - Design requirements and testing procedures		X			

3- For each presentation:

	What do you retain? What was the most relevant?	What was not clear? What needs more explanations or work?
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	The USF and the methodology to obtain it	The input = the scatter on fibre
BAM - Fatigue failure of cylinders	The statistical approach	A summary of results and findings
HEXAGON - Characterization of service life	a list of operational requirements for different types of cylinders	Temperatures in service and during fillings
FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics	influence of manufacturing defects on the performance of cylinders	Lack of evolved statistical exploitation too few specimens!
AL - Design requirements and testing procedures	Justification des réductions proposées de SF basées sur les résultats des WP	La Tg et son utilisation l'émission acoustique

4- Your comments and suggestions for further research projects on composite pressure vessels:

- / The study of the scatter in manufacturing process (which begins with a deeper analysis of WP4 results)
- / The behaviour of cylinders to impact
- / The pursuit of definition of iSF: other materials, more representative samples...

Any comments, remarks or suggestions can be transmitted to Clémence DEVILLIERS by March 31st 2014, by e-mail to: clemence.devilliers@airliquide.com

Dissemination Workshop on

“Design requirements and testing procedures for the safe storage of hydrogen in composite pressure vessels”

March 5th 2014 in Paris (AFNOR), France

Evaluation form

Name: *FOLLAIN Jean-Pierre*

Company: *Composites Aquitaine*

1- How do you evaluate the general organization of that event?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Global organization		✓			
Communication/ Announcement		✓			
Agenda proposed (time allocated to presentations vs. discussions)			✓		
Meeting room		✓			
Lunch / refreshments		✓			
Teleconference					

2- How do you evaluate the quality of presentations?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Introduction		✓			
AL - General presentation of the project		✓			
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement			✓		
BAM - Fatigue failure of cylinders			✓		
HEXAGON - Characterization of service life		✓	✓		

FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics		✓			
AL - Design requirements and testing procedures			✓		

3- For each presentation:

	What do you retain? What was the most relevant?	What was not clear? What needs more explanations or work?
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement		
BAM - Fatigue failure of cylinders		
HEXAGDN - Characterization of service life		
FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics	<i>Interest of the EA</i>	<i>- few parameters were tested → necessity to test more parameters</i>
AL - Design requirements and testing procedures	<i>Possibility to reduce the SF</i>	<i>No economic studies what can we earn with the reduction of SF and increase of control Take in account in service life</i>

4- Your comments and suggestions for further research projects on composite pressure vessels:

Any comments, remarks or suggestions can be transmitted to **Clémence DEVILLIERS** by March 31st 2014, by e-mail to: clemence.devilliers@airliquide.com

Dissemination Workshop on

“Design requirements and testing procedures for the safe storage of hydrogen in composite pressure vessels”

March 5th 2014 in Paris (AFNOR), France

Evaluation form

Name: *BLOIS Christophe*

Company: *Composites Aquitaine*

1- How do you evaluate the general organization of that event?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Global organization	<input checked="" type="checkbox"/>				
Communication/ Announcement		<input checked="" type="checkbox"/>			
Agenda proposed (time allocated to presentations vs. discussions)		<input checked="" type="checkbox"/>			
Meeting room		<input checked="" type="checkbox"/>			
Lunch / refreshments		<input checked="" type="checkbox"/>			
Teleconference					

2- How do you evaluate the quality of presentations?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Introduction		<input checked="" type="checkbox"/>			
AL - General presentation of the project		<input checked="" type="checkbox"/>			
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
BAM - Fatigue failure of cylinders			<input checked="" type="checkbox"/>		
HEXAGON - Characterization of service life		<input checked="" type="checkbox"/>			

FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics			X		
AL - Design requirements and testing procedures		X			

3- For each presentation:

	What do you retain? What was the most relevant?	What was not clear? What needs more explanations or work?
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	The methodology ^{is very interesting and} can be used for other subject, but the results seem uncompleted	All the key parameters (content, porosity, ...) are not taken into account and it's applicable on only one material (fiber + resin).
BAM - Fatigue failure of cylinders	Scatter is a key characteristic and reduce scatter is really a strong goal.	
HEXAGDN - Characterization of service life	Further markets need to increase the robustness of the vessels. the list of operational requirements -	Recommendations for big cylinders should be more explained -
FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics	Influence of some manufacturing defects on the mechanical performances -	Need to continue with some other defects, not only focus on curing -
AL - Design requirements and testing procedures	Some recommendations are interesting but industrial application seems very difficult!	Global economic study is necessary -

4- Your comments and suggestions for further research projects on composite pressure vessels:

~~Composites~~ We'll send by mail in few days proposal for further research projects.

