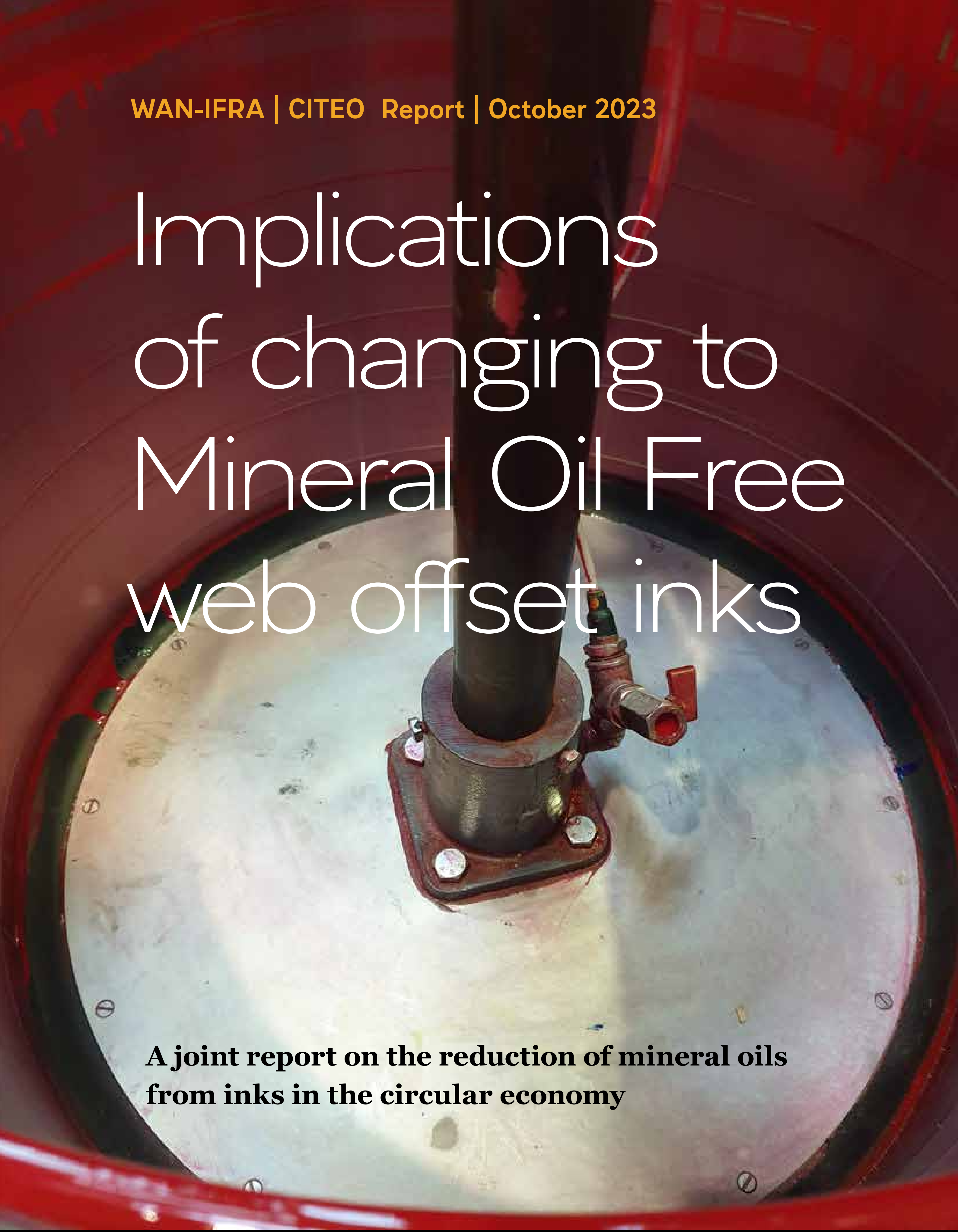


WAN-IFRA | CITEO Report | October 2023

Implications of changing to Mineral Oil Free web offset inks

A joint report on the reduction of mineral oils from inks in the circular economy

World Association of News Publishers

CITEO

IMPRINT

Implications of changing to Mineral Oil Free web offset inks

Joint special report published by WAN-IFRA and CITEO with the participation of AGRAPA and UBA on the reduction of mineral oils from inks in the circular economy

Publication date: October 2023

Managing editor: Nigel Wells

Assistant editor: Prabhu Natrajan

Contributing authors:

Carole Berrard	CITEO Project Manager , Health issues, eco-design and reuse department
Martin Drews	AGRAPA, Managing Director
Benoit Moreau	Ecograf, Managing Director
Prabhu Natrajan	WAN-IFRA Research & Material Testing Centre
Almut Reichart	UBA Environment Agency, Senior scientist responsible for pulp & paper environmental issues
Jean François Robert	Herisphere, Managing Director
Philipp Stolper	Fogra, Head of Department Materials & Environment
Nigel Wells	Ecograf Associate

Participating companies

Newspaper printers:
Frankfurter Societäts-Druckerei (FSD), Volker Hotop
Heilbronner Stimme, Tobias Sobkowiak
Le Midi Libre, Bernard Porteix
Le Progrès, Régis Caron
La Provence, Loic Le Deuff
Voix du Nord, Philippe Ceugniet
Riccobono, Apdenone Hassaïne
ICP Roto, Philippe Van Damme

Heatset printers:
Cache, Louis Cache
FOT, Finola Dunne
IPS, Jean-Philippe De Araujo
La Galiote Prenant, Armand Domingues
Mordacq, Sylvain Roux
Newsprint, Bruno Thoyer
RotoFrance, Jean-Michel Thibaut
SIB, Sylvain Hocq

Ink makers: Brancher, Flint, Huber, KMI/Wifac, Sun Chemical, S&S

Paper suppliers: Hylte Paper (Stora-Enso), UPM, Moritz J. Weig

WAN-IFRA Rotfeder-Ring 11, 60327 Frankfurt am Main, Germany
CEO: Vincent Peyrègne
COO: Thomas Jacob
World Printers Forum Director: Ingi Olafsson
Contact Info: Dean.Roper@WAN-IFRA.org, Prabhu.N@WAN-IFRA.org, Ingi.Olafsson@WAN-IFRA.org

About this report

The sustainability of ink on paper is of concern to the printing industry to ensure that it presents no environmental or circular economy risks. It is for this reason that WAN-IFRA and CITEO have co-published this Special Report on Mineral Oil Free (MOF) inks that answers these concerns for a sustainable circular economy.

This is not a new subject – WAN-IFRA published two Special Reports in 1991 and 1995* largely driven from America. In the late 1980s US news publishers started looking for MO substitutes for news inks; at the same time the American Soybean Association were looking for new markets. This coincided with soy-based news inks becoming the answer to two national issues: the serious health concerns over Mineral Oil Hydrocarbons (MOH), and the 1990 Clean Air Act to reduce volatile organic compounds (VOCs). By 1995, over 90% of US news inks had converted to soya in spite of much higher prices. The drivers in Europe were weaker at the time — news inks were not subject to compulsory identification as dangerous substances; and the US Method 24 to measure VOCs was not used in Europe. This reduced the justification for their higher price. Vegetable oil based Coldset inks were available in Europe from the mid 1990s, but their commercialisation was discontinued around 2010. The environmental and technical parameters have now changed. This comprehensive new report provides a fuller understanding of the economic, environmental and technical issues and their implications.

CITEO, the French mission-driven not-for-profit Extended Producer Responsibility (EPR) organisation dedicated to the recycling of paper and packaging, initiated this report following results of its evaluation projects. CITEO recognises that this is an international issue and consequently invited AGRAPA and UBA to participate in this Special Report: a subject where they began working in 2010.

Their combined evaluation projects were made independently and in parallel. The trials in Germany used two machines to test multiple inks, while those in France used multiple printers to evaluate comparisons of Mineral Oil (MO) and MOF inks sourced from their traditional suppliers. The result is a rich and broad overview. MOF printing inks have been developed over several years and are now fundamentally suitable for use in practice. This report also includes French trials of Waterless and Heatset low MOH (Mineral Oil Hydrocarbons) web offset inks that comply with current restrictions but will not conform with the 2025 French regulations.

Germany and France represent about 35% of Coldset newsprint consumption in Western Europe (EMGE 2022) and, consequently, they have a major influence in the sector. They have each taken different routes to implement MOF inks. France have taken a regulatory route (EC rules permit national laws for health and environmental issues), while in Germany, AGRAPA has initiated a voluntary agreement to progressively switch to MOF newspaper inks by 2028.

The quality and value of this report is the result of the proactive international cross-industry co-operation between the printers and their ink suppliers and the organisations concerned.

This Special Report is, therefore, timely for the European printing industry. It provides them with a clear overview, technical evaluations, and implications to change to MOF inks.

WAN-IFRA **CITEO**

**1991 Special Report 1.5 Vegetable oil based Newsinks and their Printability Properties. 1995 Special Report 1.12 Why are soybean based newsinks so successful in the USA?*

About the publishers

WAN-IFRA World Printers Forum (WPF) promotes the printed newspaper. Its mission is to serve its members in promoting and sustaining the printed newspaper business and technology through collaborative research and developments, global exchanges of experience, creating new standards, implementing environmental guidelines, developing new strategies and fostering innovations. Its objective is to encourage innovation and productivity as well as product development that can be instrumental to publishers seeking to exploit future-oriented news media products. WPF aims to be the central point of the international news media print community, including publishers, printers, materials suppliers and equipment manufacturers for the print production value chain, from prepress to press to product finishing and delivery. The Forum organises international exchanges, research and innovation, standardisation of processes and materials, and print strategy development. WPF is the print community within the World Association of Newspapers and News Publishers (WAN-IFRA) and advises WAN-IFRA in all aspects of the printed newspaper. Newspaper production is defined as the business of production planning, prepress data handling and processing, and press and mailroom operations, including related topics in terms of management and technical implementation. WPF also partners with other organisations working toward the same objectives.

CITEO is a mission-driven, not-for-profit organisation tasked with implementing Extended Producer Responsibility (EPR) and the transition to a circular economy. It was created by companies in the consumer goods and retail sectors to develop solutions for waste reduction, reuse, sorting and recycling. CITEO's mission is to: encourage practices and strategies consistent with the circular economy and eco-design; help develop solutions that combine environmental and economic performance; give consumers the keys to reduce the environmental impact of their consumption; co-develop and promote corporate solutions from local to international levels; and foster staff commitment to its mission. The reduction of mineral oil ink in the circular economy is an example of how CITEO identifies and quantifies a problem and then works with industry to find, test and implement a solution. Since CITEO was founded in 2017 (its predecessor Ecofolio was founded in 2006) companies in the consumer goods and retail sectors have invested more than €13 billion to develop eco-design, introduce and fund selective collection and to create recycling streams with their partners – local authorities, industry sectors and operators. In France, 72% of household packaging and 62% of paper are now recycled thanks to communities adopting the most popular environmental practice of sorting their waste.

Participating organisations

AGRAPA (Arbeitsgemeinschaft Graphische Papiere) the German Graphic Papers Working Group was formed in 1994 as a federation of graphic industry organisations, including paper makers, printers, publishers, book sellers, and recyclers. The organisation provides advice and consulting and its waste paper council includes representatives from national, regional and local governments. An early adopter of producer responsibility prior to government regulations, their initial paper recovery target of 60% is now 83%. Their goal is to improve the circular economy, restricting the introduction of substances that make recycling difficult. Their long-term printing trials (supervised by Fogra in association with ink makers and printers) resulted in the development of MOF ink systems that now offer equal performance to MO, including deinking and recyclability. This project evaluation was finalised with UBA and the voluntary commitment signed with the Minister of Environment on April 17, 2023 with a 50% transition to MOF inks in 2025 and 100% in 2028. The MOF trials demonstrate that large scale use is possible, while the challenge will be the availability of sufficient ink volumes. To address emerging issues, the phased introduction will be supported by the AGRAPA Graphic Papers Working Group comprising P.R.INT., BVDDP, (bvdm), BDZV, BVDA, MVFP, GVPG, bevh and Börsenverein des Deutschen Buchhandels. www.agrapa.de

UBA (German Environment Agency) has the mission to ensure a healthy German environment with clean air and water, free of pollutants to the greatest extent possible. UBA deals with a broad spectrum of issues, including waste avoidance, climate protection, and pesticide approvals. The agency employs biologists, chemists, economists, lawyers and engineers from all ecology related disciplines to examine issues from all aspects and develop viable solutions. Division III of UBA deals with sustainable production and products, and waste management, which includes all aspects of product life cycles, from raw material production to end-of-life disposal that causes environmental pollution. UBA assists the German federal government, EU and international government agencies and NGOs by making recommendations aimed at resolving specific problems with a groundwork for effective legal framework, economic and other instruments to achieve objectives such as the transition to MOF inks. UBA is also the owner of the voluntary Blue Angel graphic arts label (Blauer Engel) that promotes new and environmentally friendly developments that consume less resources, enable high-quality recycling, and reduce emissions and waste.

Project and Technical Management

- **Fogra Research Institute of Media Technology** is a not-for-profit organisation with some 900 members in over 50 countries. The Institute conducts scientific research in the field of printing and media technology that is consistently industry focused to offer direct and rapid benefits. Its international membership comprises small, medium and large companies across the spectrum of the industry, from producers of printed and electronic media to equipment manufacturers. Fogra is involved in the development of forward-looking and globally acknowledged process and quality inspection standards. Its capital consists of a massive and constantly expanding body of knowledge combined with a high degree of technological expertise and a detailed understanding of current developments. In addition, Fogra offers media companies an expert network and supports them in making their adjustments to structural change. In doing so it wants to stimulate the opening of new business areas and to ensure that the industry is configured for the future. Amongst governmental funded research projects, it has carried out research projects for MOF Coldset inks for the Federal Environment Agency, AGRAPA and CITEO.
- **Ecograf** is a French-based consultancy for environmental and productivity issues for the international graphic arts industry. Its environmental activities include: managing European applications and user audits of the French Imprim'Vert environmental procedures certification for printers; organising FSC and PEFC multi-site certification to improve application efficiency; the implementation of the international ClimateCalc graphic arts tools to measure the emissions of factories and print products; and the assessment of CO2 emissions for French magazine and newspapers publishers. It also provides dedicated research and project management, for example the CITEO tests to replace mineral oils in web offset inks. Ecograf is also active in the development of a CSR (Corporate Social Responsibility) programme for the French printing industry. Ecograf has developed an innovative benchmarking manufacturing efficiency programme using Lean & Green Key Performance Indices and also manages and edits international best practice cross-industry reports including "Lean & Green Sustainable Printing Plants", "Optimised Paper Handling & Logistics" and this Special Report for WAN-IFRA.

