New Ariane 5: joint success for DTA and Cryospace
Gas purifiers: setting the standard in the United States

Just before Christmas, DTA commenced delivery of two purifiers (one liquid and one gas) and their analysis systems to an American public research centre, for applications that remain confidential. Adapted to comply with all aspects of American regulations, the four units will track the ppb* of impurity in gaseous nitrogen and cryogenic nitrogen supplied by Air Liquide USA. Commissioning is scheduled for early March. This contract worth over € 900K is the first “major” reference for DTA purifiers in the United States.

Another reason to be pleased – a full system including purifier and analyzer is being supplied, as customers tend to place separate orders for these two units. The first months in use will be crucial, as other American companies are looking to make similar investments.

* part per billion

General Electric is dreaming of a superconducting alternator

99% electric output against 98.5% under current technology – this is the prospect offered by superconducting alternators and, at the scale of power of this equipment (tens of MW), it is far from negligible. All the electrical equipment giants are working on it, particularly General Electric. The American manufacturer has ordered a 20 K refrigerator (-53°C) to cool a 1.5 MW super alternator model in its R&D centre at Schenectady, New York. The planned refrigerator uses a Brayton cycle and includes a totally reliable expansion turbine with gas bearing; the production team’s main concern is how to guarantee two years’ non-stop operation. General Electric is aiming to use these tests to confirm the move onto the manufacturing stage on 100 MW alternators. Delivery, start up and user training are scheduled for end 2005 and beginning 2006. Note: the final phase in the call for tenders once suppliers had been selected and qualified took place over the Internet through a reverse auction lasting one and a half hours!

The M346 delighted with its OBOGS

After twenty hours of convincing test flights at the end of 2004, the Italian aircraft manufacturer Aermacchi is delighted to have fitted the DTA onboard oxygen generation system (OBOGS) to its military training aircraft, the M346. This equipment with a multitude of technical innovations is for use for training fighter pilots, before they are able to fly their aircraft. Aermacchi puts the world market at over 1,600 units and hopes to acquire 30% in the next few years, as many armed forces need to renew their aircraft fleets. DTA based the development of this new system on the Rafale OBOGS; additional functions are now available without an increase in size. It is already in use on the Czech L159 and is soon to be fitted to the Korean KT1 and the Cougar helicopter. Fitting the OBOGS to a training airplane more generally reflects a significant trend. Bottled oxygen with its restrictive logistics is giving way on military aircraft to on-board generators with higher initial costs but greater flexibility in use.
8 November 2004 – Innovation Day

Air Liquide teams on the various sites throughout the world took part in the second Group Innovation Day on 8 November. DTA did not miss this important event.

Conferences, exhibitions, educational panels, workshop visits, awards: DTA pushed the boat out for this outstanding day for all employees, not just the technical specialists. The program was designed to tempt the curious – a talk by Alain Benoist from CNRS (the French National Centre for Scientific Research), a major world specialist in very low temperatures and in astrophysics cryogenic applications, amongst other things; a visit to the Axane premises and a tour of the site’s “hydrogen station”, where vehicles are fuelled from fuel cells. The Innovation Day is also an occasion to reward those people whose actions have produced the greatest technological progress at Air Liquide. Three prizes for innovation were awarded to Patrick Bravais, specialist in xenon compression benches for satellite engines, Thierry Trollier for his spatial cryogenic machines and Pierre Charlat, the Axane Technical Director. Within the frame of the TRP*, the title of “Specialist Technician” or “Specialist Engineer” was therefore conferred on eight people.

Highlight: François Jackow, Group Director for R&D and leading technologies, chose to spend his day on the DTA site. The date is already set for the 3rd Air Liquide Innovation Day – 8 November 2005.

* Technical Recognition Program

India: the VECC cryostat ready for service

Delivered, accepted, tested for leaks – the liquid helium cryostat delivered to the VECC Indian research centre in Calcutta in 2004 is now ready for service.

