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Distributing neat biojet fuel through a non-dedicated system

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Executive summary

On January 22nd 2016, the start of sustainable jet fuel supply at Oslo Gardermoen Airport was announced by the ITAKA consortium and Air BP. The majority of this sustainable jet fuel is supplied directly into Oslo's fuel hydrant system, meaning that it became part of the airport's common storage and distribution system without having to rely on a segregated infrastructure.

With the SJF supply via Oslo's OLT tank farm and hydrant system, the ITAKA project demonstrated as a first time ever that SJF supply through an airport's existing infrastructure system is possible. Although the SJF supply to the airport was still segregated using road tankers, receiving into existing jointly operated jet fuel systems appeared feasible from both operational, and technical perspective. No deviations have been reported.

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Abbreviations

AFQRJOS = Aviation Fuel Quality Requirements for Jointly Operated Systems

ASTM = American Society for Testing and Materials

EI = Energy Institute

EU RED = European Union Renewable Energy Directive

EU ETS = European Union Emission Trading Scheme

GFS = Gardermoen Fuel Services

HEFA = Hydro-treated Esters and Fatty Acids

JIG = Joint Inspection Group

MCA = Monument Chemical Antwerp

OLT = Oslo Lufthavns Tankanlegg

OSL = Oslo Gardermoen Airport

PoS = Proof of Sustainability

SJF = Sustainable Jet Fuel

Definitions

ASTM: originally known as the American Society for Testing and Materials, this international standards organization develops and publishes voluntary consensus technical standards for a wide range of materials, products, systems, and services. ASTM International works with aircraft and engine manufacturers, government authorities and fuel suppliers to set the standards for aviation fuels such as the required characteristics for jet fuel.

ASTM D1655: Standard Specification for Aviation Turbine Fuel. This specification defines the minimum property requirements for Jet A and Jet A-1 aviation turbine fuel and lists acceptable additives for use in civil operated engines and aircrafts. Specification D1655 is directed at civil applications, and maintained as such, but may be adopted for military, government or other specialized uses.

ASTM D7566: Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons. The main part of this standard contains the specifications for synthetic jet fuel blended with Jet A or Jet A-1. Once certified, the blended jet fuel batch is automatically recertified to ASTM D1655 and considered a drop-in fuel batch. Blending is only allowed after the neat synthetic jet fuel batch is certified to the applicable Annex of D7566. Each Annex belongs to a specific synthetic jet fuel production pathway; a total of five pathways are currently certified.

DefStan 91-91: “Defence Standard 91-91”, the Aviation Turbine Fuel (Kerosene Type, Jet A-1) standard developed by the UK Aviation Fuels Committee (AFC) on behalf of the Ministry of Defence (MOD). Developed for use in the UK, but today also used in many European countries.

HEFA: Hydro-treated esters and fatty esters / the technology to treat triglycerides with hydrogen under increased pressure and temperature to convert them into hydrocarbons.

JIG: Joint Inspection Group. Established by numerous oil companies that share jet fuel infrastructure to and at airports, and developed a set of standard/guidelines which govern the operation of the shared fuel infrastructure.

EI 1530: Quality assurance requirements for the manufacture, storage and distribution of aviation fuels to airports. EI/JIG 1530 provides a standard for maintaining aviation fuel quality, from production through (sometimes complex) distribution systems to airports. It provides mandatory provisions and good practice recommendations for the design/functional requirements of facilities, and operational procedures.

AFQRJOS: The Aviation Fuel Quality Requirements for Jointly Operated Systems are the agreed specification requirements for jet fuel supplied into jointly operated locations. It comprises the most stringent specifications of both ASTM D1655 and DefStan 91-91.

1 Introduction

On January 22nd 2016, the start of sustainable jet fuel supply at Oslo Gardermoen Airport was announced by the ITAKA consortium and Air BP. The majority of this sustainable jet fuel is supplied directly into Oslo's fuel hydrant system, meaning that it became part of the airport's common storage and distribution system without having to rely on a segregated infrastructure.