Other technical service providers

- Centre Technique du Papier (CTP)
- Darmstadt TU Department of Paper Technology and Mechanical Process Engineering (PMV)
- PAGORA
- Saxony Institute for the Printing Industry (SID)
- WAN-IFRA Technical Centre
- INGEDE 11 laboratory analysis: CTP, PMV, PTS, Stora Enso, UPM

Glossary

AGRAPA: Arbeitsgemeinschaft Graphische Papiere — federation of graphic industry organisations.

Alternative inks (to traditional MO): Either Low MOH or MOF.

ANSES: Agence Nationale Sécurité Sanitaire Alimentaire Nationale (French food safety authority).

BfR: German Federal Institute for Risk Assessment.

Blue Angel (Blauer Engel): Voluntary independent product label owned by BMUV

BMUV: German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection.

CITEO: French EPR organisation for paper and packaging.

CMYK: Process ink colours — Cyan, Magenta, Yellow, Black.

Coldset web offset: Printed ink dries primarily through absorption into an uncoated paper.

Dampening solution (fountain or fount): Mixture of chemicals and water to prevent image acceptance on non-image areas of a printing plate.

DIP: Deinked Pulp

EFSA: European Food & Safety Authority

EPR: Extended Producer Responsibility

GCR (Grey Component Removal): Black replaces CMY ink that has a greying effect.

Grey balance: Used to objectively assess the relationship between the CMYK process colours.

Heatset web offset: Oils from the ink and dampening water evaporated by high temperature air.

JRC: Joint Research Centre is a department of European Commission that provides independent, evidence-based knowledge and science supporting EU policies.

IQCC: International Colour Quality Club of WAN-IFRA.

Low MOH : Ink based on purified petroleum solvents. May include some vegetable oils. Conforms with Blue Angel and CITEO criteria 2022.

MOF: Mineral Oil Free — Alternative inks formulated with vegetable oils (conform to French AGEC law in 2025).

MO inks: Traditional inks formulated with Mineral Oil Hydrocarbons.

MOH: Mineral Oil Hydrocarbons — of which two are the focus of concern and control:

MOSH: Mineral Oil Saturated Hydrocarbons.

MOAH: Mineral Oil Aromatic Hydrocarbons.

Offset: Lithographic printing process using a blanket to transfer image from plate to paper.

SID: Solid Ink Density, measures complementary light absorbed by a solid patch in a colour bar.

TIC: Total Ink Coverage. % of combined CMYK dot area by adding the values of each colour in the darkest area of the separation. (Same as TAC/Total Area Coverage).

Trapping: Efficiency of a wet ink film layer being accepted by an underlying wet ink layer.

TVI (Tone Value Increase) or dot gain: Physical enlargement of halftone dots during image creation, printing and paper absorption of ink (mechanical TVI), and light scatter around and under dots (optical TVI). Their combination results in tone value for total apparent TVI during the print process.

UCR (Under Colour Removal): Reduces higher priced CMY ink content in dark, neutral areas of the reproduction and replaces them with lower cost Black ink.

Web offset: Heatset or Coldset printing on a continuous web unwound from a paper roll.

Wet offset (Classic Coldset): Film of dampening water on non-image area of plates to prevent ink adherence.

Waterless offset: Layer of silicone on printing plate to prevent ink adherence.

UBA: German Environment Agency

Table of contents

Introduction

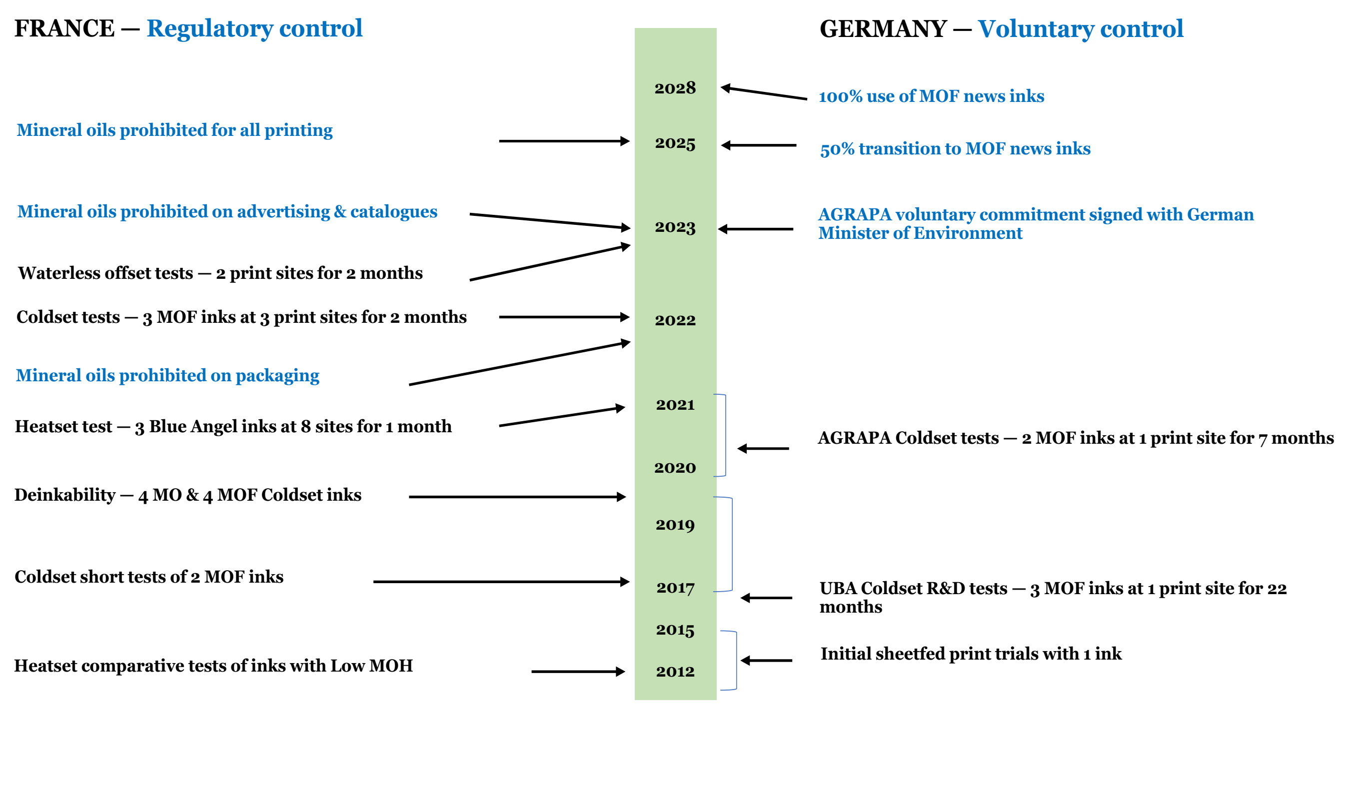
Mineral Oil Free ink types are not new. In the 1990s the USA largely adopted Coldset inks with a high soya content, while vegetable based Coldset inks were available in Europe at that time their commercialisation was subsequently discontinued. The drivers and the technologies have since evolved.

From 2000-2010, the European sheetfed offset process had largely converted to using MOF inks. Attention then began to be focused on mineral oils in web offset inks because of increasing concerns of the contamination of recycled graphic paper with mineral oil components, some of which are harmful to health. Web offset inks are one of the largest sources of contamination and consequently a priority to deal with because they can transfer mineral oil residues through the recycling process into paper-based foodstuff packaging. Issues related to recycled paper include:

- Reducing the utilisation of mineral oils.
- Recycled graphic papers are increasingly being used in packaging.
- Currently it is not feasible to completely remove these substances from recycled paper.
- Management of contaminated waste paper and its separation during collection.

This led France and Germany to look for solutions with all those involved in the value chain. CITEO in France and UBA/AGRAPA in Germany have been working for several years with members of the ink, paper and cardboard packaging sectors to find alternative solutions to inks containing mineral oils. This broad stakeholder approach provided a sound basis for the development of MOF inks. The experience and knowledge of these newspaper inks has been significantly increased during their 10-year development and they are now technically suitable for use in practice.

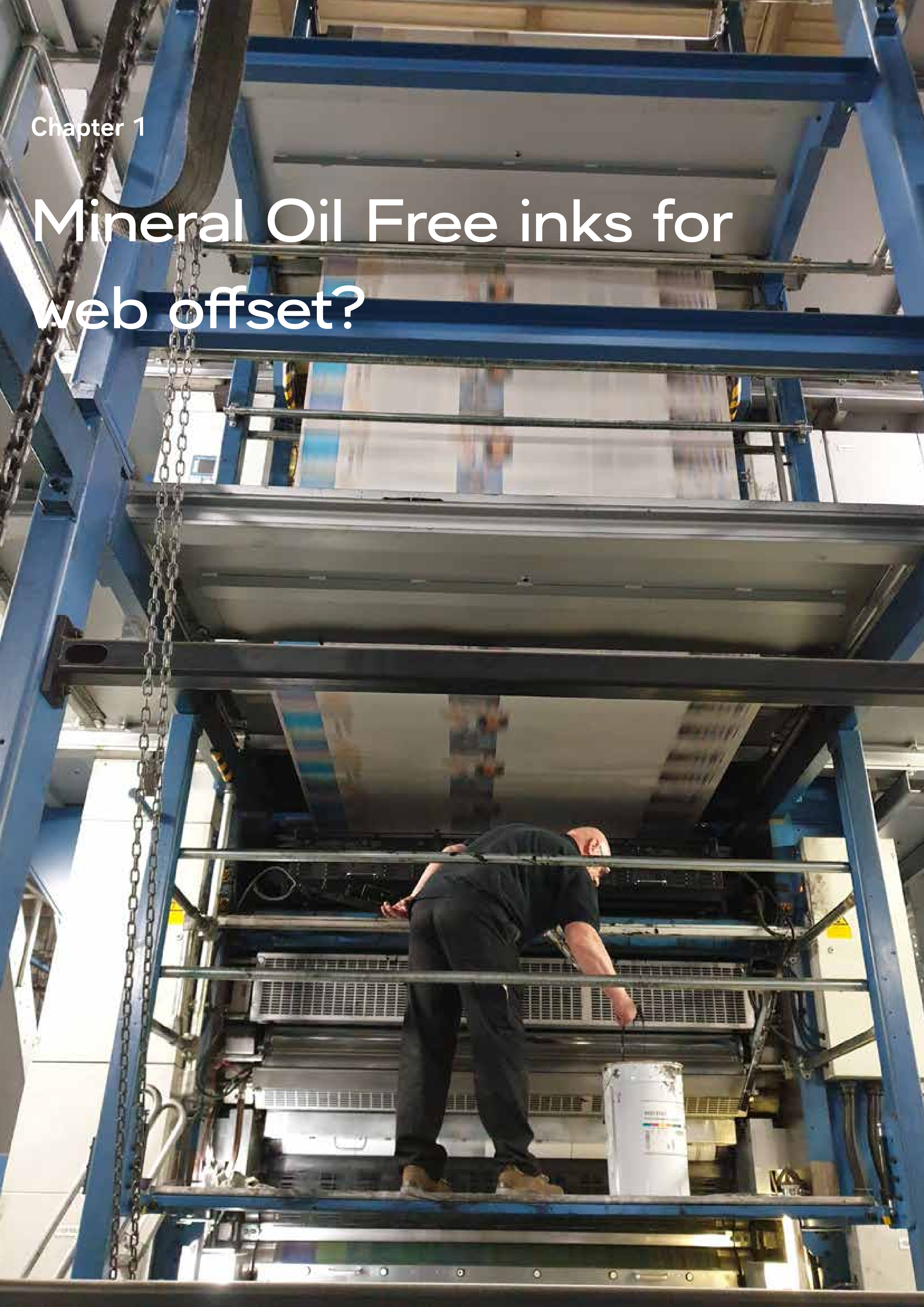
A feature of this report is that it brings together the parallel but independent work made in France and Germany to develop MOF inks. The report also addresses Low MOH inks that are a first alternative ink step.



France and German have taken different approaches to the introduction and evaluation of MOF inks, and their control.

Chapter 1

Mineral Oil Free inks for web offset?



Executive summary

Much ink has flowed to create this report. Over 93 tonnes of alternative inks have been developed, tested, optimised, re-tested and tested again to confirm they are a viable alternative to current mineral oil-based inks. This report covers the independent but parallel activities in France and Germany to reduce mineral oils in web offset inks. They have taken different paths on control to achieve similar objectives. They have made different, but complementary, test programmes which this report brings together to share their findings with the European graphic industry.

Why change to MOF inks?

The drivers for change are the increasing concerns that mineral oils are harmful to human health and that they contaminate the paper recycling chain, thereby undermining the environmental efficiency of the circular economy. Web offset inks are one of the largest sources of mineral oils and consequently a priority to eliminate to avoid the transfer of residues through recycling into paper-based foodstuff packaging.

Reduction and control

These challenges led France and Germany to look for solutions through discussions with all those involved in the value chain. While the objectives of both countries were common they have adopted different strategies — one is by voluntary reduction and the other by regulation:

- **Germany**: The AGRAPA association signed a voluntary commitment with the Minister of Environment in 2023 for a 50% transition to MOF news inks in 2025 and 100% by 2028.
- **France**: Legislation in 2020 banned mineral oils in paper, and packaging in 2022; from 2023 it is prohibited in commercial advertising, and from 2025 on all printed products (newspapers, magazines, books, catalogues). EC rules permit national laws for health and environmental issues.

Parallel ink development & testing

There have been six separate projects in France and Germany to develop and test alternative inks. The initial alpha inks were subject to intensive development tests, and subsequently beta inks were trialled under normal production conditions. An additional project evaluated commercial Heatset because this process is included in French regulations, and it is used directly or indirectly by many newspaper printers, publishers and advertisers.

Printing trials included:

- UBA testing and development of three alpha inks with one German newspaper printer
- CITEO short test with two alpha MOF inks with one French newspaper printer.
- CITEO round robin deinking tests of MOF inks from four ink suppliers.
- CITEO beta tests of four inks with five French newspaper printers (three wet offset MOF and two waterless Low MOH).
- AGRAPA beta production testing of two MOF inks at one German newspaper printer.
- CITEO Heatset evaluations of three Low MOH inks at eight French commercial printers.

Short-term sheetfed trials in 2012 helped identify research tasks and criteria for the development of MOF Coldset inks. The participating ink manufacturers undertook to develop new types of inks for which UBA organised alpha tests on a newspaper press from 2016 to 2020. The conclusion of these trials and the CITEO short trial was to establish three preconditions before further tests: deinkability, ink conformity to specifications, and roller coverings compatibility. CITEO then organised a comprehensive round robin of deinking tests. The conforming inks were then subjected to extensive beta production trials. The two national test approaches were different but complementary.

- In France, five printers made comparative evaluations of their standard MO ink alongside new alternative inks from the same ink maker over a continuous 6-8 week period.
- In Germany, AGRAPA organised significant production testing of two MOF beta inks on the same tower at one print site for three months for each ink.

The conclusion of these tests is that these inks are now technically suitable for use in production.