Herschel, project end

The thermal insulating screens on the Herschel satellite helium tanks and optical instruments were delivered to EADS-Astrium in southern Germany during December and January. These parts are a good size (1.85 external diameter and 2.5 m high) and are very delicate, as the superinsulator is fixed to structural aluminium just 0.8 mm thick.

Size tolerances are also very tight; they appear to comply, for Astrium has already been able to perform the most critical phase of integrating the screens into the cryostat five times quicker than planned!

Photo credit: EADS-Astrium GmbH

With an external diameter of 2m, it houses a super-conducting cyclotron coil cooled to 4.5 K (-269°C) in a succession of enclosures; the liquid nitrogen vacuum circulation ensure its thermal performances.

To produce the equipment, the Indian researchers had provided a file containing paper drawings describing two cyclotrons produced in the 1980s in the United States. This highly-complex file (250 drawings!) had to be validated and completed before manufacture with extreme vigilance, as tolerances were less than 1 mm for 2 meters. The cryostat supplied to VECC joins the Helial 50 helium liquefier delivered in 1988.
The supply of all the cryogenic tanks and a pressurization system meant that DTA and Cryospace played a major role in the success of the new Ariane 5 on Saturday, 12 February. Many of these

New Ariane 5: joint success

The new Ariane 5, known as ESC-A, is capable of propelling up to ten tonnes into geostationary transfer orbit (GTO) as single or double (two satellites at once) launch operations. This saving in payload required additional power, acquired on three levels: more powerful powder boosters on take-off and a lower stage with a Vulcain 2 engine; a cryogenic main stage in preference to a storable propellants stage for launching into orbit.

DTA and Cryospace had to cope with these modifications throughout the Evolution program launched in 1997.

Helium pressurization sphere
The liquid oxygen tank on the lower stage on all the Ariane 5 is pressurized by a helium circuit fed by a cryogenic storage sphere. DTA has designed this globally-unique sphere and manufactured it from the first firing. For the ESC-A, with a more powerful lower stage, the oxygen tank is larger (it carries an additional 16.5 tonnes) and the pressurization sphere must match this; its capacity has increased from 141 to 166 kg.

“*The entire internal sphere manufacturing process had to be re-qualified and the thermal and mechanical performances validated*”, explains Nicolas Balcet from DTA. The external sphere is the same size, however, with the same performance by the multi-layer insulator, but in a reduced space.

Cryogenic lower stage
You have to look very closely to see the change: a “common head” (separation between the hydrogen and oxygen tanks) lowered by 65 cm, to take on board the additional oxygen required by the Vulcain 2 engine. This slight offset - the stage is 25 m long - meant re-development from start to finish! “The ferrule dimensions change, the length of the feed lines changes, the anti-vortex and splash baffles are moved”, explains Joël Leleux, Programs Department Manager at Cryospace. “Behind the envelope, identical, it is a genuinely new stage.” The 25-strong design team had to take risks during its 4-year existence. For example, to calculate the strengthening of the thicknesses, how to “hold” to the increased launcher thrust without making it too heavy? Cryospace also reviewed its production line: welding points were moved and handling systems adapted to the volumes and shapes of the new parts. “We found manufacturing the lower stages for the ESC-A and for the generic version on the same production line the most complex aspect to deal with. Everything has to be re-arranged when moving from one to the other.”

Upper stage oxygen tank
There is little point in changing a winning team or a proven part! The
parts had already been manufactured for the generic Ariane 5 or for Ariane 4, but it took years to make the necessary modifications that cannot even be seen with the naked eye.

for DTA and Cryospace

The upper stage liquid oxygen tank is very similar to the 143 manufactured for Ariane 4 in the DTA factory. Here too, however, the entire definition package was reviewed: the launcher thrust is much more powerful, the thermal environment changes as the upper section of the tank is no longer covered with insulation. "This lack of insulation caused serious problems during tests", recounts Nicolas Balas of DTA. "The liquid oxygen was firstly too cold, then it heated by 0.2 to 0.3 degrees too much, which risked turbo-pump cavitation." A multi-layer insulator shaped like a limpet was added, therefore, to control the flows between these two tanks in the upper stage. Additional thermal calculations provided the perfect solution to controlling overheating. Another problem identified during the calculations was potential microfissuring on the lower tank head, due to dynamic force collected at take-off and during the flight. Additional, non-destructive testing with Foucault currents checked for defects likely to develop during flight.