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2 Requirements for supplying sustainable jet fuel via co-mingled airport systems

Fuel quality

Given the international character and very strict safety regulations of aviation, fuel quality is carefully managed by international fuel standards. One of the best known standardization organizations is ASTM, in which subcommittee D02.J is responsible for aviation fuels standards, e.g. D1655 for Jet A and Jet A-1, and D7566 for Jet A and Jet A-1 containing synthesized hydrocarbons. These ASTM standards are well respected within the aviation industry and used globally.

Sustainable jet fuel may only be used in turbine engines after being certified to D7566 specifications for the neat sustainable jet, blended with regular (D1655 certified) Jet A/A-1 and again certified to D7566 specifications for the blend. After the blend certification, the blend is automatically recertified to D1655. The blend then meets the same specifications as regular Jet A/A-1 should meet, and from then on can be considered a drop-in jet fuel that can be handled and used in the same way as regular Jet A/A-1.

The D7566 standard consists of two parts. The Annexes contain the specifications for neat sustainable jet fuel, in which every Annex is applicable to a specific production pathway. Currently, there are five SJF production pathways certified. After blending the SJF with regular Jet A/A-1, the blend is certified according to the general part of D7566 and with this step automatically recertified to ASTM D1655. The figure below shows a schematic overview of this certification process.

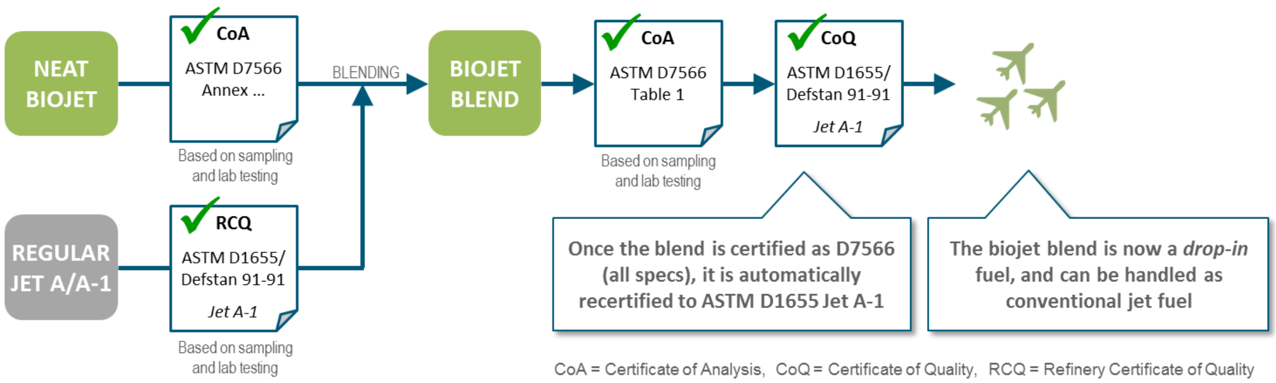


Figure 1. Schematic overview of the sustainable jet fuel certification process.

Although globally the ASTM D1655 standard is widely accepted and used, it is not the only standard for Jet A-1. The by the United Kingdom's Ministry of Defence developed Defence Standard (DefStan) 91-91 for Jet A-1 is more common in Europe. Both standards are almost identical, they only differ on some parameters, e.g. conductivity and traceability requirements. Both ASTM D1655 and DefStan 91-91 refer to the ASTM D7566 standard when it comes to synthesized hydrocarbons, hence both standards allow sustainable jet fuel to the same extend.

Operations

At large airports, many aviation fuel suppliers share the use of fuel storage tanks and fuelling systems, thereby preventing unnecessary infrastructure duplication and additional costs. The Joint Inspection Group (JIG) was established by oil companies to develop a set of standards that govern the operation of the shared fuel infrastructure on airports where the JIG companies operate. However, usage of the JIG guidelines is not limited to jointly operated locations, any operator providing aviation fuel infrastructure may use the guidelines.

Today, most European airports operate by these JIG guidelines, including Oslo Gardermoen Airport. The guidelines are not only applicable to the airport's operations (JIG 1 and 2), but also cover the jet fuel supply chain (JIG 3). The Energy Institute (EI) and JIG jointly extended the JIG 3 guideline to cover also operations further upstream, including refineries. This has become the EI 1530 guideline. The picture below shows which pieces of the supply chain are covered by which standards.