Low MOH inks

In addition, Waterless and Blue Angel Heatset Low MOH inks that meet the 2021 criteria of French eco-modulation regulations were successfully trialled. However, these formulations will not comply with stricter regulation from January 2025.

CONCLUSIONS

The transition to MOF inks is being driven by France and Germany, representing about 35% of Coldset newsprint consumption in Western Europe (EMGE 2022). They are taking different paths to the same end: legislation and eco-modulation in France and voluntary transition in Germany. Both countries have the same objectives for these new inks:

1. Conformity with MOF definitions.
2. Compatibility with existing press, rollers and consumables.
3. Print quality equivalent to standard MO inks.
4. Newspapers printed with MOF inks should be deinkable.
5. Purchase and operational costs should be viable.

The first four parameters have been fully met; the operational costs are unchanged for Coldset except that ink purchase price is higher. The implication of changing to MOF inks is predominantly neutral to positive but their higher purchase price is an important negative issue — consequently optimising ink consumption becomes a priority.

MOF inks are now fully developed and are fundamentally suitable for use in practice on the press designs tested. The participating printers and ink makers all consider that the new inks tested met their technical expectations. Apart from the economic issue, the printers would be ready to adopt these new formulations immediately. Adoption will be subject to the ink suppliers ensuring capacity to provide adequate availability of these inks. Best practice steps for changeover to these inks have been identified.

Proactive international co-operation

Overall, this transition process has created the scientific and technical basis for reducing mineral oil contamination of the waste paper cycle from printing inks. The key to its success has been the proactive international co-operation between the diverse participants in these evaluations — printers, ink suppliers, technical centres and associations. Their motivation to find an alternative to MO-based inks has been shared across the sector and will benefit the entire industry in Europe.

Possible further actions

1. Newspaper presses have a wide range of configurations and ink system designs. The available MOF inks were qualified on seven presses. However, more print trials will be needed to cover the entire range of press types and manufacturers.
2. Some optimisation of the deinkability of print products will be advisable to maintain the quality of recycled paper. Fibre yield in paper mill operations should be monitored for any impact from increased use of MOF products.
3. Better and broader understanding of ink consumption measurement for printers. Further ink developments will need their consumption to be reliably monitored.
4. Reduction of ink consumption is an important path to reducing cost impact, e.g. TIC reduction, and identify opportunities from alternative screening technologies.
5. Review the use of UCR and GCR in Coldset. Are these techniques still valid for MOF inks when Black is almost the same cost as CMY colours?
6. WAN-IFRA recommends further tests with simulated printability to provide a better understanding of ISO conformance, mileage comparison and the colour shade reproduction potentials of the inks.
7. To accompany printers in this transition, it may be advisable to form an international cross-industry platform with organisations, printers, suppliers and technical bodies to follow the evolution of inks, the various parameters they influence, and to share experiences and best practices. The use of an appropriate environmental/sustainability label for vegetable materials is recommended.
8. The impact of France and Germany changing to newspaper MOF inks in the next 2-3 years will have an impact on other European countries. This suggests that evaluation and discussions may be needed on the international implications of this web offset ink transition.
9. Heatset and Waterless inks will require new formulations to comply with stricter French regulation from January 2025. Two suppliers of Waterless inks have indicated that they will both have MOF inks available in 2024.

Why change to Mineral Oil Free inks for web offset?

The drivers for change are increasing concerns that mineral oils are harmful to human health and that they contaminate the entire paper recycling sector (graphic, packaging, hygiene) within the circular economy, thereby undermining its environmental efficiency. Certain Mineral Oil Hydrocarbons (MOH) are dangerous if they are transferred from paper to food.

What are Mineral Oil Hydrocarbons?

Mineral Oil Hydrocarbons (MOH) are a mixture of thousands of chemical compounds derived from petroleum. They can be used in the formulation and/or manufacture of many products and substances, including certain inks and adhesives used in the printing and converting of graphic papers and packaging. Mineral oils contain two main categories of compounds:

- MOSH (Mineral Oil Saturated Hydrocarbons)
- MOAH (Mineral Oil Aromatic Hydrocarbons)

Health issues of MOH

In 2012, EFSA (European Food & Safety Authority) published a scientific opinion regarding health issues of human exposure to the presence of MOH in food. It concluded that the potential human health impact varies widely depending on the type of MOH component:

- MOAH, in particular 3-7 rings polycyclic aromatic compounds, may act as genotoxic carcinogens,
- MOSH can accumulate in human tissue and may cause adverse effects in the liver.

At the time of publication, a new EFSA opinion was under preparation that tends to confirm the importance of reducing exposure to MOAHs due to the genotoxic nature of some of these compounds. Exposure to MOSH would be considered to be of lower concern, with the need to improve knowledge of the hazards associated with the potential bioaccumulation of certain MOSH.

Widespread human exposure to mineral oils is related to packaging. Several studies in the 1990s, particularly from the Zurich Cantonal Laboratory, showed the presence of mineral oil in different types of foods. These studies underlined that there are several sources of MOH in food, including treatments applied to crops or livestock, or process contamination such as lubricating oils or cleaning products, or by migration from packaging such as jute or sisal sacks used for transport, metal cans or paper-and-board packaging.

In 2009, the Zurich Cantonal Laboratory published a methodology to determine the total concentration of aromatic hydrocarbons from mineral oils in foodstuffs (Biedermann M, Fiselier K, Grob K. Aromatic hydrocarbons of mineral oil origin in foods: Method for determining the total concentration and first results. J Agric Food Chem. 2009). Subsequently, in 2010 and 2011, the laboratory published several studies about the migration mechanism of mineral oils contained in paper-and-board packaging for food.

MOH components can migrate into food products even through intermediate packaging (2009 BfR German Federal Institute for Risk Assessment). Paper and board producers along with food brand owners and retailers worked together with ink manufacturers to define a European voluntary engagement to stop using MO based inks to reduce the human exposition to MOH in foodstuffs from paper-and-board packaging migration.

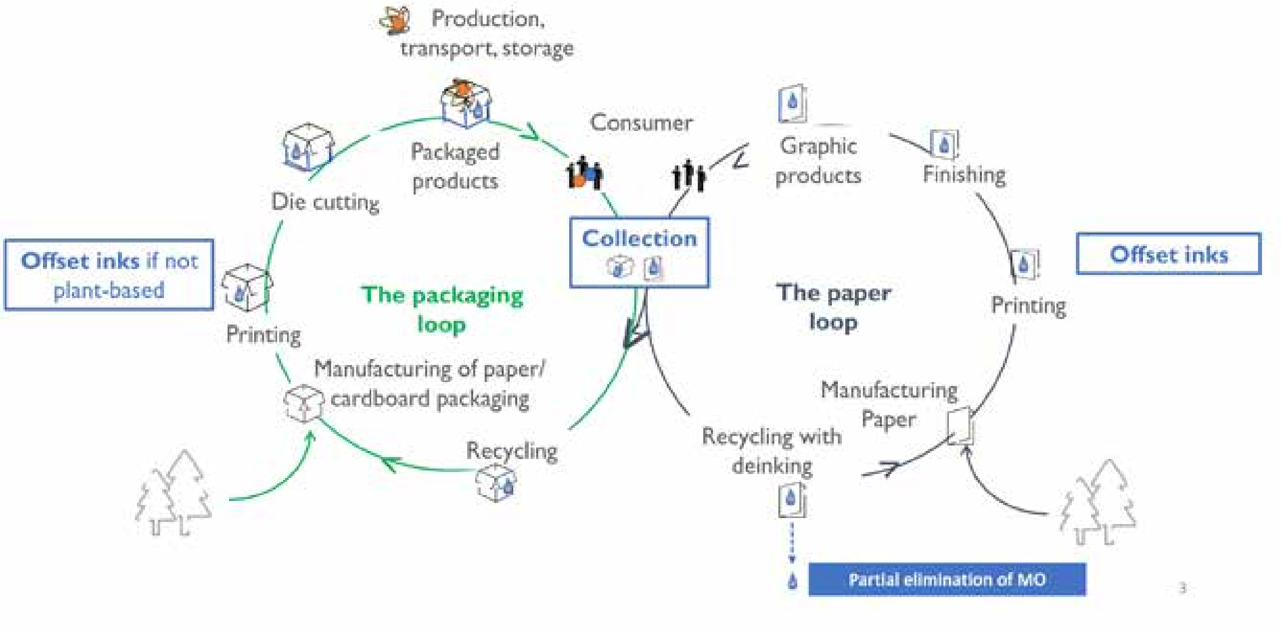
These voluntary engagements have been well followed by most European stakeholders. Because many packaging converters and printers are producing both food and non-food packaging, this switch to MOF inks to print paper-and-board packaging also concerns much non-food packaging.

Remaining traces of MO inks in recycled paper-and-board packaging were detected in 2010 in spite of the strong and broad change in the European paper-and-board packaging sector. Most of these remaining MOH traces are derived from the fraction of graphic paper partially recycled with paper and cardboard packaging that contains web offset ink particles.

The German Ministry of Food and Agriculture (BMEL) and the BfR identified the transfer of mineral oil from recycled paper and cardboard as a major source of food contamination that should be minimised as soon as possible.

In 2017, ANSES (French food safety authority) published recommendations to reduce the exposure of consumers to MOH, especially by reducing the principal exposure sources that are paper-and-board packaging and reducing the use of inks formulated with MOH not only to print packaging but also for graphic papers.

It took until 2019 for the EU Joint Research Centre to published a guidance on sampling, analysis and data reporting for the monitoring of mineral oil hydrocarbons in food and food contact materials (JRC Publications Repository - Guidance on sampling, analysis and data reporting for the monitoring of mineral oil hydrocarbons in food and food contact materials (europa.eu))



Interaction between graphic paper and the paper-and-board packaging circular economy shows the main sources of MOH and cross-contamination. Source: CITEO study 2018.

In 2018, a study by CITEO found that less than 5% of paper-and-board packaging delivered to the French market presented the risk of still being printed with MO inks. However, about 50% of graphic paper products delivered to the French market were printed with offset inks containing MOH (in the context of this study, only web offset inks were considered likely to be formulated with mineral oils).

While both France and Germany wanted to control mineral oils, they adopted different strategies – one is voluntary reduction and the other is by regulation:

Germany: Reducing the foodstuff MOH contamination risks. Since may 2013 (first draft of German Mineral Oil ordinance) Germany is preparing a national regulation to limit foodstuff mineral oil contamination risks from packaging through either MOH prevention in the packaging or by using barrier material between packaging and food. The last version of the draft was published in July 2022 but was not approved by the German Bundesrat.The German Ministry of the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) relies on voluntary measures within the framework of the voluntary commitment of the Arbeitsgemeinschaft Graphische Papiere - AGRAPA (AGRAPA 2020).

France: Reducing risks on circular economy due to MOH. In 2020, France published the law n° 2020-105 (LOI n° 2020-105 du 10 février 2020 relative à la lutte contre le gaspillage et à l'économie circulaire - Légifrance (legifrance.gouv.fr) which notably introduces a ban on mineral oils on paper and packaging. The 2022 decree specifies that the ban concerns mineral oil inks used for packaging and paper printing (Arrêté du 13 avril 2022 précisant les substances contenues dans les huiles minérales dont l'utilisation est interdite sur les emballages et pour les impressions à destination du public - Légifrance (legifrance.gouv.fr)).

The pending EU Packaging & Packaging Waste Regulations (PPWR) and Extended Producer Responsibility (EPR) are addressing the presence of substances of concern in packaging within the context of circular economy and increased recycled content in packaging.

See page 18 for sources and references.

Mineral Oils and the paper-and-board circular economy

The circular economy is the primary environmental approach to adapt the economic and organisational cycle of production, consumption, and waste management. It aims to reduce the usage of natural resources by reusing several times the extracted resources (reuse and/or recycling).

Using waste as raw material often reduces energy consumption needed to produce new product, particularly paper, glass, metals etc. But recovered materials are also circulating with substances that have been added to it voluntarily (additives, inks, adhesives, coatings, etc.), or unintentionally (other product residues, misuse, soiling, etc.). The presence of the substances must be considered in a context of the developing circular economy.

In 2011 and 2012, the UBA pointed out the problem of mineral oil contamination in food and the connection to newspaper printing and called on the respective players to refrain from using production aids (e.g. parafins used as demoulding agents) and printing inks containing mineral oil (UBA 2011; UBA 2012).

In 2018, CITEO launched a large working program in co-operation with the main stakeholders of paper-and-board packaging and graphic paper value chains, in association with the French environment ministry, to identify the best strategy to identify and reduce the risks of mineral oil contamination in graphic paper and paper-and-board packaging (https://www.citeo.com/le-mag/huiles-minerales-notre-plan-dactions-pour-accompagner-les-entreprises & https://www.citeo.com/le-mag/huiles-minerales-enjeux-et-solutions-pour-securiser-les-boucles-de-recyclage/). This transversal approach was very useful to identify and evaluate the interactions between circular economy loops for paper-and-board packaging and for graphic paper.

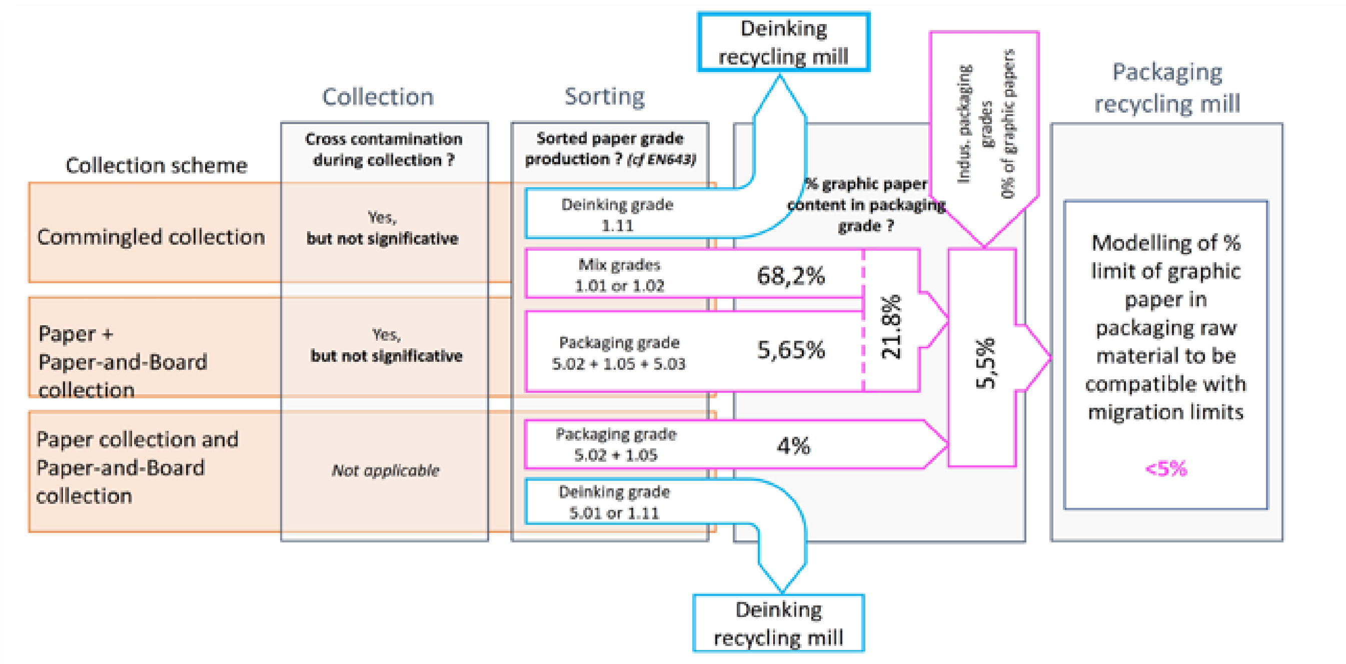
While graphic papers are primarily intended to be recycled to produce new graphic papers, and paper-and-board packaging is essentially recycled into new packaging, there are interaction points when they are collected and sorted:

- Cross-contamination during collection between graphic papers and paperboard packaging has been evaluated as non-critical.
- It was estimated that about 20% of graphic paper waste is recycled into the paper-and-board packaging sector, while 80% is recycled into graphic or hygiene papers. This represents about 5% of recycled materials used to produce recycled paper-and-board packaging — this was evaluated as the limit to respect MOH migration from packaging to food.