Any comments, remarks or suggestions can be transmitted to Clémence DEVILLIERS by March 31st 2014, by e-mail to: clemence.devilliers@airliquide.com

Dissemination Workshop on

“Design requirements and testing procedures for the safe storage of hydrogen in composite pressure vessels”

March 5th 2014 in Paris (AFNOR), France

Evaluation form

Name:

Company:

1- How do you evaluate the general organization of that event?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Global organization		X			
Communication/ Announcement		X			
Agenda proposed (time allocated to presentations vs. discussions)		X			
Meeting room			X		
Lunch / refreshments		X			
Teleconference					

2- How do you evaluate the quality of presentations?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Introduction		X			
AL - General presentation of the project		X			
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	X				
BAM - Fatigue failure of cylinders					
HEXAGON - Characterization of service life			X		

FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics		X			
AL - Design requirements and testing procedures		X			

3- For each presentation:

	What do you retain? What was the most relevant?	What was not clear? What needs more explanations or work?
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	<i>time is important for degradation</i>	
BAM - Fatigue failure of cylinders		
HEXAGON - Characterization of service life	<i>wide range of loads</i>	<i>set of reference loads for simulation of degradation</i>
FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics		
AL - Design requirements and testing procedures		

4- Your comments and suggestions for further research projects on composite pressure vessels:

Any comments, remarks or suggestions can be transmitted to **Clémence DEVILLIERS** by March 31st 2014, by e-mail to: clemence.devilliers@airliquide.com

Dissemination Workshop on

“Design requirements and testing procedures for the safe storage of hydrogen in composite pressure vessels”

March 5th 2014 in Paris (AFNOR), France

Evaluation form

Name: *Pietro Floreto*

Company: *JRC, E. Commission*

1- How do you evaluate the general organization of that event?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Global organization	<i>X</i>				
Communication/ Announcement		<i>X</i>			
Agenda proposed (time allocated to presentations vs. discussions)			<i>X</i>		
Meeting room		<i>X</i>			
Lunch / refreshments				<i>X</i>	
Teleconference					<i>X</i>

2- How do you evaluate the quality of presentations?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Introduction					
AL - General presentation of the project		<i>X</i>			
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	<i>X</i>				
BAM - Fatigue failure of cylinders			<i>X</i>		
HEXAGON - Characterization of service life		<i>X</i>			

FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics		α			
AL - Design requirements and testing procedures	α				

3- For each presentation:

	What do you retain? What was the most relevant?	What was not clear? What needs more explanations or work?
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	—	—
BAM - Fatigue failure of cylinders	The impression is that BAM received less time than ARMINES, probably	Due to lack of time, Type IV case was presented too quickly.
HEXAGON - Characterization of service life	Due to the coffee break, pity.	Perhaps not absolutely needed, just add up anything to the major issues of the workshop.
FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics		A bit more rationale on the choice of the defect to be done.
AL - Design requirements and testing procedures	Everything very relevant!	Not clear = the French-English! ☺ Some RECOMMENDATIONS should be downgraded to WISHES/PROPOSALS

4- Your comments and suggestions for further research projects on composite pressure vessels:

Representatives of ISO TC197 were present, but not "used" to get an overview of the international RCS main challenge and to make visible the (presently weak) link between MyComp and standardization bodies.

Any comments, remarks or suggestions can be transmitted to Clémence DEVILLIERS by March 31st 2014, by e-mail to: clemence.devilliers@airliquide.com

Dissemination Workshop on

“Design requirements and testing procedures for the safe storage of hydrogen in composite pressure vessels”

March 5th 2014 in Paris (AFNOR), France

Evaluation form

Name: R. S. IRAM

Company: GPS Ltd.

1- How do you evaluate the general organization of that event?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Global organization	✓				
Communication/ Announcement	✓				
Agenda proposed (time allocated to presentations vs. discussions)		✓			
Meeting room		✓			
Lunch / refreshments			✓		
Teleconference					✓

2- How do you evaluate the quality of presentations?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Introduction					
AL - General presentation of the project		✓			
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	✓				
BAM - Fatigue failure of cylinders			✓		
HEXAGDN - Characterization of service life		✓			

FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics	✓				
AL - Design requirements and testing procedures		✓			

3- For each presentation:

	What do you retain? What was the most relevant?	What was not clear? What needs more explanations or work?
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	Good model derived	Need to apply to actual cylinders from laboratory tests.
BAM - Fatigue failure of cylinders	Confused speaker & not very clear.	
HEXAGDN - Characterization of service life	The current safety factors take into account the "unexpected incidents".	Need to include concept of low/shallow cycles for ambient temperature variations.
FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics	Very little change needed to current standards. Barcol test essential.	More work on the AS System for reproducibility.
AL - Design requirements and testing procedures	A bit too simplified. Needs much more details.	Need to develop a good/cheap NDT method.