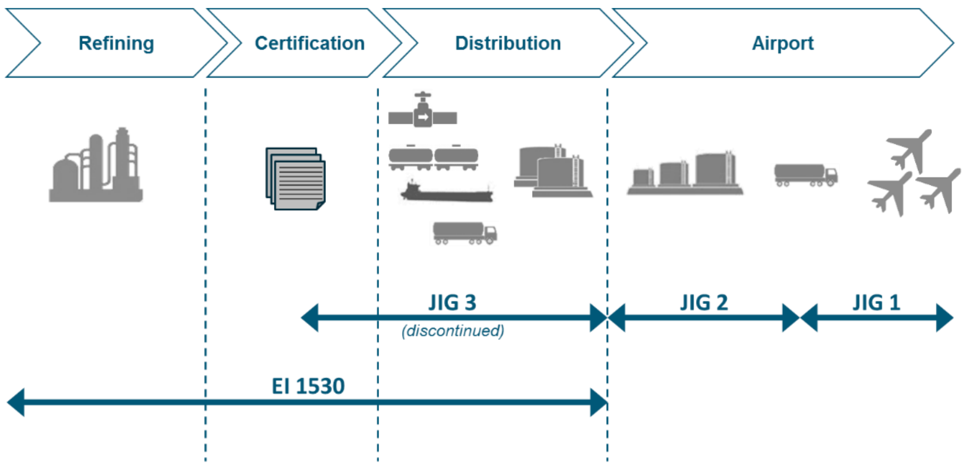


Figure 2. Overview of JIG guidelines coverage in aviation fuel supply chains.

Part of the JIG guidelines is the Aviation Fuel Quality Requirements for Jointly Operated Systems (AFQRJOS), defining the fuel quality requirements for supply into jointly operated fuelling systems. It embodies the most stringent requirements of both ASTM D1655 and DefStan 91-91. Since 2012, both JIG and EI 1530, hence also the AFQRJOS, follow ASTM and DefStan regarding allowance of synthetic components to be blended with Jet A-1 for up to 50%. In other words, JIG allows SJF to be used in existing jet fuel infrastructure to and at airports.

Although fuel standards and operating guidelines allow the use of sustainable jet fuel in co-mingled systems for some years already, it hadn't taken place so far. Given the still relatively limited experience, combined with strict aviation safety regulations and complex and jointly operated supply chains, stakeholders tended to be a bit hesitant in using SJF via the co-mingled systems in the beginning. For the ITAKA SJF deliveries through the co-mingled system though, full support and confidence was obtained from all parties involved fuel supply at Oslo Gardermoen Airport (OSL). This included Air BP, OSL's commingled aviation fuel storage provider OLT and OSL's into planer GFS.

For the ITAKA SJF deliveries via the co-mingled system, the JIG and EI 1530 guidelines had to be taken into account throughout the entire supply chain and by all the ITAKA downstream supply chain partners. Eg. Neste followed JIG/EI 1530 Section 10 guidelines for transport and applied the HM50 procedures (prescribed by JIG/EI1530) for the vessel transport of neat and blended SJF.

One of the JIG/EI 1530 guidelines states that receiving up to three jet fuel batches into one commingled storage tank is allowed without having to fully recertify the received fuel to all AFQRJOS specifications; only a key parameters check is required (e.g. density, freeze point, flash point, etc.).

> EI/JIG 1530, section 4.6.1
> "*When batch traceability or integrity is lost, for example, when several batches are mixed in a system in unknown proportions, or where more than three batches are added to the heel in a tank (where the heel is less than 3% of the total volume), it is necessary to retest the new batch against the complete specification and produce a CoA.*"

In case more than three batches are received, it is considered a blending operation (in terms of JIG this is equal to production) and a full certification of the fuel is required. In order not to negatively influence the jet fuel operations at OSL, this implied that the SJF batch delivered into the commingled jet fuel tank needed to be one of the total three received batches, or be smaller than 120 CBM (which is 3% of the storage tanks capacity) minus the actual tank heel volume. Furthermore, following JIG guidelines, the SJF batch needed to be compliant to the AFQRJOS.