Ink removal (deinking) can partially remove MO; it is a standard treatment of recovered graphic paper to obtain recycled paper that is as bright as possible. However, deinking is not used in the production of paper-and-board packaging from recovered fibre because its lower whiteness requirements do not make this necessary. (Using deinking in a mill dedicated to paper for packaging is not economically and environmentally realistic because it is associated with fibre losses < 20% and higher chemical, water and energy consumption.)

In terms of the circular economy, MOH inputs in the graphic sector should be considered as inputs in the paper-and-board packaging sector.

CITEO studied the possibility to avoid graphic paper in recycled raw materials for packaging by changing collection and sorting organisation. This study showed that, whatever the collection organisation, there are three main schemes:



Synthesis on MOH contamination of packaging depending on collection and sorting scheme used. Source: French mineral oil working group /CITEO 2018.

1. **Comingled collection + sorting:** Packaging (including paper-and-board) and graphic paper are collected in the same waste stream and deposited in a sorting centre to produce several material streams - the principal French collection scheme.
2. **Paper + paper-and-board collection + sorting:** Graphic papers and paper-and-board collection are collected in the same waste stream separate from other packaging materials. This fibrous waste stream is sent to a specialised sorting centre -— this is the principal collection scheme in Europe.
   - Both types of sorting centre will produce for graphic paper and paper-and-board packaging:
   - Deinking grade of recovered paper (grade 1.11 of the EN643 standard) that will be recycled and deinked in a paper mill to produce graphic or hygiene papers.
   - Packaging grades (grades 1.05, 5.02, 5.03 of the EN643 standard) that will be recycled in a packaging mill.
   - Mixed grades of graphic paper and paper-and-board packaging (grade 1.01 or 1.02 of the EN643 standard). This mix is a co-product of high-quality deinking and high-quality packaging grades. Mixed grades can only be recycled in a packaging mill.
3. **Graphic paper collection and packaging collection + sorting:** Graphic papers are collected in a dedicated waste stream, while paper-and-board packaging is collected in a waste stream with other packaging materials. Graphic paper waste stream is usually sent directly to a paper mill with a deinking facility or paper mill using Deinked Pulp (DIP) and packaging waste is sent to a sorting centre to produce material streams. This sorting centre produces only packaging grade (1.05, 5.02, 5.03) and will contain residual graphic paper due to household sorting error.

The decrease in European newspaper consumption has reduced graphic paper for recycling and may also increase graphic paper entering the packaging recycling loop. In 2018, Western Europe consumed 4,65 million tonnes of newsprint, this fell to 3,15 million tonnes in 2022. During this period, eight newsprint production lines were either shut or repurposed, removing approximately 1,4 million tonnes of capacity. Source EMGE.

The French stakeholders with CITEO prioritised the reduction of mineral oil ink sources in paper and paper-and-board material loops by focusing on testing new ink formulations for both Heatset and Coldset web offset. CITEO then launched short- and long-term trials of these MOF inks in France.

UBA addressed matters at source through discussions with all German stakeholders in the value chain and initiated short- and long-term printing trials to test develop low mineral oil inks to print newspapers. This was continued with AGRAPA printing trials.

Subsequently, AGRAPA, UBA and CITEO decided to collaborate by sharing and cross-referencing the results of their respective programmes — these evaluations are presented in Section 2 and their implications in Section 3.

Control and regulatory approaches

CITEO's recommendation: Each tonne of graphic paper delivered to the French market makes a financial EPR contribution (via CITEO) to manage its end of life. This contribution is modulated with bonuses and maluses depending on its eco-design performance (recyclability, incorporation of recycled fibres, etc.). To motivate editors and printers to switch to alternative inks, a 10% malus to the financial contribution of graphic paper EPR was implemented in 2021, raised to 20% in 2022. Traceability is required to avoid this malus, editors need to ensure the ink used on products respects the MOSH and MOAH limits (see table) by using a standard certificate from the printer to the editor, and the ink manufacturer to the printer.

French regulation to ban MO inks

To reduce MOH particles in the circular economy, the French environmental law AGEC of February 10, 2020 established a ban on mineral oil inks to print packaging and graphic papers. This applies to all graphic paper products from January 1, 2025 and on January 1, 2023 for printing advertising material and packaging (see following ink definitions). The ban includes all graphic paper products delivered to the French market, irrespective of whether they are printed in France or elsewhere. EC rules permit national laws for health and environmental issues.

The control conditions related to this ban are defined in the Application decree of April 13, 2022 (Arrêté du 13 avril 2022 précisant les substances contenues dans les huiles minérales dont l'utilisation est interdite sur les emballages et pour les impressions à destination du public - Légifrance (legifrance.gouv.fr)) that stipulates compliance to the MOSH and MOAH limits (see table in page 17) can be implemented pre- or post-printing. This means that control may be made with documentation and/or through laboratory analysis on inks or on printed products.

Heatset web offset printers in France are using Low MOH inks based on the reference Blue Angel 2015 (updated in 2021) under the MOH working plan, malus and ban perspectives, improving from less than 23% of printers in 2019 to more than 97% in 2022. However, the reduction in MOSH and MOAH will not be sufficient to comply with the French ban requirements applicable in 2025. The same applies to Low MOH Waterless inks.

Voluntary control in Germany

AGRAPA, the federation of graphic industry organisations, signed a voluntary commitment with the Minister of Environment on April 17, 2023 for a 50% transition to Coldset MOF inks in 2025 and 100% in 2028. This is an update and extension of the declaration of voluntary commitment of the Graphic Papers Working Group and will lead to an improvement in the circular economy of graphic papers as companies voluntarily commit themselves to a higher use of recovered paper in the production of graphic papers, together with a gradual phase-out of the use of newsprint inks with mineral oil by 2028.

The Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) is the owner of the voluntary Blue Angel label (Blauer Engel) that promotes new and environmentally friendly developments that consume less resources, enable high-quality recycling, and reduce emissions and waste. The independent Environmental Label Jury is the decision-making body for the Blue Angel that develops the basic technical criteria for award of the Blue Angel. As one of the world's first environmental labels, it has stood for independence and credibility for over 35 years. The new award criteria for Blue Angel UZ195 requires the use of inks reduced in mineral oil content with the aim of reducing on environmental and economic grounds mineral oil components in the use of the recovered paper in contact with foodstuffs. https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%20195-202101-en%20Criteria-V2.pdf

Definition of Mineral Oil Free (MOF) inks

The German and French decisions to pursue reduction at source meant new ink formulations were expected from manufacturers. This required the definition of their technical specification in terms of operational performances and the limits of each type of MO component.

Both Germany and France share the same expectations of MOF operational specifications:

1. New inks should be compatible with existing newspaper presses and papers.
2. Print quality should be equivalent to the quality from current MO inks.
3. Printed products should be deinkable (minimum Deinking ERPC score of 70, based on INGEDE 11 method).
4. Costs (purchase and operational) should be acceptable for the newspaper market.

In terms of ink composition, several specifications can be considered as MOF inks:

AGRAPA: German federation of graphic industry organisations.

Blue Angel: German eco-label applicable to paper products versions 2013 and 2021.

CITEO: French EPR malus has been applied since 2020 on paper-and-board packaging printed with inks formulated with MOH containing more than 1% of MOAH and MOSH; and applicable from 2021 for graphic papers printed with inks formulated with more than 1% of MOAH and more than 1,5% of MOSH C20-C30.

French regulatory ban (AGEC law article 112). January 1, 2023: Inks with more than 1% of MOAH 1-7 aromatic rings are forbidden to print packaging and unsolicited printed advertising papers. From January 1, 2025: MO inks with more than 0,1% of MOSH C16-C20 and more of 0,1% of MOAH 1-7 aromatic rings or more than 1ppm of MOAH 3-7 aromatic rings are forbidden to print packaging and all graphic paper products, including newspapers. Ban applies to inks only, concerns all packaging materials and papers, in all sectors (not only post-consumer EPR). Possible controls before printing or on finished products. One year delay to comply after each entry into force.

In Spain, a Royal Decree adopted on December 27, 2022 implemented the same financial EPR malus as France for paper-and-board packaging printed with inks containing more than 1%.

Specifications considered as Low MOH and MOF inks

	UBA/AGRAPA research projects	DE UZ 195 (Blue Angel) 2021	CITEO Recom-menda-tion	French regulatory ban
Aliphatic hydrocarbons from mineral oil	Only substances of chain length C10 to C20 may be used as constituent components in the printing inks. In addition, the following high molecular weight compounds without solubility properties may be used if they have a carbon number of C > 35 and the proportion of C20 to C35 is max. 5 %: microcrystalline waxes, vaseline, polyolefin, kerosene, or Fischer-Tropsch waxes	Only substances of chain length C10 to C20 may be used as constituent components in the printing inks. In addition, the following high-molecular weight compounds without solvent properties may be used if they have a carbon number of C > 35 and the proportion of C20 to C35 is max. 5 %: microcrystalline waxes, vaseline, polyolefin waxes, paraffin waxes or Fischer-Tropsch waxes	Less than 1,5% in ink mass of MOSH C20 to C30.	Less than 0,1% in ink mass of MOSH C16 to C35.
Aromatic hydrocarbons from mineral oil	Less than 0,1 % by weight	Less than 0.1 % by weight exemption: in Heatset web offset printing, it is permissible for up to 1% by mass of aromatic hydrocarbons from mineral oil to be used as solvents because the oils are largely destroyed in the dryer	Less than 1% in ink mass of MOAH.	Less than 0,1% in ink mass of MOAH with 1 to 7 carbon cycles or Less than 1 ppm of MOAH with 3 to 7 carbon cycles
Polycyclic aromatic hydrocarbons **(PAH)**	PAHs regulated by EU Regulation No. 1272/2013 shall be subject to the limit value specified therein	Not more than 0,2 mg/kg of each of the following PAHs: Benzo[a]pyrene, Benzo[e] pyrene, Benzo[a]anthracene, Benzo[b]fluoranthene, Benzo[j] fluoranthene, Benzo[k] fluoranthene, Chrysen, Dibenzo[a,h]anthracene, Benzo[g,h,i]perylene, Indeno[1,2,3-cd]pyrene. the sum of all the abovenamed PAHs in the printing ink should be below 1 mg/kg		

Inks tested for this report

All of the wet offset Coldset inks are 100% MOF vegetable based. The newspaper beta tests in France and Germany used the same inks from two of the manufacturers. Waterless and Heatset are Low MOH inks comply with current restrictions but will not conform with the French regulations in 2025.

Literature & sources

AGRAPA - Arbeitsgemeinschaft graphische Papiere (2020): AGRAPA Jahresberichte und Zusatzberichte. https://www.agrapa.de/jahresberichte (accessed 27/08/2021).

AGRAPA - Arbeitsgemeinschaft graphische Papiere (2001): Fortschreibung der Selbstverpflichtung vom 26. September 1994 für eine Rücknahme und Verwertung gebrauchter graphischer Papiere, Erklärung an das Bundesumweltministerium 2001 (accessed 01/09/2021).

BfR - Bundesinstitut für Risikobewertung (2009): Transfers of mineral oil from packaging materials to food. Opinion No. 008/2010 of 09/12/2009. https://www.bfr.bund.de/cm/343/uebergaenge_von_mineraloel_aus_verpackungsmaterialien_auf_lebensmittel.pdf (accessed 01/09/2021).

BfR - Federal Institute for Risk Assessment (2020): Fragen und Antworten zu Mineralölbestandteilen in Lebensmitteln. https://www.bfr.bund.de/de/fragen_und_antworten_zu_mineraloelbestandteilen_in_lebensmitteln-132213.html (accessed 27/08/2021).

Blue Angel 2021: https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%20195-202101-en%20Criteria-V2.pdf

Blue Angel 2021: Basic award criteria for printed matter DE UZ 195: https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%20195-202101-en%20Criteria-V2.pdf (accessed 25/04/2023)

BMEL - Federal Ministry of Food and Agriculture (2020): Entwurf der Zweiundzwanzigsten Verordnung zur Änderung der Bedarfsgegenständeverordnung. https://www.bmel.de/SharedDocs/Downloads/DE/_Verbraucherschutz/Produktsicherheit/MineraloelVO_Entwurf.html (accessed 27/08/2021).

BMEL - Bundesministerium für Ernährung und Landwirtschaft (2017): Entwurf der Einundzwanzigsten Verordnung zur Änderung der Bedarfsgegenständeverordnung - Notifizierte Fassung. https://www.bmel.de/SharedDocs/Downloads/DE/_Verbraucherschutz/Produktsicherheit/DruckfarbenVO-DE.html (accessed 27/08/2021).

BMUV/AGRAPA 2023: https://www.agrapa.de/aktuelles?tx_news_pi1%5Baction%5D=detail&tx_news_pi1%5Bcontroller%5D=News&tx_news_pi1%5Bnews%5D=5297&cHash=c173ea81f6791a6cde78ad6942923e83

Castle L, Kelly M, Gilbert J. Migration of mineral hydrocarbons into foods. 3. Cheese coatings and temporary casings for skinless sausages. Food Addit Contam. 1993 Mar-Apr;10(2):175-84.

Castle L, Kelly M, Gilbert J. Migration of mineral hydrocarbons into foods. 2. Polystyrene, ABS, and waxed paperboard containers for dairy products. Food Addit Contam. 1993 Mar-Apr;10(2):167-74.

Fogra - Forschungsinstitut für Medientechnologien e.V. (2021): Wie kommt das Mineralöl in die Schokolade? https://fogra.org/stories/wie-kommt-mineraloel-in-die-schokolade (accessed 27/08/2021).