4- Your comments and suggestions for further research projects on composite pressure vessels:

Develop a NDT method.

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Dissemination Workshop on

“Design requirements and testing procedures for the safe storage of hydrogen in composite pressure vessels”

March 5th 2014 in Paris (AFNOR), France

Evaluation form

Name: *Romy DAVAZ*

Company: *LUXFER*

1- How do you evaluate the general organization of that event?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Global organization	✓				
Communication/ Announcement	✓				
Agenda proposed (time allocated to presentations vs. discussions)		✓			
Meeting room	✓				
Lunch / refreshments	✓				
Teleconference					

2- How do you evaluate the quality of presentations?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Introduction	✓				
AL - General presentation of the project	✓				
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	✓				
BAM - Fatigue failure of cylinders			✓		
HEXAGDN - Characterization of service life		✓			

FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics		✓			
AL - Design requirements and testing procedures		✓			

3- For each presentation:

	What do you retain? What was the most relevant?	What was not clear? What needs more explanations or work?
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement		
BAM - Fatigue failure of cylinders		I have not understood what was the purpose of the study
HEXAGON - Characterization of service life		
FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics		Relevant: acoustic emission and (or) other NOT method
AL - Design requirements and testing procedures		

4- Your comments and suggestions for further research projects on composite pressure vessels:

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Dissemination Workshop on

“Design requirements and testing procedures for the safe storage of hydrogen in composite pressure vessels”

March 5th 2014 in Paris (AFNOR), France

Evaluation form

Name: *CASSAND Gilles*

Company: *COMPOSITES AQUITAINE*

1- How do you evaluate the general organization of that event?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Global organization	<i>α</i>				
Communication/ Announcement	<i>α</i>				
Agenda proposed (time allocated to presentations vs. discussions)		<i>α</i>			
Meeting room	<i>α</i>				
Lunch / refreshments	<i>α</i>				
Teleconference					<i>—</i>

2- How do you evaluate the quality of presentations?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Introduction					
AL - General presentation of the project	<i>α</i>				
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement		<i>α</i>			
BAM - Fatigue failure of cylinders			<i>α</i>		
HEXAGON - Characterization of service life		<i>α</i>			

FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics		X			
AL - Design requirements and testing procedures	X				

3- For each presentation:

	What do you retain? What was the most relevant?	What was not clear? What needs more explanations or work?
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement		Add some information about the specimen and the manufacturing process used (fiber winding) to manufacture the plates
BAM - Fatigue failure of cylinders		
HEXAGON - Characterization of service life		
FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics		Why and how the 4 types of defects have been selected at the beginning of the project
AL - Design requirements and testing procedures	Safety factors explanations for different standards and Hyond's recommendations	

4- Your comments and suggestions for further research projects on composite pressure vessels:

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Dissemination Workshop on

“Design requirements and testing procedures for the safe storage of hydrogen in composite pressure vessels”

March 5th 2014 in Paris (AFNOR), France

Evaluation form

Name: PHIL HOOKER

Company: HSL. U.K.

1- How do you evaluate the general organization of that event?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Global organization		✓			
Communication/ Announcement			✓		
Agenda proposed (time allocated to presentations vs. discussions)		✓			
Meeting room		✓			
Lunch / refreshments		✓			
Teleconference					✓

2- How do you evaluate the quality of presentations?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Introduction		✓			
AL - General presentation of the project		✓			
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement		✓			
BAM - Fatigue failure of cylinders			✓		
HEXAGON - Characterization of service life		✓			

FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics		✓			
AL - Design requirements and testing procedures			✓		

3- For each presentation:

	What do you retain? What was the most relevant?	What was not clear? What needs more explanations or work?
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	The role of the resin in transferring load & the failure mechanism	
BAM - Fatigue failure of cylinders	The importance of test result scatter & link to test sequence	A lot of information on one graph - hard to follow.
HEXAGON - Characterization of service life	Good summary of the variety of treatments a cylinder could have	More on chemical interactions (oil, salt, paints?)
FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics	Interesting review of major manufacturing faults.	
AL - Design requirements and testing procedures	Rationale for changing SF well explained. Thought provoking recommendations.	

4- Your comments and suggestions for further research projects on composite pressure vessels:

~~I~~ I AM INTERESTED IN COMBINATIONS OF TESTS RELATING TO LINKED EVENTS, ESPECIALLY FIRE RESISTANCE AFTER IMPACT DAMAGE, OR FIRE RESISTANCE OF AGED CYLINDERS. THESE ARE REAL WORLD TESTS & TOTALLY FORESEEABLE EVENTS.