3 Overview of non-segregated supply and operations

The SJF that was supplied at OSL was produced by Neste from feedstock supplied by the Camelina Company. The fuel was blended on ship by Neste and Air BP and subsequently stored in a shore tank at the ST1 terminal in Gävle (Sweden). From there on the fuel was trucked to OSL for supply into the co-mingled storage system of OLT and (a smaller part) for supply to segregated KLM/Embraer flights. A schematic overview of the supply chain is shown below.

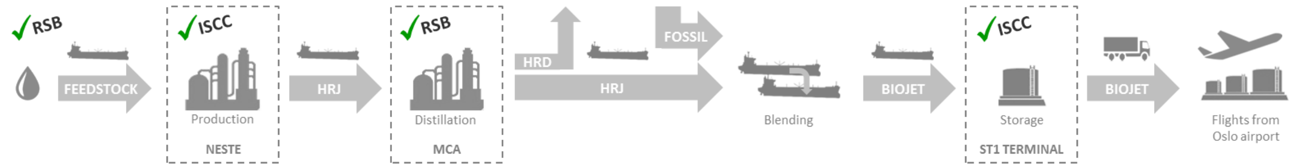


Figure 3. Schematic overview of the SJF supply chain towards Oslo Gardermoen Airport.

Supply of blended SJF to and at OSL

OLT Tank farm at Oslo airport

At OSL, OLT is responsible for the jet fuel storage in their commingled tank farm and the fuel infrastructure (pipelines, hydrant system, etc.). The tank farm consists of 3 tanks of 4.000 CBM each, filled by pipeline from the nearby rail terminal. For security of supply, jet fuel can also be received by trucks via a separate reception tank of 50 CBM. Each 4.000 CBM tank holds jet fuel for approx. 2 days and are therefore alternating operational modes: 1) receiving new jet fuel, 2) closed for certification, or 3) ready for discharge via the hydrant system or refueler trucks. GFS is responsible for actually fueling the aircrafts at OSL.

They operate the dispenser trucks that connect the hydrant system to the aircrafts, and the refueler trucks for fueling aircrafts at gates where no hydrant system pit is available, or when a segregated supply is desired, e.g. the KLM/Embraer flight program.

SJF deliveries to OLT: per truck

In the existing infrastructure, jet fuel is delivered on a regular basis to OLT by rail cars from the port of Oslo to a rail terminal 20 km outside OSL, and from there by pipeline into OLT. It was evaluated whether it would be efficient to use this infrastructure as well for supplying the SJF to OLT. However, based on Air BP's airline agreement to supply SJF ratably throughout the year, the total SJF volume was divided into smaller monthly batches, making the logistics per vessel to the port of Oslo, or per rail to OSL unnecessarily expensive. In addition, for supplying jet fuel to smaller regional airports, Air BP used road tankers already connecting Gävle and Oslo on a weekly basis. It was therefore decided to supply the SJF from the ST1 terminal to OLT on a weekly basis using Air BP's existing road tanker route. Next to the SJF deliveries no other jet fuel deliveries by road tankers occurred.

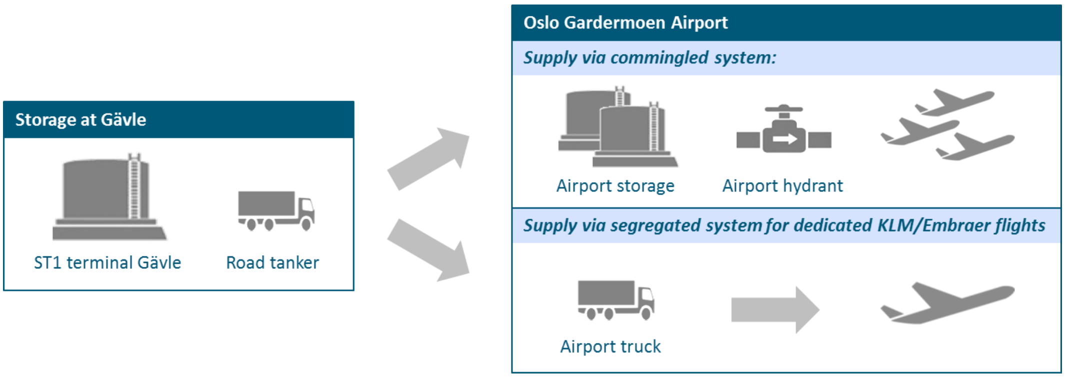


Figure 4. Schematic overview of SJF supply from Gävle to OSL.