French ban of mineral oil inks : Loi n° 2020-105 du 10 février 2020 relative à la lutte contre le gaspillage et à l'économie circulaire (1) - Légifrance (legifrance.gouv.fr); Arrêté du 13 avril 2022 précisant les substances contenues dans les huiles minérales dont l'utilisation est interdite sur les emballages et pour les impressions à destination du public - Légifrance (legifrance.gouv.fr)

Financial EPR Malus on graphic papers France (CITEO) (https://bo.citeo.com/sites/default/files/2021-09/20210929_EVOLUTION_CRITERES.pdf)

Financial EPR Malus SPAIN : BOE-A-2022-22690 Real Decreto 1055/2022, de 27/12 de envases y residuos de envases.

Grob K, Biedermann M, Artho A, Egli J. Food contamination by hydrocarbons from packaging materials determined by coupled LC-GC. Z Lebensm Unters Forsch. 1991 Sep;193(3):213-9.

Grob K, Anna Artho, Maurus Biedermann, Adrian Caramaschi, Heinz Mikle, Batching Oils on Sisal Bags Used for Packaging Foods: Analysis by Coupled LC/GC, Journal of AOAC INTERNATIONAL, Volume 75, Issue 2, 01/03/1992, Pages 283–287

Grob K, Artho A, Biedermann M, Mikle H. Verunreinigung von Haselnüssen und Schokolade durch Mineralöl aus Jute- und Sisalsäcken [Contamination of hazel nuts and chocolate by mineral oil from jute and sisal bags]. Z Lebensm Unters Forsch. 1993 Oct;197:370-4.

International Sustainability and Carbon Certification (https://www.iscc-system.org)

INGEDE - International Association of deinking Industry (2018): INGEDE Method 11 Assessment of print product recyclability - Deinkability test. http://pub.ingede.com/methoden/ (accessed 31/08/2021).

Jickells SM, Nichol J, Castle L. Migration of mineral hydrocarbons into foods. 6. Press lubricants used in food and beverage cans. Food Addit Contam. 1994 Sep-Oct;11(5):595-604.

Lorenzini R, Fiselier K, Biedermann M, Barbanera M, Braschо I, Grob K. Saturated and aromatic mineral oil hydrocarbons from paperboard food packaging: estimation of long-term migration from contents in the paperboard and data boxes from the market. Food Additives and Contaminants vol.72 n°12, 12/2010. P1765-1774.

Moret, S., Grob, K. & Conte, L. Mineral oil polyaromatic hydrocarbons in foods, e.g. from jute bags, by on-line LC-solvent evaporation (SE)-LC-GC-FID. Z Lebensm Unters Forsch 204, 241–246 (1997)

Murray R, Cohen P, Hardegree MC. Mineral oil adjuvants: biological and chemical studies. Ann Allergy. 30/031972 (3):146-51.

Pro Terra Foundation (https://www.proterrafoundation.org)

Robert, JF (CITEO) (2020): Mineral oils French situation. Presentation at the final expert meeting of the UFOPLAN project, FKZ: 3715313190. Virtual event on 29/10/2020.

Roundtable on Sustainable Biomass (https://rsb.org), Sustainable Palmoil (https://rspo.org), Sustainable Soy Oil (https://responsiblesoy.org)

UBA - German Environment Agency (2021): Further development and use of mineral oil-free newspaper inks in newspaper printing. Final report on the research project. Departmental research plan of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), FKZ: 3715 31 319. UBA-Texte 99. https://www.umweltbundesamt.de/publikationen/weiterentwicklung-einsatz-mineraloelfreier (accessed 27/08/2021).

UBA – German Environment Agency (2012): Federal Environment Agency press release of 29.11.2012: Mineral oil residues in Advent calendars are avoidable https://www.umweltbundesamt.de/presse/pressemitteilungen/mineraloelrueckstaende-in-adventskalendern-sind (accessed 27/08/2021).

UBA - German Environment Agency (2011): Press release of the Federal Environment Agency dated 23/11/2021: Think about recycling already when printing on paper! https://www.umweltbundesamt.de/presse/pressemitteilungen/bereits-beim-bedrucken-von-papier-ans-recycling (accessed 27/08/2021).

UBA 2021: https://www.umweltbundesamt.de/publikationen/weiterentwicklung-einsatz-mineraloelfreier

UMID 2021: Entlastung des Altpapierkreislaufes durch mineralölfreien Zeitungsdruck – neue Forschungsergebnisse (Development of mineral oil free coldest inks to protect the recovered paper cycle – latest research results): Reichart, Almut; Stolper Philipp, UMID – UMWELT + MENSCH INFORMATIONSDIENST, No. 2/2021, 11/2021

Vollmer A, Biedermann M, Grundböck F, Ingenhoff J-E, Biedermann-Brem S, Altkofer W, Grob K. Migration of mineral oil from printed paperboard into dry foods: survey of German market. European Food Research and technology vol. 232 n°1, p175-182, 10/2011

Credits:
Chapter head photos were taken at La Provence in Marseilles by Benoit Moreau during the first ink trials in France.

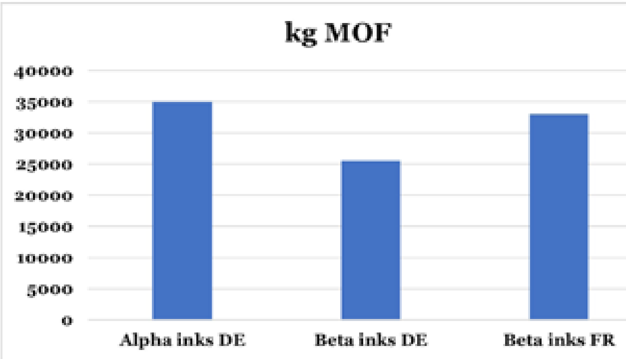
Chapter 2

Ink development & testing

Production evaluations & organisation

There have been six separate projects in the development and testing of alternative inks. One for deinkability; four are Coldset newspaper production and one test on a hybrid Coldset-Heatset press. Heatset was also undertaken because this web offset process is included in French regulations, it is used directly or indirectly by many newspaper printers and publishers to produce magazines and advertising materials, and it shares the same waste recovery stream as newspapers.

MOF tests are grouped as alpha trials when inks were under intensive development, and beta trials with inks that are capable of normal production.



A total of 93 500 kg of ink was printed in the alpha and beta test series.

Principal printing trials were:

- UBA testing and development of three alpha MOF inks with one German newspaper printer
- CITEO short test with two alpha MOF inks with one French newspaper printer.
- CITEO round robin deinking tests of MOF inks from four ink suppliers.
- CITEO beta tests of four inks with five French newspaper printers (three Coldset wet offset MOF and two Waterless Low MOH).
- AGRAPA beta production testing of two MOF inks at one German newspaper printer.
- CITEO Heatset evaluations of three Low MOH inks at eight French commercial printers.

Initial steps — 2012

When this research began, MOF inks were known to be, in principle, suitable for newspaper printing. Short-term trials by Fogra identified technical limitations to be resolved in the next research step to:

- Increase the experience in the production and use of MOF newspaper inks
- Develop ink systems for long-term printing trials on a production press
- Overcome the existing technical limitations (ink setting speed, problems with ink and fountain solution, colour rendering)
- Prove deinkability of printed products using these new inks
- Confirm the absence of mineral oils using standardised measurement methods.

Drawing on the Ecolabel UZ 195 (2015 and 2021), the UBA defined development criteria for the inks that do not contain any critical mineral oil components as constitutional contents.

Printer	Press	Configuration	Weeks	Year
Frankfurter Societäts-Druckerei	KBA Commander	Sattelite	>35	2015-22
Heilbronner Stimme	KBA Commander	Blanket-to-blanket	23	2020-22
La Provence	KBA Commander	Sattelite	0.2	2019
Le Midi Libre	Wifag OF 370 GTD	Blanket-to-blanket	8	2022
Le Progrès	Goss Mainstream 80	Blanket-to-blanket	8	2022
Voix du Nord	Wifag OF 371	Blanket-to-blanket	8	2022
Riccobonno	KBA Cortina waterless	Blanket-to-blanket	8	2023
ICP	KBA Cortina waterless heatset	Blanket-to-blanket	7	2023

The printers who participated in the newspaper printing trials with a variety of press types and ink unit configurations with ink from five manufacturers.

Requirements:

1. The aliphatic hydrocarbons should only range from C10 to C20. High molecular weight compounds that are not solvents may be used if they contain more than 35 carbon atoms and the fraction from C20 to C35 does not exceed 5%: microcrystalline waxes, vaseline, polyolefin- paraffin- or Fischer-Tropsch-waxes.
2. Less than 0,1% by weight of MOAH as constitutional components in inks. The maximum value for polycyclic aromatic hydrocarbons in EU Regulation No. 1272/2013 shall apply.
3. The use of raw materials originating from rainforest deforestation, coconut and palm oil is not permitted.

The participating ink manufacturers undertook to develop new types of newspaper inks. This required intensive monitoring through laboratory measurements to avoid any damage to the press during the subsequent trials in a printing plant.

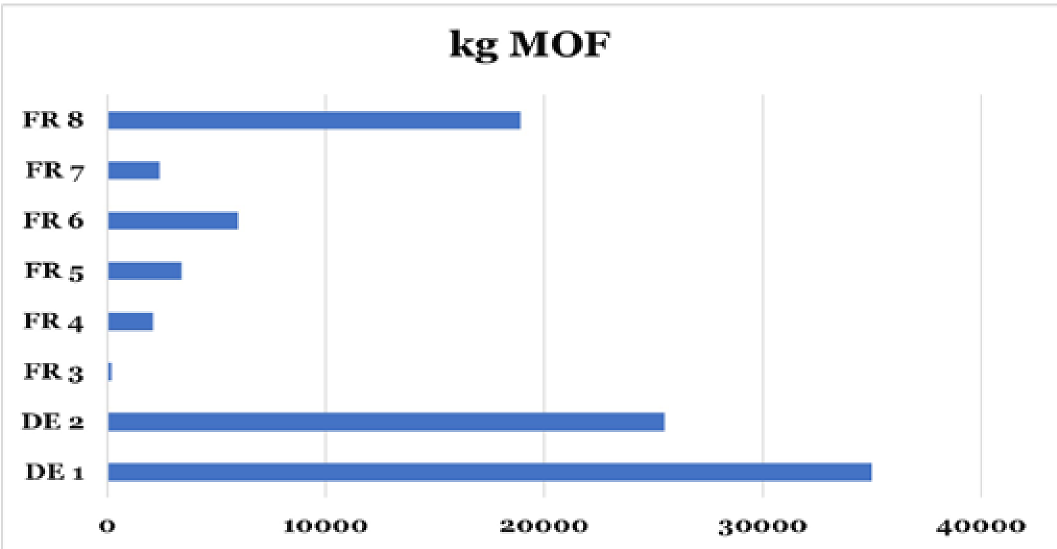
Short-term sheetfed print trials — 2015

Print trials on newspaper presses make considerable demands on press time and the volume of ink and paper consumed. Therefore, the initial trials were made on a Heidelberg sheetfed offset press at Fogra to ensure that it was possible to print with these new types of inks. This allowed comparative investigations of conventional newspaper MO inks with the new MOF variants. The inks were optimised over several trials for Tone Value Increases (TVI), ink/water balance and drying behaviour, and physical properties like flow behaviour, etc. This established problem-free runability and provided printed samples to evaluate the deinking, which was found to be good.

Short-term print trials on newspaper presses - 2016

A more precise assessment of printing behaviour required several one-day trials for each ink on the newspaper press of Frankfurter Societäts-Druckerei (FSD). Three ink makers each supplied 50 kg of ink per colour and the ink ducts were hand filled. Between 30,000 to 60,000 copies of the test forme were printed — the minimum needed to assess ink soiling behaviour. Two different test formes were used for quality control and to determine ink consumption. These trials focused on: ink/water balance, ink consumption, evaluation of soiling and postpress behaviour.

Short trials were also made at La Provence in France in 2019, with 50 kg of ink per colour from two manufacturers that were hand filled into the ducts of the same tower. Test formes from Centre Technique du Papier were printed on the same paper with standard MO inks and MOF inks from Schuite & Schuite and Sun Chemical. These trials enabled print products to be analysed for print quality and deinking by CTP. Print quality and runability were largely comparable to the reference ink. There were problems with two ink colours that were different to each manufacturer, deinking was not satisfactory and MOSH and MOAH concentrations were too high. The inks need improvements to these points. However, they were compatible with the roller elastomers.



Inks tested by the eight printers. About 35000 kg of alpha inks were tested by Printer 1. The beta series tested 25 500 kg in Germany and 33 000 kg in France. The duration of tests were 6-8 weeks in France with daily production of a single alternative ink series that ranged from 4-24 hours. In Germany a single site tested two different inks.

Long-term alpha print trials on a newspaper press — 2016-2000

Long-term print trials were then carried out at FSD with each ink set. A dedicated tower was supplied with process CMY inks pumped from slip tanks (500 to 1000 kg) to the ink ducts. One of the two underground ink tanks was emptied and filled with 3000 kg of MOF Black that was pumped to the ducts. It was not possible to fully clean this tank, which left residues of MO inks during the MOF print trials.

Because ink ageing effects and other phenomena may only show themselves after some weeks, a three-month trial term was determined with the ink manufacturers to adequately test the printing behaviour of both fresh and older ink. (The time between an ink's production and its use can vary from a few weeks to nine months depending on ink maker's production organisation and the printer's stock holding strategy.)

During the project, almost all the initial printing problems with MOF newspaper inks were overcome — scumming, slow absorption, colour rendering.

Preconditions:

The conclusion of the UBA trials at FSD and the CITEO short trial at La Provence was that some essential preconditions had to be met before further print testing of the next development of MOF inks: deinking, ink conformity and roller covering tests.

As a consequence, CITEO organised a round robin test with four ink makers, each supplying MO and MOF inks for a comparative analysis — see page 24.

Full production beta trials — 2022-2023

The development of inks that conformed to these preconditions allowed extensive beta production trials to be made. The two national approaches are different but complementary.

- In France, five printers made comparative evaluations of their standard MO ink alongside a new alternative ink from the same ink maker, printed on adjoining print towers on the same product and paper. These beta trials used a continuous 6-8 week test period that was agreed with all participants. Four beta inks were evaluated.
- In Germany, AGRAPA organised significant production testing of two beta inks on the same tower at one print site.

Their combined results provide a rich and complementary overview with in-depth testing in Germany and evaluation of ink tandems at five French sites with different press configurations.

The inks are now technically suitable for use in practice. Overall, this process has created the scientific and technical basis for reducing the mineral oil contamination of the waste paper cycle from printing inks in the medium term.

Heatset ink evaluations at eight French printers — 2021

CITEO organised these Heatset printing tests with Low MOH inks to meet the criteria of the 2021 French eco-modulation regulations. Alternative inks with reduced mineral oils that respect these limits were already widely used in Germany (conforming to the Blue Angel label 2015 and 2021) but their use was more limited in France. As a result of these trials, the use of these inks went from less than 20% of printers to 95%.