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Dissemination Workshop on

“Design requirements and testing procedures for the safe storage of hydrogen in composite pressure vessels”

March 5th 2014 in Paris (AFNOR), France

Evaluation form

Name: *Nony Talie*

Company: *OEA*

1- How do you evaluate the general organization of that event?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Global organization	<i>2</i>				
Communication/ Announcement	<i>2</i>				
Agenda proposed (time allocated to presentations vs. discussions)	<i>2</i>				
Meeting room	<i>2</i>				
Lunch / refreshments	<i>2</i>				
Teleconference	<i>NA</i>				

2- How do you evaluate the quality of presentations?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Introduction		<i>2</i>			
AL - General presentation of the project		<i>2</i>			
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement		<i>2</i>			
BAM - Fatigue failure of cylinders			<i>2</i>		
HEXAGON - Characterization of service life		<i>2</i>			

FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics		α			
AL - Design requirements and testing procedures		α			

3- For each presentation:

	What do you retain? What was the most relevant?	What was not clear? What needs more explanations or work?
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	degradation mechanisms influence of temperature intrinsic st.	limitations of model - the upscale specimen \rightarrow vessel \rightarrow size - taking into account fiber/matrix interface - taking into account multiple fiber breaks
BAM - Fatigue failure of cylinders	- effect of aging - influence of scatter	- representativity of low P vessels
HEXAGON - Characterization of service life	- different operating cond ^o	- the filling station buffer use (amplitude of cycling, frequency)
FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics	- to be completed. - modularized understanding of structural effects	- the explanations
AL - Design requirements and testing procedures	of recommendations actual min value criteria.	type testing vs batch testing

4- Your comments and suggestions for further research projects on composite pressure vessels:

- Move forward to the probabilistic approach coupled to experimental characterization for real definition of end of life α criteria publ. RSD?
- ~~the~~ Aggregate more data on COPV to strengthen or adjust the recommendations for RSD particularly based on virgin and "retired from service" cylinders from \neq volume, design, manufacturer

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↳ Try to reduce the interval of parameters for testing in type approval.

Dissemination Workshop on

“Design requirements and testing procedures for the safe storage of hydrogen in composite pressure vessels”

March 5th 2014 in Paris (AFNOR), France

Evaluation form

Name: JOANNÈS

Company: ARMINES

1- How do you evaluate the general organization of that event?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Global organization	X				
Communication/ Announcement					
Agenda proposed (time allocated to presentations vs. discussions)	X				
Meeting room		X			
Lunch / refreshments		X			
Teleconference					

2- How do you evaluate the quality of presentations?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Introduction		X			
AL - General presentation of the project		X			
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	X				
BAM - Fatigue failure of cylinders		X			
HEXAGON - Characterization of service life		X			

FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics		X			
AL - Design requirements and testing procedures	X				

3- For each presentation:

	What do you retain? What was the most relevant?	What was not clear? What needs more explanations or work?
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement		
BAM - Fatigue failure of cylinders		
HEXAGON - Characterization of service life		
FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics		
AL - Design requirements and testing procedures		

4- Your comments and suggestions for further research projects on composite pressure vessels:

- L'effet combiné de la température et de la charge augmente et accélère les ruptures de fibres par une modification des transferts de charge → la quantification précise de ce phénomène est nécessaire.
- ⇒ Ce sont bien les paramètres de la résine (au sein, T_g) qui pilotent le comportement à long terme du composite (résine + interface), possible.
- Mieux comprendre les mécanismes de fatigue, notamment sur la résine.
 - ↳ essai représentatif.

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- L'histoire de chargement (so. connaissance) est indispensable pour évaluer le niveau d'endommagement dans le composite ---
- Modélisation et changements d'échelles... matériaux VRR composite stratifié résine...

Dissemination Workshop on

“Design requirements and testing procedures for the safe storage of hydrogen in composite pressure vessels”

March 5th 2014 in Paris (AFNOR), France

Evaluation form

Name: *Heng-Yi CHOU*

Company: *Armines*

1- How do you evaluate the general organization of that event?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Global organization		x			
Communication/ Announcement		x			
Agenda proposed (time allocated to presentations vs. discussions)		x			
Meeting room		x			
Lunch / refreshments		x			
Teleconference					x

2- How do you evaluate the quality of presentations?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Introduction		x			
AL - General presentation of the project		x			
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement		x			
BAM - Fatigue failure of cylinders		x			
HEXAGON - Characterization of service life		x			

FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics		X			
AL - Design requirements and testing procedures	X	⊗			

3- For each presentation:

	What do you retain? What was the most relevant?	What was not clear? What needs more explanations or work?
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement		
BAM - Fatigue failure of cylinders		
HEXAGON - Characterization of service life		
FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics		
AL - Design requirements and testing procedures		

4- Your comments and suggestions for further research projects on composite pressure vessels:

- * The effect of fatigue loading on damage mechanism, in particular the effect of strain amplitude.
 - * The effect of temperature on damage accumulation with various applied creep stress level, which will certainly affect the lifetime & scatter of the material.
 - * Statistical analysis should be performed on ~~every~~ ^{up to the AR signature} Any comments, remarks or suggestions can be transmitted to Clémence DEVILLIERS by March 31st 2014, by e-mail to: clemence.devilliers@airliquide.com
- reference for cylinder quality control test.