Batch volume requirements

Given OLT's limited fuel storage capacity, OLT prevents in their normal operations the full certification of the stored fuel, by not storing more than three different batches at a time and performing a key performance analysis. In order not to deviate from this procedure, the delivered SJF volume either needed to be less than 3% of the storage tank capacity, or be one of the three supplied batches.

As the SJF was to be delivered rateably and a schedule of one truck per week (40 CBM) turned out to work best from operational perspective, the delivered volume was significantly smaller than 3% of the storage tank capacity (120 CBM) and hence didn't form an issue. Also, during the KLM/Embraer flight program, where the delivery frequency was temporarily increased to two deliveries per week, we were still well below the 3% limit.

For future, larger supply chains, meeting the <3% tank capacity will become difficult. The SJF batch to be inserted in the co-mingled airport system would then become a separate batch according to JIG. Once supply is big enough this will not form an issue in terms of preventing recertification, as an SJF batch would just replace a fossil jet A batch. There will probably be an intermediate period in which the SJF supply chain would result in SJF batches supplied to the co-mingled systems, that are bigger than the 3% limit, but not big enough to be one of three batches. Solutions for this intermediate period, would be either to allow for this recertification, concentrate deliveries so batch size is big enough to be one of the three batches or to already commingle the SJF more upstream at locations where less batches are commingled per tank, or where storage capacity is less constraint, e.g. at large tank terminals.

Discharge into commingled jet fuel pool

Following standard procedures, the truck driver was registered at OLT in advance, and subsequently allowed to enter OLT's truck terminal. Discharging jet fuel into the reception tank without supervision of OLT was possible if the time between loading and discharging road tankers was less than 4 hours and the road tanker was sealed directly after loading. All road tankers were sealed after loading, but the large distance between Gävle and Oslo, more than 4 hours, required that OLT performed a Control Check (water test, density measurement and clear & bright test) on the delivered SJF prior to discharging. After each delivery, the volume in the reception tank was pumped through OLT’s general import filter and into one of the large storage tanks, making it part of the commingled jet fuel pool.

Fuel conductivity

Since the SJF is supplied into the jointly operated commingled fuel storage systems, the AFQRJOS specifications applied to the SJF. AFQRJOS requires conductivity to be in between 50 pS/m and 600 pS/m), which is achieved by the addition of Stadis 450, the only allowed Static Dissipater Additive (SDA). Usually, SDA is added at the refinery, or when more practical further downstream at large tank terminals. Due to SDA’s poor solubility, the addition of SDA in small fuel volumes is a cumbersome operation and hence not preferred.

Within the ITAKA supply chain, Stadis 450 was added during production at Neste and re-added during blending at Gävle. The blended SJF was stored at Gävle with a reported conductivity of 160 pS/m (at 18°C). Usually this is sufficient for supplying to airports, however, two factors may significantly influence the conductivity:

- Transport; conductivity dropping more with turbulent transports, e.g. in road tankers.
- Temperature; conductivity dropping with lower temperatures, especially in winter conditions like in Sweden and Norway.

Since the ITAKA ‘non-dedicated’ deliveries still involved truck transport to the airport, there was a risk of conductivity dropping that needed to be taken into account. OLT and AirBP were prepared to re-add Stadis at the airport, but conductivity checks at the airport in the end turned out that this was not to necessary.

4 Technical evaluation non-dedicated system

OLT runs inspections on their infrastructure. Although the volumes of SJF supplied to OSL in percentage of total volume consumed at OSL were small, we did want to know whether OLT would see any deviations in their inspections.