Requirements for Production

The conclusion of the UBA trials at FSD and the CITEO short trial at La Provence determined the following three essential preconditions that MOF inks had to meet before further print testing.

MOF ink conformity

UBA had evaluated the extent to which mineral oils were absent from the inks by determining the mineral oil content with the currently used BfR method: an extract from the printed product, or ink is initially separated into two fractions: MOSH and MOAH; the analytes are quantified in a second stage (reference DIN EN 16995:2017-08 "Foodstuffs – plant oils and plant oil-based foodstuffs – determination of MOSH and MOA with online HPLC-GC-FID; German edition EN 16995:2017"). The use of raw materials from coconut or palm oil is not permitted for Blue Angel inks.

The samples evaluated from the FSD print trials found no significant differences in the measured MOSH and MOAH contents between the inks containing MO and those with MOF. The ink manufacturers stated that no mineral oils were present as constitutional components of the inks.

The processes and conditions that were potential sources of contamination were identified as:

- Ink manufacturing systems used to produce conventional MO and MOF inks on the same line in alternating batches.
- Transport containers and tankers.
- Piping from the separate tanks to the press unit at the printing plant.
- Residues of conventional ink in underground tanks.

Roller cover tests

It is essential to ensure that new inks do not cause any significant alterations to the elastomers in the coverings of the ink and fountain rollers because inks can cause either swelling or shrinking of elastomers. These effects are largely irreversible and lead to a permanent change in the properties of the rubber's hardness and thickness. In the worst case, rollers become unusable and have to be changed causing avoidable costs and printing failures.

The long-established industry evaluation method is based on DIN 53521 (testing of rubber and elastomers: determining their behaviour when exposed to liquids, vapours and gases) and DIN 53505 (changes in Shore hardness A) or their following standards DIN ISO 1817 and DIN ISO 7619 for testing the effect of ink on the dimensions, volume and Shore hardness A of elastomers. This involves a model set of various elastomer test bodies (36.6 mm diameter discs with a minimum thickness of 6 mm) being placed in the ink for one week at 50°C and the effect characterised by the difference in the values measured before and after exposure.

When this evaluation was first used it was not possible to approve any of the new MOF inks for print trials because the elastomers for damping rollers exhibited excessive shrinkage.

The swelling evaluation of the various elastomers was made for each individual press tested between the ink supplier and the roller covering manufacturer concerned. The compatibility of the MOF inks with the elastomers was within the tolerances, making it possible to conduct long-term print trials. It is also useful to bear in mind that conventional inks generally cause some changes in diameter when tested.

Deinking

The recycling and deinking potential of products printed with MOF inks is a priority for the circular economy. The INGEDE test method guidelines are:

- Determination of the luminosity Y and the colour value a* on the filter pads of the deinked pulp in accordance with INGEDE Method 2 and DIN 6174.
- Ink particles having an equivalent ink diameter >50 µm not eliminated from the deinked pulp by flotation are quantified by measuring the dirt particle area A on the laboratory sheets.
- Determination of the ink elimination in accordance with INGEDE Methods 1 and 2 on the filter pads for the non-deinked and the deinked pulp.
- The darkening of the filtrate that results from the retention of the deinked pulp by the filter pads is determined by means of Sartorius cellulose nitrate filters (pore size: 0,45 µm). The drop Delta Y in the luminosity Y of the cellulose filter provides a measure of the filtrate darkening.

The so-called "Deinkability Score" is the aggregate of six parameters: luminosity Y, colour coordinate a*, dirt particle area A50 / A250, ink elimination IE and filtrate darkening Delta Y. The Deinkability Score is usually represented as a bar chart that integrates all six results and where the height of the bar is determined by the scores recorded for the six individual values (Y, a*, A50, A250, IE and Delta Y). Using this score, it is possible to grade the deinkability of printed products in four categories: "Good deinkable", "Satisfyingly deinkable", "Sufficiently deinkable" and "Deinking not applicable".

The INGEDE Method 11 was developed to identify only very poorly deinkable products. The method cannot simulate the entire recycling process and industry practice because a mixture of old papers is always recycled. This means that when considering individual results, the luminosity Y requires more detailed interpretation. A luminosity of 30 roughly corresponds to brown board, whilst a value of 65 is typical of newsprint. Magazines (high luminosity) are already included in the old paper mix to achieve a luminosity of 65. According to INGEDE, the average luminosity score for newspapers using Method 11 is 54. When considering the brightness of the comparison products (the same print products on the same paper with either MO or MOF ink from the same manufacturer), the luminosity values Y of the MO print products is higher than those with MOF inks in comparable pairings. This lower luminosity would have a negative impact on deinking if all newspapers were produced with MOF inks. If these inks are only a small proportion of the overall volume, then the consequences would not be significant.

2.1: CITEO round robin deinkability test - 2021

To make certain that the inks to be used in the beta series of print trials were deinkable, CITEO organised with Fogra a comprehensive round robin test. The deinkability of four vegetable oil-based MOF Coldset inks from four suppliers was assessed against MO inks from the same suppliers. They were printed on two different newsprint papers (100% recycled and a 70% recycled paper) on a sheetfed press at Fogra.

To ensure assessment reliability the inks were assessed to the INGEDE 11 standard by six European laboratories (two from the manufacturers of the papers used). A total of 72 samples were analysed. With the exception of one ink, which has since been reformulated, the other three inks proved to be deinkable.

While the traditional inks showed a better deinkability than the MOF inks, three MOF inks confirmed their deinkability with an INGEDE 11 score higher than 70 obtained by all laboratories. The MOF ink that did not reach the score of 70 has since been reformulated and tests by this supplier have confirmed its deinkability (with an INGEDE 11 score of 83 in a "good deinkability".

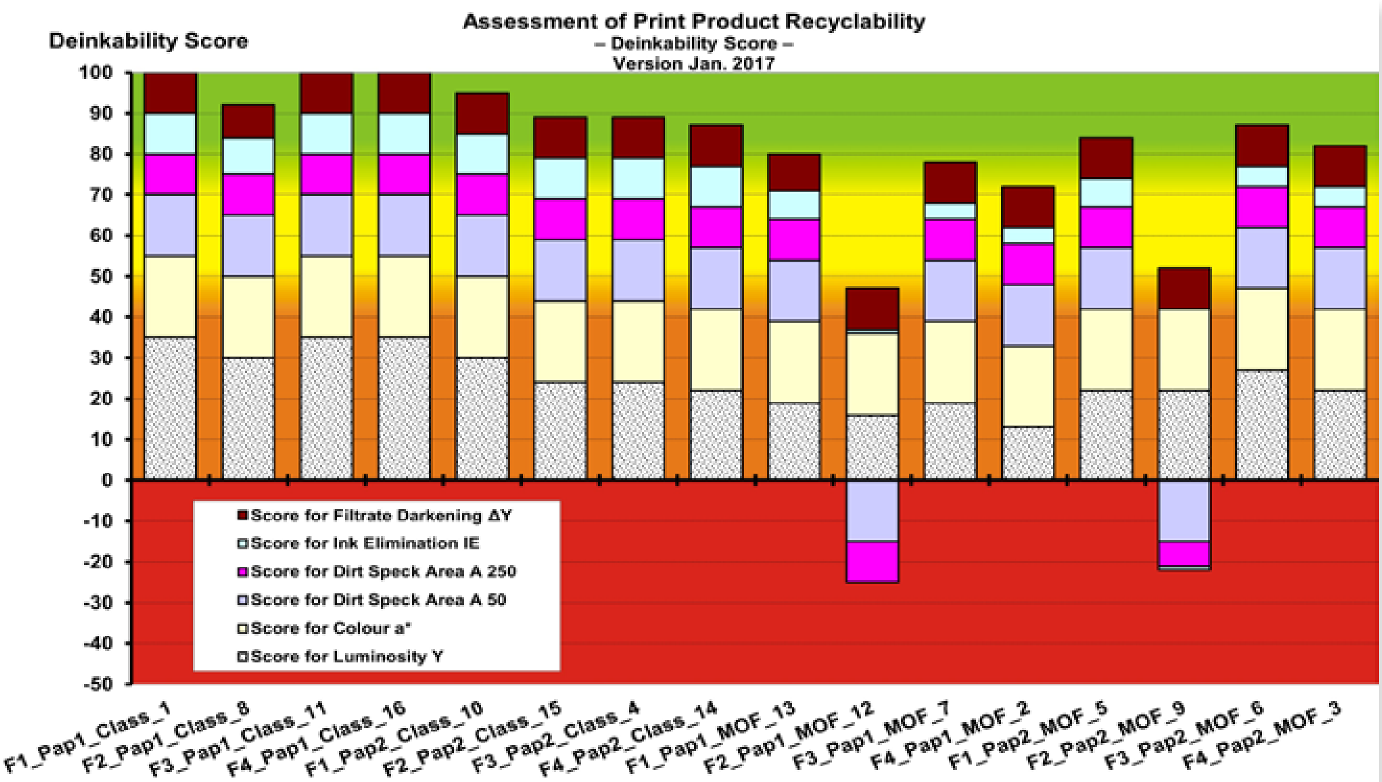
Results

The results presented in the deinkability scorecard provide a good overview of the influence of the paper as well as of the inks:

The round robin test showed good conformity of results from the different laboratories in terms of their deinkability scores seen in the graphs.

The overall deinkability score of conventional MO inks (left side of graphs) results in higher values than the scores of the MOF inks. This is mainly due to differences in the parameters of luminosity and the ink elimination that both show poorer values for MOF inks.

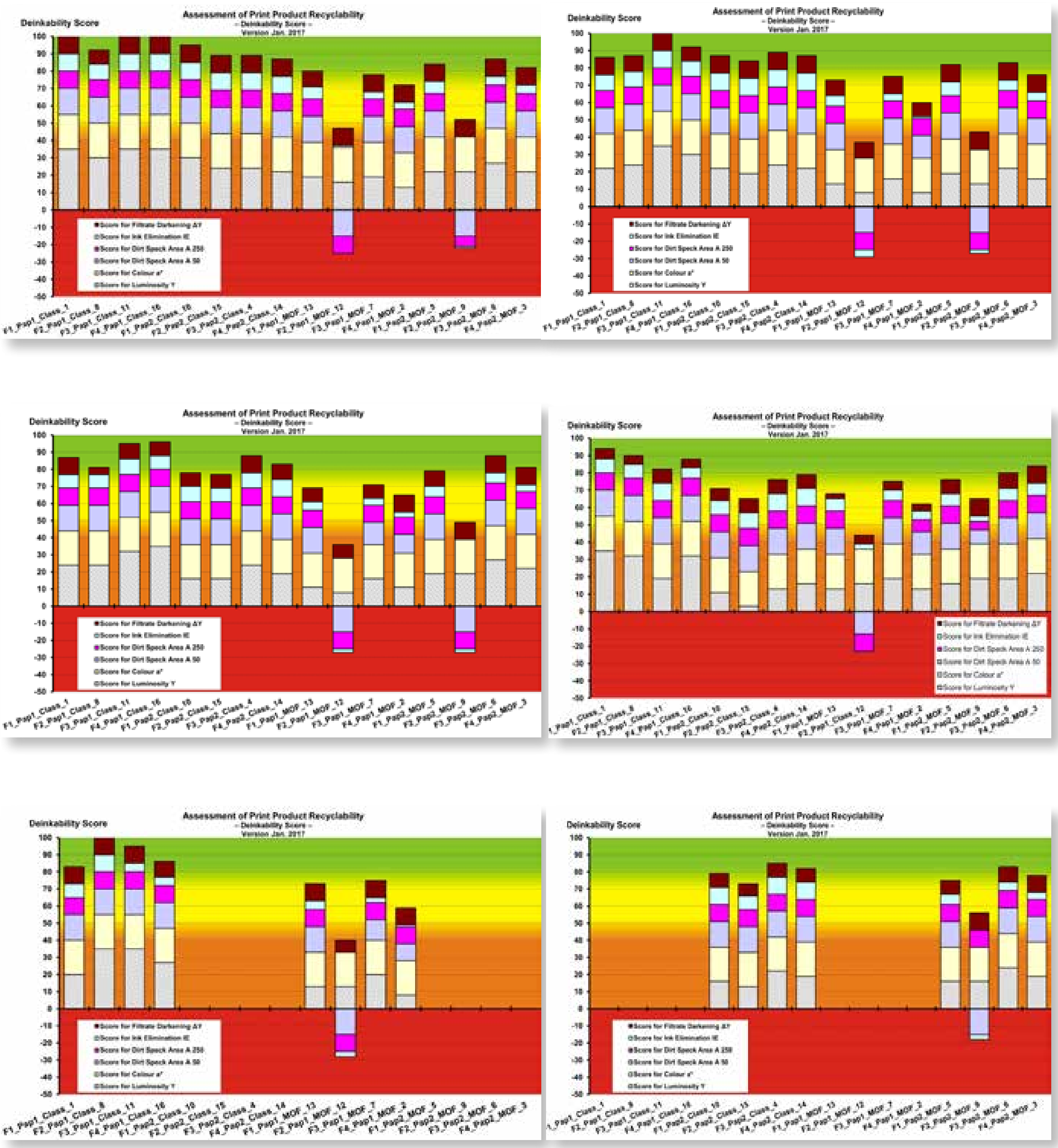
The influence of the paper is visible. The 100% Deinked Pulp (DIP) paper generally shows higher luminosity with conventional inks than the paper with 70% DIP with MOF inks. In general, the luminosity values after deinking according to INGEDE 11 show a decrease of 2 to 5 points, which, according to papermakers, needs to be



The data is named as F1, F2, F3 and F4 for the ink manufacturers, Pap1 and Pap2 for the two different papers used in the round robin test (DIP is deinked pulp) and Class is either conventional mineral oil or MOF inks. Source CITEO/Fogra considered for the papermaking process. As no bleaching is included in the INGEDE 11 method, the luminosity could be increased with this additional step.

The effect of paper is of minor importance for ink elimination. No significant differences between the results of the two papers occur. The ink elimination also shows poorer values for MOF inks of about 15 %.