Upper stage hydrogen tank

Its lower, convex head that supports 3.5 bar pressure makes this tank totally unique. It was, however, important to "cap" the oxygen tank and gain back the external diameter from the rest of the launcher, i.e. 5.40 m. "Stiffeners had to be added to hold it under pressure and buckling", explains Joël Leleux at Cryospace. "The thermal insulation gave us a few headaches: the thermal inputs were too large at the junction between the diffuser head and the walls and the liquid hydrogen was overheating." This weakness detected during full-scale tests at Kourou required modifications to the insulation. With this new thermal protection, the hydrogen tank was reviewed under the pre-firing launch program at Kourou in October. With excellent results! "Thankfully, we could rely on acquired experience", concludes Joël Leleux. "We used existing items as much as possible and our seventy technicians can manufacture either this tank or those for the lower stage."

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View of welding bench on the ESC hydrogen tank with the diffuser head being moved towards it.
If a “green automobile planet” exists, Shanghai was the place to find it in October! Some 140 vehicles designed by manufacturers and laboratories assembled on the city’s Formula 1 track for the Michelin Bibendum Challenge. They included thermal/electric engine hybrids, battery-operated electric cars, cars fuelled by natural gas, biofuels and fuel cells, in short a full-size line-up of new engine systems being researched throughout the world.

A rally and a test of autonomy
The objective was not to raise the bonnets for detailed examination of the technologies: “It was far more to provide a showcase for this work and meet potential partners”, explains Laurent Allidières from DTA. “We firm ed up the supply of a hydrogen station to BP in Singapore, for delivery in 2005.”

No question either of leaving the cars in the car park: they could confront each other on the F1 track, take part in tests for autonomy, braking, road-holding (don’t let’s forget that Michelin manufactures tires…) and in a rally in Shanghai. In other words they really moved! Hence the presence of the DTA hydrogen station, designed and produced in France then assembled in two days by a team of local technicians. It filled up a hundred or so vehicles in five days, pumping over 350 kg of hydrogen. It was admittedly free of charge and no driver was going to let such an opportunity pass. “We based the external design on the station already supplied to Luxembourg and Madrid for their bus fleets,” clarifies Laurent Allidières. “Everything here was contained in a similar size to a traditional petrol pump: electrical cabinet, hydrogen detectors, control and instrumentation panel, etc.” The whole system was supplied by hydrogen bottles at 420 bar, themselves connected to a 18,000 liter tank at 200 bar via a compressor.

Sleepless night to re-stock the station
The system had been designed in France by Christophe Boutelou (Design Office) and tested by Yves Lacombe and Thomas Charbonneau (tests), based on filling up three vehicles per day. Including test days, there were five times more! Which meant that Laurent Allidières and the Chinese technicians spent a sleepless night halfway through to re-stock the installation. “The problem was maintaining the highest pressures possible in the 420 bar tank. Given the amount of hydrogen distributed, we could no longer cope and we spent an entire night re-pressurizing these tanks to their rated pressures before the day set aside for autonomy testing. In the morning, ten minutes before the test started, we had a stream of eighteen vehicles wanting to fill their tanks to the brim!”

This re-stocking passed unnoticed by the motorist “customers” who only had praise for their supplier: the fuel cell vehicles, with the exception of the 50-seater bus, filled up in one to four minutes – similar to the time for filling up with petrol. This seemingly simple operation
Challenge organized by Michelin in Shanghai. An occasion for the DTA hydrogen station to function flat out for five days: around a hundred vehicles filled up.