Dissemination Workshop on

“Design requirements and testing procedures for the safe storage of hydrogen in composite pressure vessels”

March 5th 2014 in Paris (AFNOR), France

Evaluation form

Name: *Pedro Vieira*

Company: *Amtral - Alfa*

1- How do you evaluate the general organization of that event?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Global organization		X			
Communication/ Announcement		X			
Agenda proposed (time allocated to presentations vs. discussions)	X				
Meeting room		X			
Lunch / refreshments		X			
Teleconference					

2- How do you evaluate the quality of presentations?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Introduction					
AL - General presentation of the project					
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement					
BAM - Fatigue failure of cylinders		X			
HEXAGDN - Characterization of service life		X			

FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics			X		
AL - Design requirements and testing procedures		X			

3- For each presentation:

	What do you retain? What was the most relevant?	What was not clear? What needs more explanations or work?
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	<p>The main problem is the lines (Statistics are more important than min values)</p>	
BAM - Fatigue failure of cylinders	<p>Ⓟ</p>	
HEXAGON - Characterization of service life		
FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics	<p>Cracking is very important.</p>	
AL - Design requirements and testing procedures	<p>Need to revise S.F.</p>	

4- Your comments and suggestions for further research projects on composite pressure vessels:

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“Design requirements and testing procedures for the safe storage of hydrogen in composite pressure vessels”

March 5th 2014 in Paris (AFNOR), France

Evaluation form

Name: Lucas BUSTAMANTE VALENIA

Company: Air Liquide

1- How do you evaluate the general organization of that event?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Global organization	X				
Communication/ Announcement		X			
Agenda proposed (time allocated to presentations vs. discussions)		X			
Meeting room	X				
Lunch / refreshments		X			
Teleconference					

2- How do you evaluate the quality of presentations?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Introduction		X			
AL - General presentation of the project		X			
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement			X		
BAM - Fatigue failure of cylinders	X				
HEXAGON - Characterization of service life		X			

FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics	X				
AL - Design requirements and testing procedures	X				

3- For each presentation:

	What do you retain? What was the most relevant?	What was not clear? What needs more explanations or work?
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	Trop dense	
BAM - Fatigue failure of cylinders	—	
HEXAGON - Characterization of service life	Analyse intrusive	Stratégie par exploit. les résultats
FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics	Influence de la cure. Très claire	
AL - Design requirements and testing procedures	Propositions bien claires et exposées.	"Final safety factor" ne semble pas être une approche réaliste.

4- Your comments and suggestions for further research projects on composite pressure vessels:

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Dissemination Workshop on

“Design requirements and testing procedures for the safe storage of hydrogen in composite pressure vessels”

March 5th 2014 in Paris (AFNOR), France

Evaluation form

Name: *Beatriz ACOSTA*

Company: *EC - JRC*

1- How do you evaluate the general organization of that event?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Global organization			X		
Communication/ Announcement		X			
Agenda proposed (time allocated to presentations vs. discussions)			X		
Meeting room		X			
Lunch / refreshments		X			
Teleconference					—

2- How do you evaluate the quality of presentations?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Introduction		X			
AL - General presentation of the project		X			
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement		X			
BAM - Fatigue failure of cylinders			X		
HEXAGDN - Characterization of service life			X		

FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics	X				
AL - Design requirements and testing procedures	X				

3- For each presentation:

	What do you retain? What was the most relevant?	What was not clear? What needs more explanations or work?
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	- Clusters of fibers breaking is the leading mechanisms of damage	• How to transfer from micro- to macro-scale and to cylinder scale • How do you validate the model (comparison to real situation)
BAM - Fatigue failure of cylinders	Scatter in cylinder properties BoL vs EoL scatter	Proper assessment of the scattering in properties ⇒ Proper methodology
HEXAGON - Characterization of service life		Missed feedback from 42 cylinders already used or in operation...
FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics	Cylinders are properly made, impact of variation in manufacturing parameter is minimal. standards properly address the issue(s)	Need more work for the AE to become an established QC method
AL - Design requirements and testing procedures	Nice presentation, all is important and the explanation of SF was very good	I was not expecting so much "discussion" regarding Acoustic Emission AE for In-service inspection will need qualification