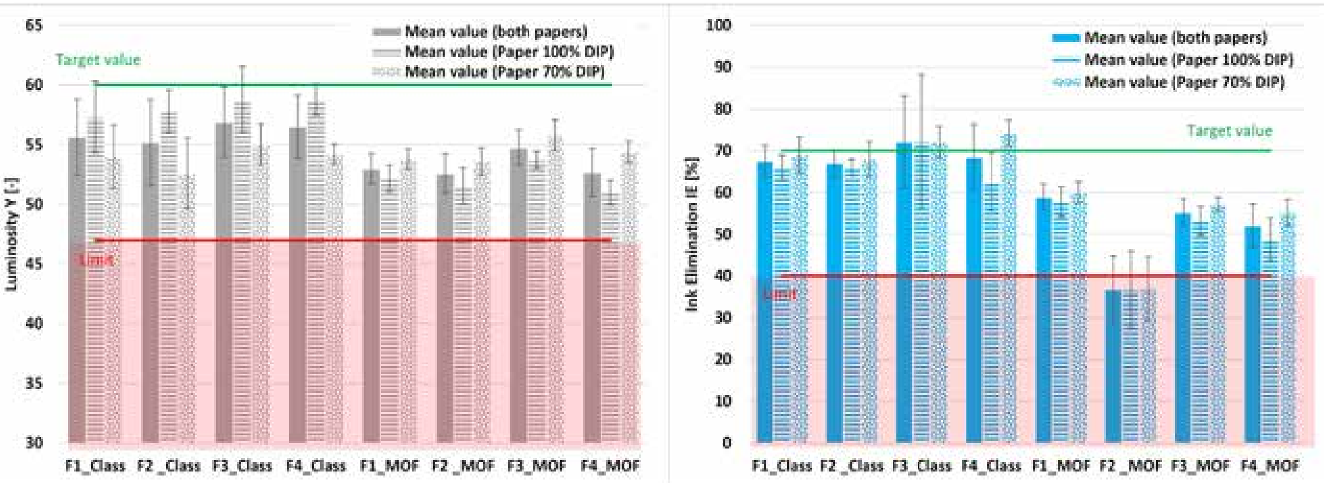
One reason for the poorer ink elimination is the results for the dirt speck areas of larger (A250) and smaller particles (A50). These are also the crucial parameters that were failed by the MOF ink of ink manufacturer 2, besides the ink elimination, and thus rated not suitable for deinking. The differences between the conventional and MOF depend on the inks. Whereas the dirt speck



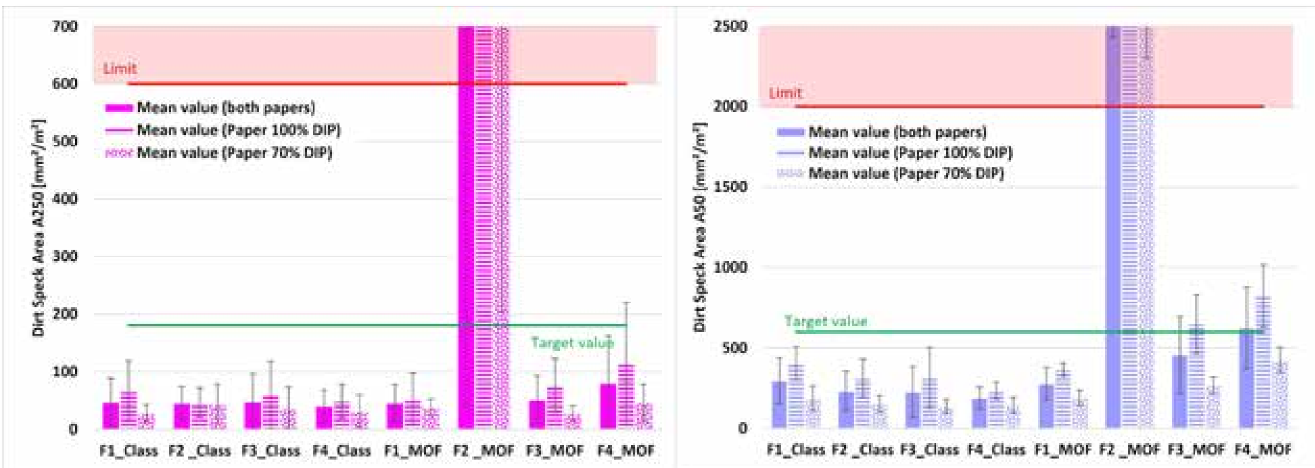
Deinking results of the participating laboratories Lab 1 to Lab 6 — results divided by ink type and paper. Source CITEO/Fogra areas for the inks of ink manufacturer 1 are almost equal and even meet the target value, the differences for ink manufacturers 3 and 4 are clearly visible for both A50 and A250 and the target value is not always reached. The dirt speck areas of the MOF inks of manufacturer 2 show values to over 9000 mm²/m² for A250 and up to over 4000 mm²/m² for A50. These values are far from meeting the requirements and no explanation for them could be determined. For these values of ink manufacturer 2, the results of the six participating laboratories show high deviations, but in all cases the limits were not reached.

The two remaining parameters for the deinkability score are filtrate darkening Delta Y and the colour a*. These do not show significant differences between the conventional and MOF inks and these parameters can be rated uncritical to the deinking of MOF inks.

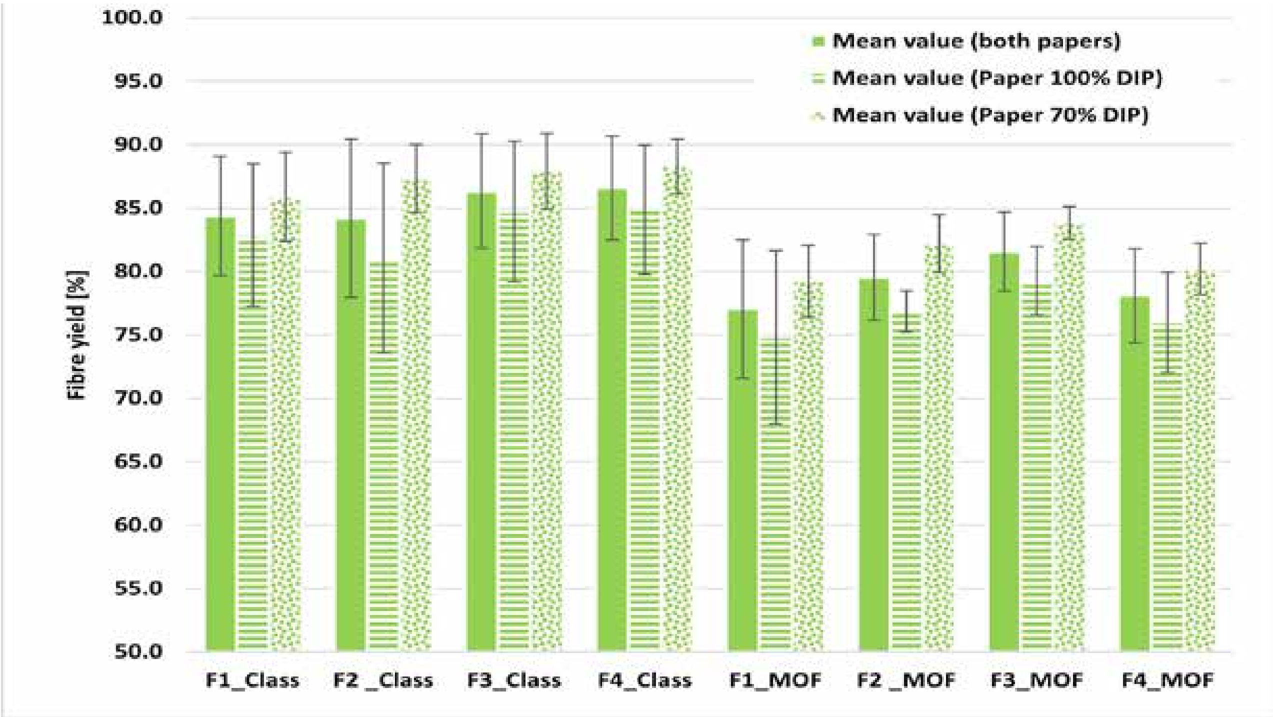
Another parameter that is not taken into account for the deinking score is the fibre yield after the deinking process. After the laboratory, deinking process the fibre yield of products with MOF inks is lower than with conventional inks by about 6%. This indicates a slightly different deinking behaviour of the two ink types. This may not be important for deinking in paper mills as, normally, there are additional steps to recover the fibres. However, a lower deinking yield can have a negative impact on the efficiency of the mill, and a further analysis of the potential impact is recommended.



Mean values of the different labs measuring data of the luminosity (left) and the ink elimination (right) of the conventional (=Class) and mineral oil free inks (= MOF). Source CITEO/Fog



Mean values of the different labs for the measuring data of the dirt speck areas A250 (left) and A50 (right) of the conventional (=Class) and mineral oil free inks (= MOF). The values for inks of manufacturer 2 (=F2) go up to over 9000 mm²/m² for A250 and up to over 4000mm²/m² for A50. Source CITEO/Fogra



Mean values of the different labs for the fibre yield after the deinking process. Source CITEO/Fogra

Conclusions

Overall, the round robin tests showed that the six different laboratories achieved similar results for the different samples. The tests showed that products printed with vegetable oil-based MOF Coldset inks could be rated as good deinkable with the exception of one ink. Despite this rating, the elimination of the ink from the paper is a bit poorer than that of products produced with conventional inks. This is clearly visible in the parameters of ink elimination, luminosity and the dirt speck areas of small and larger particles.

Epilogue

Subsequently the company that did not initially qualify reformulated its inks to be good deinkable. A fifth ink for waterless printing was also qualified.

More deinking results can be found on pages 39, 40, 44 and 52.

The quality of the paper can have a significant impact on the INGEDE 11 score. This was observed at tests made on samples printed on two Waterless presses with identical inks that highlighted the score variability from paper.

Reducing the TIC of newspaper printing may improve brightness of recycled paper originally printed with Low MOH inks. An initial test with a reduction from 220 to 200% showed no tangible result. Further research may be required to better understand this relationship.

2.2: CITEO beta ink evaluation at five sites in France: 2022-2023

CITEO organised and financed printing evaluations of four alternative Coldset inks. These inks were subjected to a simultaneous and comparative evaluation against MO inks under real production conditions. These structured evaluations were made in two parts:

- 2022 at three classic newspaper Coldset printers with MOF inks
- 2023 at two waterless newspaper printers, one using permanent Heatset drying, with Low MOH inks.

Production "tandems"
The key to the success of the project was to create "tandems" of a printer with their normal ink supplier to make a direct comparison of their traditional MO ink to an alternative series with the same ink pigment concentration printed on the same press and paper, under normal production conditions over 6-8 weeks. Their comparative assessment used structured evaluation methods. This approach made it possible to avoid potential biases related to differences in colorimetry between ink suppliers and any risk of commercial conflict. Project agreements were made between each printer, its ink supplier and CITEO.

2022 Classic wet offset newspaper Coldset with MOF inks

Production tests
The tests were carried out under real production conditions for 6-8 weeks with three newspaper printers using Classic Coldset (wet offset) presses at "Le Progrès", "Le Midi Libre" and "La Voix du Nord" and their ink suppliers Sun Chemical, Huber, and Flint.

These three companies supply more than 90% of the French market for Coldset inks. A fourth supplier, Schuite & Schuite, also delivers to this market. None of these inks are produced in France, they are made in Germany, Spain and Sweden. While some of these inks had previously had some testing in Europe, it was decided that in France to subject them to a structured monitoring under continuous real production conditions for 6-8 weeks.

Evaluation
MOF inks were used on one printing tower, while the other towers on the same press continued with their normal MO conventional inks. A relevant simultaneous comparison could therefore be ensured between the two types of ink being used on the same press, with the same paper and for the same work.

The results are based on the information collected by the printers during the tests. A monitoring protocol based on weekly production data, defined by CITEO, was completed by all sites. The evaluation criteria were defined, before the tests were launched, in partnership with the printers, ink suppliers and other participants such as WAN-IFRA. This evaluation protocol has four parts:

A) Preconditions: Prior to testing to ensure that the inks conform to the MOSH and MOAH content limits, that they are deinkable, with safety data sheets transmitted to the printer. The roller coverings were assessed for any volume variations when in contact with the alternative inks — this was organised between the ink and roller suppliers. The printers measured the circumference and Shore hardness of one or more inking and dampening rollers before and after the tests. The printers selected the test tower(s) to be used and checked their condition. The MOF ink supply method was defined by the printer and the ink supplier.

B) Pretest: A half-day assessment was made by each printer to confirm the printability of MOF inks before the production test.

C) Weekly production test report: The printer completed an evaluation of the ink's comparative behaviour on press each week.

D) End of test: After <8 weeks testing, each printer wrote a summary report and estimated, when possible, consumption of alternative inks compared to their traditional inks. Each printer re-measured the circumference and Shore hardness of the rollers measured before the tests started.

This information was completed by a review meeting with each production manager, his employees, the ink supplier concerned and the CITEO team (one closing meeting per site).

Quantitative measurements were made using the WAN-IFRA Cuboid to complete the evaluations (page 34).

Test organisation

CITEO identified regional daily press printers on the basis of three criteria:

1. Motivation of the printing company's management team and production staff.
2. Ability of each printer to work with their traditional ink supplier, who had to be able to offer an alternative ink. Each supplier's ink was tested at a single production site and compared to the MO ink currently being used.
3. Their presses and configurations were representative of the sector.

Le Midi Libre (St Jean de Véda, Occitanie) with inks from Huber Group. The tests were made on a 1996 Wifag OF 370 GTD press equipped with Sauer rollers and Trelleborg blankets. The eight ink ducts of the MOF test tower were hand-fed using 10 kg buckets. The trials were held over two months with an average of four hours production per day. The plant manager monitored the relative evolution of the rollers by installing new inking and dampening rollers on both the MOF test tower and the MO reference tower.

Le Progrès (Chassieu, Auvergne-Rhône-Alpes) with inks from Sun Chemical. Tests were made on a tower of a 2003 Goss Mainstream 80 press equipped with Sauer rollers and Flint blankets. The inks were supplied in CGI packs and the test tower fed through pumps and pipes connected to 200 kg drums. The eight-week test had an average daily production time of six hours. The company measured the circumference of four ink rollers and four dampening rollers at three points before and after the tests.

La Voix du Nord (Marcq-en-Barœul, Hauts-de-France) with inks from Flint. Tests were carried out on two towers of a 2007 Wifag OF 371 press equipped with Sauer rollers and Trelleborg blankets. The tests ran for eight weeks with an average production time of four-and-a-half hours per day. The test towers were fed by pipes and pumps from 1000 kg containers. The company measured the circumferences (edges and centre) of four inking rollers and four dampening rollers before and after the tests were made, Shore hardness was also measured on each.

		Results		
	Print quality	**Printer 1**	**Printer 2**	**Printer 3**
1	Printing stability	=	=	=
2	General image quality	=	=	=
3	Printing WAN-IFRA Cuboid	=	+	=
	Printability			
4	Printing speed	=	=	=
5	Trapping	=	**Not evaluated**	**Not evaluated**
6	Ink-water balance (Toning edge/Damp values)	=	+	=
7	Behaviour when changing speed	=	+	=
8	Start-up sequence warm press	=	=	=
9	Start-up sequence cold press	=	=	=
9	Start-up sequence cold press	=	=	=
10	Blanket build-up & cleaning	=	=	=
11	Smearing - set-off - marking	=	=	—
12	Build-up on path rollers	=	=	=
13	Ink misting-splatter	=	+	—
14	Rheology no stiff ink in ducst	=	+	=

Average of the weekly performance assessment by the press crew at each site: + Better / — Worse / = Same. Source CITEO/Ecograf.