**Formula 1 track in Shanghai**

nevertheless masked a minor technical exploit: "We were dealing with all sizes of tanks in all types of materials, with the hydrogen stored between 120 and 350 bar. One difficulty in filling up is to prevent the gas from overheating, a potential risk for the composite used for the bottles. You have to be quick, but never too quick, in constantly-changing circumstances."

**Safety: no lowering the guard!**

CRCD* and DTA had in any case anticipated this problem by patenting a control system for bottle heating. When the vehicle fills up, data is checked constantly against the its temperature indicator. The system has proved satisfactory and may be used in other hydrogen stations. The only aspect annoying the motorists turned out to be the strict application of safety rules: impossible to remain in the car or watch the station functioning, for a security limit of several meters was in operation. Many curious people got nowhere, despite their insistence. "We still view hydrogen as a chemical transmitter, not an energy vector, and we take suitable precautions," underlines Laurent Allidières. "This can be tricky with respect to the general public who see extra precautions as meaning increased danger. "But these technologies are still too under-developed to take useless risks." Air Liquide also met fuel cell manufacturers during these ten days in Shanghai, entertained its main hydrogen customers for China based there, organized a conference of its hydrogen business developers from all over the world and established contacts for future contracts.

As for the station itself, it was sufficiently convincing for DTA to become a partner rather than a supplier in the new European fuel cell project, CUTE Plus, which is due to be validated shortly by Brussels. China a springboard for the future!

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* CRCD: Claude Delorme Research Centre.

**Cars unlike all others**

Clean or not, enthusiasts of out-of-the-ordinary cars revelled in the vehicles shown in Shanghai. Madame Courrèges, the wife of the celebrated fashion designer, had personally financed a strange white, egg-shaped device that was both modern and outdated. A Chinese laboratory, Institut 683, presented a golf cart. General Motors stood out for its designer car controlled entirely by electricity, including the steering! Peugeot, Citroën, Audi, Mercedes, BMW, Ford, Hyundai, Nissan and several Chinese manufacturers were also present, proof that nobody is remaining indifferent to "sustainable mobility" based on clean energy.
Jean-Louis Étienne and the Mobixane cell on Clipperton: “Importing a fuel cell into a hostile environment was something of a gamble”

The main use for the equipment supplied by Axane: silent supply for the filming equipment, particularly the lighting balloon.

Is this the only use for the cell?
We also use it to supply the lighting balloon during nocturnal expeditions at sea. We have light to prepare the base camp and we leave the balloon lit when we leave – we use it as a beacon to estimate our distance from the coast. We have to cross a fragile coral reef on each voyage; it is easy to judge how far we are from it and to be ready thanks to this “beacon”.

Did you find it difficult to install or use?
We were trained at Axane and the user’s manual is very simple, as is the operation of the cell itself. It started the very first time! I think it was quite a gamble to import a fuel cell into such a hostile environment, with logistics that are far from ideal for the equipment. Axane took up the challenge. Everyone here was impressed to find this equipment.

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Why have you taken the Mobixane fuel cell to Clipperton?
Firstly, for educational reasons. With the National Education authorities who are backing my expedition, we decided to promote renewable energies in this expedition. The second reason is technical: to shoot the films, we needed a silent and hopefully non-polluting source of electricity to supply the Airstar lighting balloon. The first tests took place in January during a night ride and were very conclusive: the Axane cell-Airstar balloon combination worked perfectly and I imagine that other outside film crews will be tempted by it in the future.

Do you not use the cell as a back-up system at all?
It has enough power (2 kW) to tide us over on the thankfully rare days when we have no sun or wind on the island. Our other energy sources are photovoltaic panels and two 1 kW wind generators! Lastly, researchers working outside the camp use it to supply their computers and measuring instruments.

The cell landing on the island, a delicate operation.