4- Your comments and suggestions for further research projects on composite pressure vessels:

- 1) Assessment of the scattering, more test required & relation with the existing tests for type approval
- 2) Statistical Evaluation of cylinders that have been in-service (proposal of Composite Aquitaine)
- 3) Acoustic Emission: Qualification of the technique as an In-service-Inspection NDE
- 4) Risk based analysis (on basis of project 2)

Any comments, remarks or suggestions can be transmitted to Clémence DEVILLIERS by March 31st 2014, by e-mail to: clemence.devilliers@airliquide.com

Dissemination Workshop on

“Design requirements and testing procedures for the safe storage of hydrogen in composite pressure vessels”

March 5th 2014 in Paris (AFNOR), France

Evaluation form

Name: *Anthony BUNSON*

Company: *Formerly Ecole des Mines de Paris
now Consultant*

1- How do you evaluate the general organization of that event?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Global organization	<input checked="" type="checkbox"/>				
Communication/ Announcement		<input checked="" type="checkbox"/>			
Agenda proposed (time allocated to presentations vs. discussions)	<input checked="" type="checkbox"/>				
Meeting room	<input checked="" type="checkbox"/>				
Lunch / refreshments		<input checked="" type="checkbox"/>			
Teleconference					<input checked="" type="checkbox"/>

2- How do you evaluate the quality of presentations?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Introduction					
AL - General presentation of the project		<input checked="" type="checkbox"/>			
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	<input checked="" type="checkbox"/>				
BAM - Fatigue failure of cylinders		<input checked="" type="checkbox"/>			
HEXAGDN - Characterization of service life		<input checked="" type="checkbox"/>			

FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics		X			
AL - Design requirements and testing procedures	X				

3- For each presentation:

	What do you retain? What was the most relevant?	What was not clear? What needs more explanations or work?
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	effect of rate of loading	
BAM - Fatigue failure of cylinders	Order of loading changes the results	
HEXAGON - Characterization of service life	Stress corrosion of glass fibre composites	Load cycles for stationary refueling stations
FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics	Effect of poor curing Visual effects did not reveal any of the induced defects	Does the porosity have an influence?
AL - Design requirements and testing procedures	How to reduce the safety factors	How to conduct in-service tests

4- Your comments and suggestions for further research projects on composite pressure vessels:

A comparison is required between the effects of steady loading and cyclic loading. The effects of small cyclic loads on top of a high average load. The model should be used to explore the effects of changes in material properties such as scatter in fibre strength or material properties such as shear modulus of the resin. Damage has been shown to occur throughout the wall thickness. How should this be quantified. What is the role of porosity on properties and should it be reduced.

Any comments, remarks or suggestions can be transmitted to Clémence DEVILLIERS by March 31st.

2014, by e-mail to: clemence.devilliers@airliquide.com

Dissemination Workshop on

“Design requirements and testing procedures for the safe storage of hydrogen in composite pressure vessels”

March 5th 2014 in Paris (AFNOR), France

Evaluation form

Name: MARK TRUDGEON

Company: LUXFER

1- How do you evaluate the general organization of that event?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Global organization	x				
Communication/ Announcement	x				
Agenda proposed (time allocated to presentations vs. discussions)		x			
Meeting room	x				
Lunch / refreshments		x			
Teleconference					x

2- How do you evaluate the quality of presentations?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Introduction					
AL - General presentation of the project	x				
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	x				
BAM - Fatigue failure of cylinders				x	
HEXAGON - Characterization of service life			x		

FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics	7	X			
AL - Design requirements and testing procedures				X	

Due to batch
Test recommendations

3- For each presentation:

	What do you retain? What was the most relevant?	What was not clear? What needs more explanations or work?
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	Interesting project well presented	
BAM - Fatigue failure of cylinders	Good subject to examine. Difficult to understand choices	Confusing series of tests. Summary rushed.
HEXAGON - Characterization of service life	Some interesting ideas.	Summary and conclusions would have been good.
FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics	Interesting work although further work needed	Not comprehensive
AL - Design requirements and testing procedures	Burst rather rationale was good	Some dangerous recommendations without rationale

4- Your comments and suggestions for further research projects on composite pressure vessels:

Work on impact damage and fire exposure test.
Cycle testing regime for MDWP rather than TP.
Leak rate / permeation rate for T4.

