INTERMEDIATE INFORMATION DAYS

- Actions carried out and results achieved for Activities: 3

- Actions planned and expected results for Pilot 3

Global Service and lab. PERCRO - Scuola Superiore Sant’Anna

Speaker: Andrea Papini
Activity 3. Pilot and Demonstration: adaptation of a diesel Reach Stacker to be powered with a dual fuel engine.

Actions carried out by GS and PERCRO-SSSA:

1) General assessment of the technical feasibility;

2) Identification of the most appropriate reach stacker model to undergo the dual fuel conversion;

3) Identification of the most appropriate engine to undergo the dual fuel conversion;

4) Identification and preliminary selection of potential suppliers;

5) Design.
General assessment of the technical feasibility

A technical feasibility study has been conducted by Global Service team on four reach stackers of three different brands equipped with three different types of engine:

- **Kalmar** mod DRF 450/65S5. Engine on board **Cummins QSM11**.
- **Konecranes** mod SMV TB5 - engine on board **Volvo TAD 1250 VE** - diesel fuel tank capacity: 650 litres.
- **CVS** mod F478 - engine on board **Scania DC 1258** - diesel fuel tank capacity: 530 litres.
General assessment of the technical feasibility

LNG tank dimensioning
In case of diesel substitution rate = 50% LNG tank should ensure to reach stackers approximately the same autonomy as if it operates 100% Diesel

LNG tank of 410 NET litres produced by “Chart Inc.” (model HLNG-119)
Total GROSS volume 1,300 litres

Customize LNG tank of 400 NET litres by “HVM srl” (in case of particular positioning issues)
LNG tank placement on reach stackers

All Reach Stackers models have enough space to place the LNG tank on the right side (Kalmar and Konecrane) or on the left side (CVS) of the cockpit.

The Kalmar reach stacker has also space for the LNG tank under the chassis in front of the rear wheels.

Example of possible LNG tank positioning in the Kalmar reach stacker
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General assessment of the technical feasibility

Dual fuel system adaptation kit suppliers
Global Service team has sought and has obtained the cooperation of Ecomotive Solutions (Holdim Group) which has a considerable international experience in this specific field.

Source: Working scheme of the D-GID dual fuel system developed by Ecomotive Solutions
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**General assessment of the technical feasibility**

Technical characteristics of Volvo, Scania and Cummins engines do not create particular problems for the modifications with the dual fuel conversion kit.
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2) Identification of the most appropriate reach stacker model to undergo the dual fuel conversion;

- Reach Stackers model technically most suitable for the dual fuel conversion;
- Manufacturer most available to collaborate in pilot 3 (Kalmar, Konecranes or CVS)

Main technical aspects analyzed:

- General technical adaptability;
- LGN tank positioning and length of the cryogenic line,
- Encumbrances and weight distribution,
- Industrialization perspectives.
Kalmar is the reach stacker brand selected for the pilot.

The choice has been based on the following aspects:

1. In the analysis and study of the three brands (CVS, Konecranes and Kalmar) Kalmar model results to be the most suitable for the conversion: it allows different hypotheses of LNG tank positioning without exceeding the length of the cryogenic line;

2. Among the three companies, Kalmar showed the greatest interest giving its willingness to cooperate in the implementation of the pilot demonstrator and foreseeing industrial perspectives.

3. Global Service has a high and solid experience in the use and maintenance of Kalmar Reach Stackers;
Activity 3. Pilot and Demonstration: adaptation of a diesel Reach Stacker to a dual fuel engine.

3) Identification of the most appropriate engine to undergo the dual fuel conversion;

After a joint investigations by Kalmar & Global Service in Sweden, the Cummins engine was chosen. Cummins choice allow the possibility to make all conversion process in Italy without limitation in choosing the most suitable conversion kit.
Activity 3. Pilot and Demonstration: adaptation of a diesel Reach Stacker to a dual fuel engine.

Identification data of the selected Reach Stacker engine for pilot 3

Model: Cummins QSM11

- Diesel – 4 stroke
- Number of cylinders – compression (cm³): 261 – 2000
- Power according to ISO 3046 – at revs (kW/rpm): 1830 – 1100-1400
- Torque according to ISO 3046 – at revs (Nm/rpm): 6 – 16.3:1
- Alternator, type – power (W): AC – 2400
- Number of gears, forward – reverse: 4 – 4
Diagram of the performance data of the engine Cummins QSM11

Torque output

Power output

![Graph showing torque and power output vs. engine speed for Cummins QSM11 engine.]
Activity 3. Pilot and Demonstration: adaptation of a diesel Reach Stacker to a dual fuel engine.

Selected Kalmar Reach Stacker for pilot 3

Model: Kalmar DRF450-65S5
- Diesel powered
- Engine: Cummins QSM11
- Lifting capacity: 45000 – 31000
- Lifting speed, unloaded – at 70% of rated load (m/s): 0.42 – 0.25
- Starting battery, voltage – capacity (V – Ah): 2×12 – 140
- Fuel volume (l): 550
4) Identification and preliminary meeting with potential suppliers

The following potential suppliers were identified and chosen in collaboration with the designer of Kalmar:

- For the conversion kit: the Ecomotive Solutions Holdim group;
- For cryogenic tanks: the Chart for standard models or the HVM for tailored models;
Preliminary meeting with potential suppliers

Meetings were held to plan terms and possible contributions of each supplier for the realization of pilot 3, with surveys of the Kalmar reach stackers in the TDT.
Identification of LNG refueling solution for testing

For the LNG refueling during the tests in TDT, Global Service and HAM company are studying the most suitable solution between a mobile station (truck tanker) and a temporary tank.
1) General assessment of the technical feasibility;

2) Identification of the most appropriate reach stacker model to undergo the dual fuel conversion;

3) Identification of the most appropriate engine to undergo the dual fuel conversion;

4) Identification and preliminary selection of potential suppliers;

5) Design in progress

Kalmar designers, in close collaboration with Global Service technicians and Ecomotive Solutions, has started the executive planning phase.
The design in progress includes:
- definition of specifications;
- architectural and structural modifications;
- firmware and electronics.

The specific aspects of the design concern:
- power requirements: peak and average;
- map of dual fuel mode;
- time between fueling;
- interaction with on-board systems (electronic devices and interfaces);
- injection modification;
- fuel tank and fuel inlet: dimensioning (on the base of real usage data), localization;
- cryogenic line;
- mechanical adaptation.
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<td>Installation of the engine and tank aboard, its connections to power and control network</td>
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THANKS FOR YOUR ATTENTION!

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