The inspections that OLT does on a frequent basis are:

- Monthly Millipore test of the import and hydrant filters in the system (Millipore test is a standard test in which fuel is passed through a fine filter membrane to determine the cleanliness of the fuel).
- 3 monthly full inspection of the filters in the hydrant system

See in the picture below where those filters are located (in the red marked area, “Pumpestasjon”).

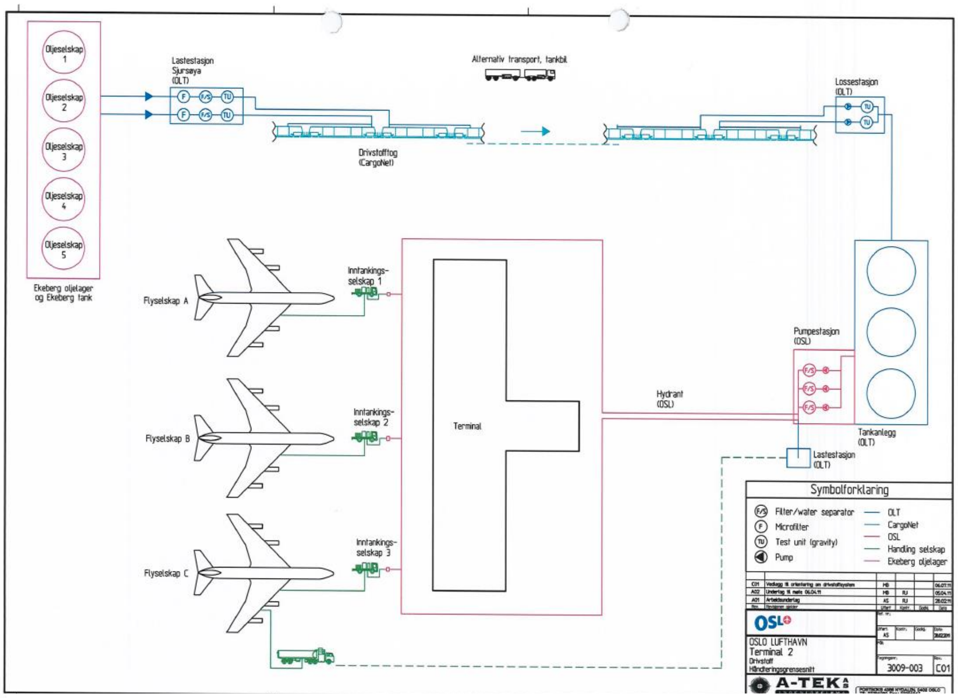
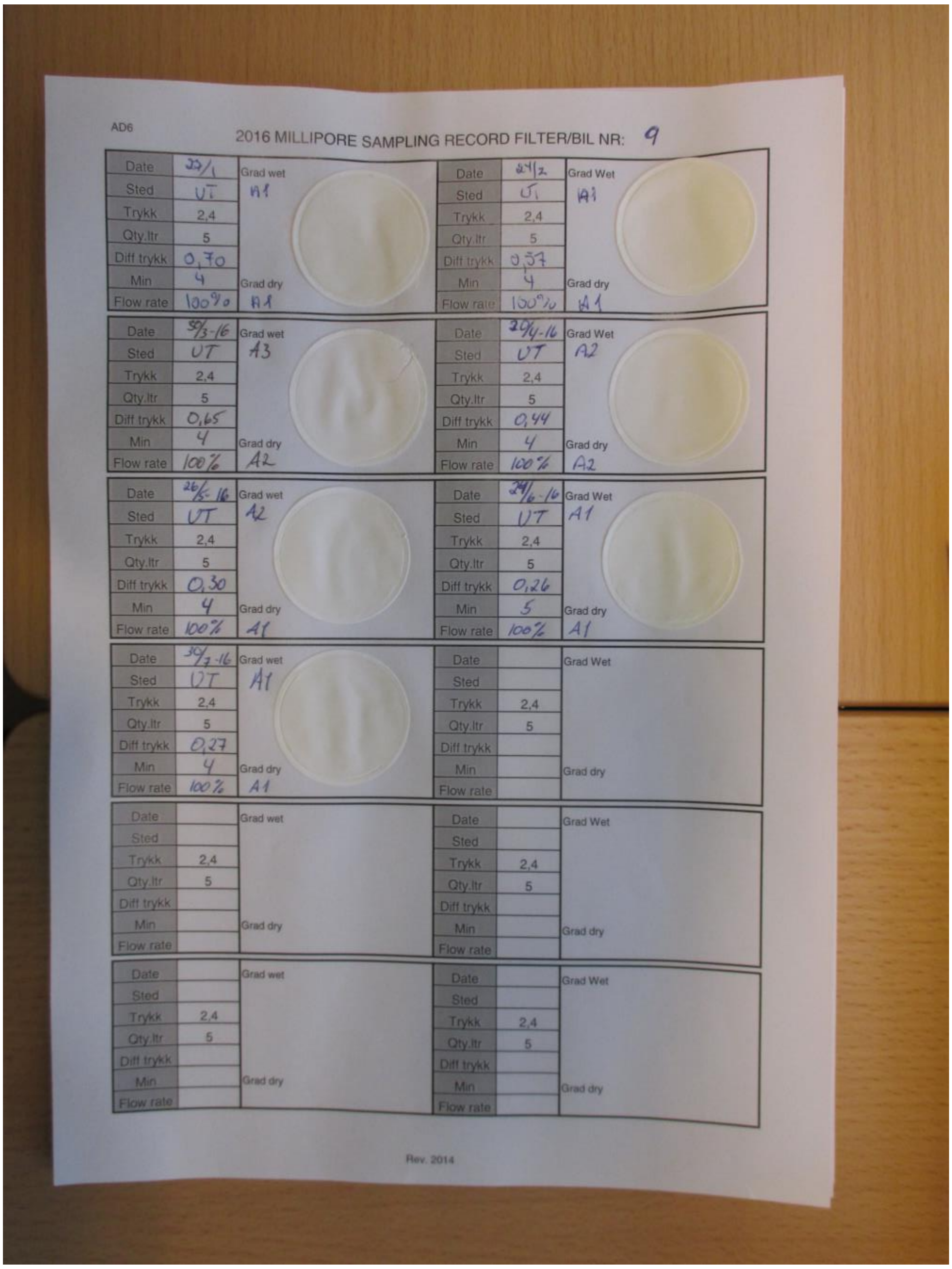