Any comments, remarks or suggestions can be transmitted to Clémence DEVILLIERS by March 31st 2014, by e-mail to: clemence.devilliers@airliquide.com

Dissemination Workshop on

“Design requirements and testing procedures for the safe storage of hydrogen in composite pressure vessels”

March 5th 2014 in Paris (AFNOR), France

Evaluation form

Name: BARDOLK

Company: AIR LIQUIDE

1- How do you evaluate the general organization of that event?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Global organization	X				
Communication/ Announcement					X
Agenda proposed (time allocated to presentations vs. discussions)	X				
Meeting room		X			
Lunch / refreshments	X				
Teleconference		X			

2- How do you evaluate the quality of presentations?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Introduction		X			
AL - General presentation of the project		X			
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	X				
BAM - Fatigue failure of cylinders			X		
HEXAGON - Characterization of service life		X			

FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics		x			
AL - Design requirements and testing procedures	x				

3- For each presentation:

	What do you retain? What was the most relevant?	What was not clear? What needs more explanations or work?
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	clear. leading to an important conclusion concerning iJF	
BAM - Fatigue failure of cylinders		Curves were not so clear from my point of view.
HEXAGDN - Characterization of service life	Trends to be expected by the customers.	
FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics	Finally few impact	
AL - Design requirements and testing procedures	clear.	It would be interesting to schedule tests with vessels designed with the proposed safety factor.

4- Your comments and suggestions for further research projects on composite pressure vessels:

Any comments, remarks or suggestions can be transmitted to Clémence DEVILLIERS by March 31st 2014, by e-mail to: clemence.devilliers@airliquide.com

Dissemination Workshop on

“Design requirements and testing procedures for the safe storage of hydrogen in composite pressure vessels”

March 5th 2014 in Paris (AFNOR), France

Evaluation form

Name: Norm Dewhurst

Company: Hexagon Lincoln

1- How do you evaluate the general organization of that event?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Global organization		X			
Communication/ Announcement		X			
Agenda proposed (time allocated to presentations vs. discussions)		X			
Meeting room		X			
Lunch / refreshments			X		
Teleconference					X

2- How do you evaluate the quality of presentations?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Introduction					
AL - General presentation of the project		X			
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement		X			
BAM - Fatigue failure of cylinders			X		
HEXAGON - Characterization of service life		X			

FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics		X			
AL - Design requirements and testing procedures	.	X			

3- For each presentation:

	What do you retain? What was the most relevant?	What was not clear? What needs more explanations or work?
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement		CONCERN ABOUT USING FLAT PANELS INSTEAD OF CYLINDERS
BAM - Fatigue failure of cylinders		SLOWER BURST JUST SEEMS TO ADD STRESS RUPTURE TO STRENGTH, WHICH COMPLICATES EVALUATION
HEXAGDN - Characterization of service life		
FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics		
AL - Design requirements and testing procedures		

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Evaluation form

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Company:

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Agenda proposed (time allocated to presentations vs. discussions)	✓				
Meeting room	✓				
Lunch / refreshments	✓				
Teleconference					✓

2- How do you evaluate the quality of presentations?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Introduction		✓			
AL - General presentation of the project		✓			
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	✓				
BAM - Fatigue failure of cylinders	✓				
HEXAGON - Characterization of service life					✓

FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics		✓			
AL - Design requirements and testing procedures			✓		

3- For each presentation:

	What do you retain? What was the most relevant?	What was not clear? What needs more explanations or work?
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	Good explanation on UD - specimens	How to take more complex loads into consideration
BAM - Fatigue failure of cylinders	interesting results but T3 testing is not done on repr. cyl.	Too complex presentation. No clear message
HEXAGON - Characterization of service life	-	-
FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics	A good try to see/measure effects of insufficient manufacture	No clear message
AL - Design requirements and testing procedures	Many of the recommendations are questionable	No clear message

4- Your comments and suggestions for further research projects on composite pressure vessels:



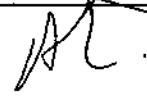


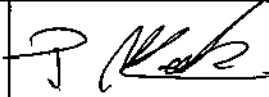


and need further discussions within the

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HyCOMP dissemination workshop

AFNOR, Paris, March 5th

Design requirements and testing procedures for the safe storage of hydrogen



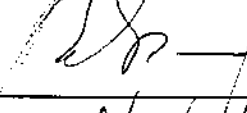
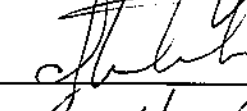
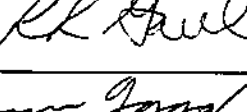
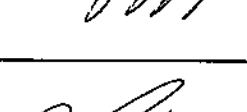

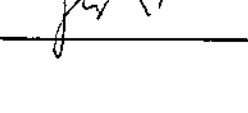
Family name	First name	Nationality	Company	Signature
DEVILLIERS	Clémence	French	Air Liquide	
BARTHELEMY	Hervé	Franch	Air Liquide	
ALLIDIÈRES	Laurent	French	Air Liquide	
WEBER	Mathilde	French	Air Liquide	
ACOSTA IBORRA	Beatriz	Spanish	JRC-IET	
MORETTO	Pietro	Italian	JRC-IET	
NEWHOUSE	Norm	US	Hexagon	
HEGGEM	Per	Norwegian	Hexagon	

BREUER	Patrick	German	Hexagon	
CASSAND	Gilles	French	CAQ	
LANGLOIS	Christophe	French	CAQ	
GASIOR	Pawel	Polish	WUT	
AGNOLETTI	Alberto	Italian	Faber	
NONY	Fabien	French	CEA	
MAIR	Georg	German	BAM	
JOANNES	Sébastien	French	Armines	
BUNSELL	Anthony	French	Armines	
CHOU	Heng-Yi	Taiwan	Armines	





HyCOMP dissemination workshop

AFNOR, Paris, March 5th

Design requirements and testing procedures for the safe storage of hydrogen

Family name	First name	Nationality	Company	Signature
BLOIS	Christophe	French	CAQ	
FOLLAIN	Jean-Marc	French	CAQ	
BEHRNING	Stefan	German	TUEV Rheinland Group	
WEBSTER	Craig	Canadian	CSA group	
GAMBONE	Livio	Canadian	CSA group	
YEGGY	Brian	US	Hexagon Lincoln	
DAVAL	Romary	French	Luxfer	
AUGUSTIN	Anja	German	TÜV Thüringen	

JAMES	Charles	US	DOE	 (absent)
TRUDGEDN	Mark	German (?) CASA	Luxfer	
BASSANINI	Gianluca	Italian	Tenaris	 (absent)
IRANI	Roy	English	Gas Package Solutions (GPS) Ltd	
SAMVATSAR	Pramod	Indian	Everest Kanto Cylinder Limited	By teleconference
SCHMIDT	Dirk	German	Kessels	
KESSELS	Alexander	German	Kessels	
SMITH	John H.	US	JHS Associates	By teleconference
HERRMANN	Michael	German	Adam Opel AG/ General Motors	By teleconference
BORTOT	Paolo	Italian	Tenaris	Paolo Bortot
BAUNE	Emmanuel	French	Air Liquide	

BUSTAMANTE	Lucas	French	Air Liquide	
BARDOUX	Olivier	French	Air Liquide	
HOOKER	Phil	English	HSL	
VIEIRA	Pedro	Portugues	Amtrol-Alfa	

PETERS

Ursula

German

Opel / GM

By teleconference

Dissemination Workshop on

“Design requirements and testing procedures for the safe storage of hydrogen in composite pressure vessels”

March 5th 2014 in Paris (AFNOR), France

Evaluation form

Name: *E. Banno*

Company: *AL*

1- How do you evaluate the general organization of that event?

	Excellent	Good	Satisfying	Non satisfying	No opinion
Global organization		<i>✓</i>			
Communication/ Announcement	<i>✓</i>				
Agenda proposed (time allocated to presentations vs. discussions)	<i>✓</i>				
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Lunch / refreshments	<i>✓</i>				
Teleconference	<i>✓</i>				

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ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement	<i>✓</i>				
BAM - Fatigue failure of cylinders			<i>✓</i>		
HEXAGON - Characterization of service life			<i>✓</i>		

FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics	K				
AL - Design requirements and testing procedures	K				

3- For each presentation:

	What do you retain? What was the most relevant?	What was not clear? What needs more explanations or work?
ARMINES - Damage accumulation in the composite wrapping: impact, rate and measurement		- <i>Boh vs. EoL parameters?</i> ↑ <i>how to define EoL?</i>
BAM - Fatigue failure of cylinders	- <i>Dispersion in perf. difficult to interpret</i>	<i>from some batch makes it results...</i>
HEXAGON - Characterization of service life	- <i>Parameters in service.</i>	- <i>what link between ident. f. parameters and test program in HyComp?!</i>
FABER - Manufacturing Quality Assurance: effect of variability of fiber and matrix characteristics	- <i>Effect of manuf. parameters T_g fibers, % hardener...</i>	- <i>Effect of T on performance.</i> → <i>identify in standards if T effect was removed!</i> - <i>Role of Alt manuf. parameters on impact...</i>
AL - Design requirements and testing procedures	- <i>Safety factor: what recommendation for type 3 vs. type 4?</i> - <i>influence of impact / damage on performance</i> <i>Difficulty to trace efficiency. Visual w. other NDT?</i>	<i>recommendation for type 3 vs. type 4?</i>

4- Your comments and suggestions for further research projects on composite pressure vessels:

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