Figure 5 Hydrant system Oslo airport

OLT have performed the above inspections and did not report any deviations. The pictures on the next pages show their colour millipore report of the first 7 months in 2016. Filter 1 is from the hydrant filter and filter 9 is from the import filter.

Figure 6 Milipore test on hydrant filter



AD6

2016 MILLIPORE SAMPLING RECORD FILTER/BIL NR: 9

	1	2	3	4	5	6	7	8	9	10	11	12
Date	22/1	24/2	30/3-16	20/4-16	26/5-16	24/6-16	30/7-16					
Sted	UT	UT	UT	UT	UT	UT	UT					
Trykk	2,4	2,4	2,4	2,4	2,4	2,4	2,4	2,4	2,4	2,4	2,4	2,4
Qty.ltr	5	5	5	5	5	5	5	5	5	5	5	5
Diff trykk	0,70	0,57	0,65	0,44	0,30	0,26	0,27					
Min	4	4	4	4	4	5	4					
Flow rate	100%	100%	100%	100%	100%	100%	100%					
Grad wet	A1	[illegible]	A3	A2	A2	A1	A1					
Grad dry	A1	A1	A2	A2	A1	A1	A1					

Rev. 2014

Figure 7 – Milipore test on import filter

5 Conclusion

On January 22nd 2016, the start of sustainable jet fuel supply at Oslo Gardermoen Airport was announced by the ITAKA consortium and Air BP. The majority of this sustainable jet fuel is supplied directly into Oslo's fuel hydrant system, meaning that it became part of the airport's common storage and distribution system without having to rely on a segregated infrastructure.

With the SJF supply via Oslo's OLT tank farm and hydrant system, the ITAKA project demonstrated as a first time ever that SJF supply through an airport's existing infrastructure system is possible.

During the supply of SJF at OSL airport, no deviations were reported in infrastructure inspections.