The production sites are owned by different press groups for printing regional daily newspapers, but they also print weekly and some national daily newspapers, and occasionally advertising. Tests used 42 gsm newsprint made with 100% or partial recycled fibres.

Although the ink suppliers had experience of the printability of their inks, all the printers made a half-day pre-test before the production test was launched.

The viscosity of the MOF inks tested was either medium flow ("Le Progrès") or long flow ("Midi Libre" and "Voix du Nord").

To objectively assess the comparative print quality, WAN-IFRA Cuboids were printed twice (usually the third and sixth week of the test). Each Cuboid was printed with MO and MOF inks on different webs of the same job. The samples were analysed by WAN-IFRA.

Performance summary of MOF compared to MO traditional inks

1. Print stability: Stability was judged to be equivalent or better by the printers; one considered it better than their traditional inks. Another noted a "too strong Black" due to an excess of water. At the end of the test one printer progressively replaced the MOF inks as they ran out by MO inks without washing the ducts. This period lasted one month and the use of MO and MOF inks simultaneously on the same tower did not disturb printing stability and quality.

2-3. Overall quality of printed matter: One printer noted an improvement in quality of the Black ink, which was seen to be more consistent. Another printer reported a better "hold". Overall, MOF quality was judged to be equivalent or better by the results of the analysis of the Cuboids (see page 34).

4. Printing speed: The use of MOF inks did not have any reported impact on press speed at any site. One printer noted a "good performance at speed".

5. Trapping: This parameter was evaluated by only one printer who noted no evolution.

6. Ink-water balance: Two printers observed a reduction in the need for water, which is an improvement. The third printer observed a greasy appearance on the Black from the third week. The following week, dampening had to be reduced on some of the Magenta and Black pages, a week later the level of Black was too high. No further changes were observed during the last three weeks of testing.

7. Speed change behaviour: During the first week, one printer noted a loss of Black and Cyan density during acceleration, while at the same time an improvement for Magenta and Yellow during the same phases. The two other printers considered the behaviour of MOF inks equivalent to that of traditional inks during speed changes.

8-9. Start-up sequence (hot and cold press): One printer noted an improvement in the start-up sequence with MOF inks when the press is hot but a deterioration when the press is cold. Another reported a lack of consensus among operators: some noted the need to reduce inking to avoid dryness when starting — whether the press was hot or cold, whereas others noted an improvement of these sequences. This printer also noted a significant greasing of the Black after a 20-minute stop related to the MOF inks compared to traditional inks. The third printer reported no significant changes.

10. Blanket build-up and cleaning: No specific comments were made on this variable, which means the impact of MOF inks can be considered as negligible or nil.

11. Smearing – Set-off – Marking: One printer noted an increase in smearing due to the increase in spray (the projection of ink droplets when running at full speed). However, at the closing meeting this printer considered this observation as subjective and did not consider that ink spray interfered with production. A second printer noted a decrease in soiling. The third saw no change and remarked that the plates clean up well. Finally, the external press cleaning service for one of the printers did not make any comments following the use of MOF ink.

12. Build-up on path rollers: Only one printer noticed accumulation on the rollers during the second week of testing. This was not observed again during the following six weeks. The two other printers did not report anything.

13. Ink misting – Splatter: During the third week, one printer observed an increase in misting, which led to faster soiling over the top of the ink trains but without impacting production (see 11 above). Another printer observed a slight misting during the first week of testing, in the third week an increase in the misting of the Black linked to a viscosity problem. Overall, this printer observed a reduction of misting, except for the Black. The third printer noted during the first week of test an increase in the projection of ink on the protective sheets but apparently unrelated to the MOF inks as this increase was seen on another tower.

14. Rheology/Evolution of the ink over time: During the third week of testing, one printer observed the appearance of mould on the surface of the ink in tanks; this did not develop during the following weeks — its presence and origin remain unexplained. Another printer noted during the first week the cleanliness of the ink ducts and the freshness of the inks. At the end of the test, the low presence of rigid ink in the ink ducts was noted. On the other hand, the same printer notes Black had a too strong viscosity.

Other: One printer reported a strong and unpleasant odour of the inks tested — the filling of the ink fountains with buckets could have contributed to the diffusion of this odour in the workshop. The other printers did not make any particular remarks.

Ink consumption was more generally addressed during the closing meetings, as a weekly monitoring of consumption could not be organised.

Evaluations of MOF ink on rollers

Before starting the tests, one printer installed two new roller sets: one for the traditional MO ink tower and the other for the MOF tower. For each set, two ink and two dampening rollers were measured in three places (edges and centre). These measurements (by the ink supplier) were repeated four times: before the start of the test, twice during the test and at the end of the test. While results have the reservation of a small number of measurements, it was observed that:

- Shrinkage of the ink rollers is lower with MOF inks (-0,8 mm approximately) than with traditional inks (-1,4 mm approximately). This difference could be interpreted in the past as a swelling of the rollers in the presence of MOF inks; we see that this reasoning was erroneous, the swelling being in fact a difference in shrinkage.
- Difference in shrinkage between MO and MOF ink is less on dampening rollers (delta of 0,1 to 0,2 mm) than on inking rollers (delta of about 0,6 mm).
- A hypothesis, to be taken with caution, is that the shrinkage is more continuous with the MOF inks than with MO. A brutal retraction after three months of test with the traditional inks can be observed whereas this fall is not noted with the MOF inks.

The Shore hardness was also measured of one ink and one dampening roller using MO ink, and two dampening rollers and an ink roller using MOF ink. One printer measured the rollers using MO ink before the start of the tests, then 15 days later, then at one month for the other rollers using MOF ink. These measurements showed a perfect hardness stability of all the inking rollers (no difference between the measurements) and a very slight increase for the dampening rollers in presence of MOF ink.

The second printer used a digital caliper to measure the circumference at three points (centre and outer edges) of four ink rollers and four dampening rollers. To minimise operator bias, the same person made these measurements before and after the tests. The rollers measured were recent but not new. Hardness was not measured. As the same procedure could not be performed on rollers that were exposed to MO ink, the interpretation of the results is difficult. Nevertheless, it can be seen that all the rollers have shrunk. The average shrinkage is 0,21 mm with a maximum of 0,44 mm (only three measurements out of 24 show a shrinkage higher than 0,4 mm). Finally, the dampening rollers tend to shrink more than the inkers (trend to be confirmed). It should be noted that these shrinkages did not cause any particular problem of production.

The third printer measured the circumference of four inking rollers and four dampening rollers at three points before and after the tests, along with the evolution of the hardness. These rollers were not new. The results show that out of the eight rollers, three had no variation in circumference, two had a very small variation (1 mm shrinkage only in the centre), two had a homogeneous shrinkage (-1 mm on the three measured points) and one dampening roller had a shrinkage on the edges (-2 mm outside edge/ 0 in the centre/ -1 mm inside edge).

The printers observed only small shrinkage variations — the maximum corresponds to about 1% of the circumference of the roller. Shore hardness variation: five rollers saw a decrease in their hardness (variation around -4 on an initial hardness between 38 and 49), two remained constant (a dampener and an inker) and one dampening roller slightly increased (+1).

In conclusion, the evolution of the circumferences of the dampening and inking rollers and of their hardness had no impact on the production conditions. When the circumferences of the rollers vary, this evolution is always weak shrinkage. The evolution of Shore hardness is more complex, one printer having noted a small increase and another a small decrease.

2023 Waterless Coldset and Heatset evaluations of Low MOH

Waterless is an offset printing process that does not require a dampening solution. Around 20 sites in Europe are equipped with KBA Cortina Waterless presses, three of which have Heatset dryers that use the same ink as Coldset. The tests were carried out under real production conditions over six weeks with two French commercial printers equipped with these presses at Groupe Riccobono and ICP Roto (Heatset/Coldset).

The Waterless printing inks are specially formulated for this process from Huber Germany and KMI South Korea (distributed in Europe by Wifac). Only Low MOH inks were available at the time of the project from KMI. Their lower MOSH and MOAH concentrations comply with the requirements of the Blue Angel label and the CITEO 2022 criteria. This ink is formulated from a mix of vegetable oil and purified petroleum solvents. Although these Low MOH inks had already been trialled in Europe, the tests carried out in France were subject to structured monitoring over a six-week period.

Groupe Riccobono prints newspapers, magazines and catalogues at multiple sites in France. In Paris Tremblay, they tested KMI inks on a tower of a 2009 Cortina press line equipped with Böttcher rollers and Continental blankets. During the test a total of six million copies were printed with 2400 kg of ink (1200 kg of Black and 400 kg each CMY colour) fed through pumps and pipes connected to 200 kg barrels.

ICP ROTO is a hybrid newspaper and commercial printing centre on the island of Reunion (Indian Ocean). They tested inks on a tower of their 2017 Cortina equipped with Sauer rollers and Continental blankets. This press prints both Coldset and Heatset on uncoated and coated papers. The print tower is fed through ink pumps and pipes connected to 900 kg slip containers. The average production is 24 hours/6 days a week. A total of 14,900 kg of ink was printed (4325 kg of Black and 10,575 kg CMY). In addition, the pre-tests used 4 x 200 kg and 4 x 900 kg slip tanks.

	Print quality	Printer 4	Printer 5
1	Printing stability	=	=
2	General image quality	=	+
3	Print WAN-IFRA Cuboid	=	+
	Printability		
4	Printing speed	=	=
5	Anilox roller temperature	+	=
6	Plate temperature	+	=
7	Doctor blade wear	=	=
8	Behaviour when changing speed	=	=
9	Start-up sequence warm press	+	=
10	Start-up sequence cold press	=	=
11	Blanket build-up & cleaning	+	=
12	Smearing - set-off - marking	+	=
13	Build-up on path rollers	+	=
14	Ink misting-splatter	=	=
15	Tearing	+	=
16	Toning	+	=
17	Rheology no stiff ink in duct / flow in Inkduct	=	=
18	Plate condition & wear	=	=

Average of the weekly performance assessment by each press crew at each site: + Better / — Worse / = Same. Source CITEO/Ecograf.

Performance summary of Waterless Low MOH compared to traditional MO inks

1. Printing stability: Rated as equivalent to excellent. After only three days of testing, one printer's operators reported better stability. While the other printer found no significant difference between the two inks. No anomalies were noted when Low MOH and MO Black were mixed, or using MO Black ink with Low MOH process inks during a supply shortage.

2. General image quality: One printer judged the Low MOH quality to be equivalent to MO inks, while the other found a better brightness with them.

3. Print quality WAN-IFRA Cuboid: The overall results were similar to those of wet web offset. There is no significance difference between the MO ink and Low MOH ink of both Waterless printers.

4. Printing speed: The use of Low MOH inks has no apparent impact on press speeds.

5. Anilox roller temperature: One printer noted an improved temperature range — this means less cooling, reducing energy consumption. The other printer did not observe any change.

6. Plate temperature: The impact of Low MOH inks is negligible or nil.

7. Doctor blade wear: A parameter difficult to assess. One printer noted a slight improvement as Low MOH inks are apparently slightly less abrasive.

8. Behaviour when changing speed: The impact of Low MOH inks is negligible or nil.

9. Start-up sequence warm press: One printer noted improved sequences on a hot press.

10. Start-up sequence cold press: No impact was observed on a cold press.

11. Blanket build-up & cleaning: The impact of Low MOH inks can be considered negligible or nil.

12. Smearing - set-off - marking: One printer observed a slight soiling increase on the turner bars after the dryer, but this is not seen as a problem. The other printer noted a clear reduction in marking.

13. Build-up on path rollers: The impact of Low MOH inks is negligible or nil.

14. Ink misting-splatter: The impact of Low MOH inks is negligible or nil.

15. Release: One printer noted a significant improvement.

16. Toning: The impact of Low MOH inks is negligible or nil.

17. Rheology no stiff ink in duct: The impact of Low MOH inks is negligible or nil.

18. Plate condition & wear: The impact of Low MOH inks is negligible or nil.

Conclusions

ICP Roto and Riccobono agree that the inks tested meet their technical expectations. Tests of waterless Low MOH inks have shown their excellent technical quality and show some improvements over MO inks. On the completion of the tests, ICP Roto decided to permanently use these Low MOH inks.

The high print quality is remarkable as the tests were carried out without modifying the calibration curves. ICP Roto noted better luminosity. No publishers or advertiser complained about the quality of the printing produced during these tests.

An increase in the operating temperature range was found by one printer, which could lead to a reduction in cooling energy consumption and improve flexibility of use.

Compatibility between MO inks and Low MOH inks was confirmed.

Low MOH inks have no impact on rollers and can be used without modifying the press.

The INGEDE 11 scores show that Low MOH inks have a “fairly good” or “good” deinking capacity even if slightly poorer than MO scores. While the inks were identical at the two printers, papers were different, and the quality of the paper seems to have a significant impact on the INGEDE 11 score.

Two points need to be clarified over several months: any impact on ink consumption and any abrasiveness of these inks on doctor blades and plates.

Low MOH inks are a transition to full MOF for 2025

Low MOH inks do not meet the requirements of the AGEC law and Waterless inks will therefore require new formulations to comply with stricter French regulation from January 2025. KMI and Huber are currently working on new full MOF inks that will need to be tested.

Cuboid measurements

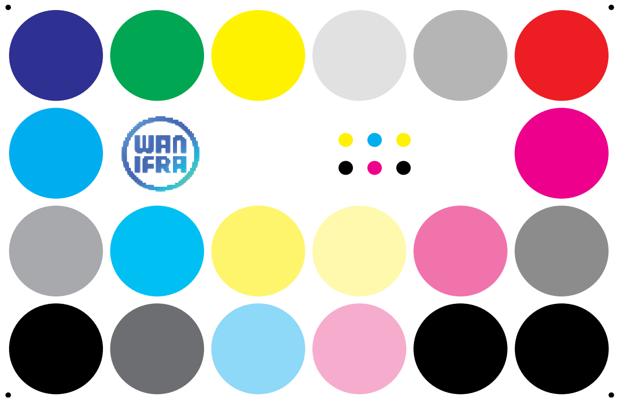
The WAN-IFRA Cuboid was used to provide an objective and independent evaluation of the production quality between the different inks.

For the CITEO ink evaluation, the Cuboids were printed with MO ink and MOF ink to help evaluate any differences in quality performance between them when printed on the same press with the same paper at the same time. Two series of Cuboids, i.e. 12 Cuboids (2 x 2 per company) were printed in the middle and at the end of the tests. The analyses of the printed Cuboids was made by the WAN-IFRA Technical Centre according to the ISO12647-3 standard for Coldset printing.

This evaluation makes it possible to measure seven criteria of which the first three, defined as primary, relate to the colorimetry (grey balance, gamut, DeltaE). Points are awarded for each of the seven criteria in accordance with the degree to which the target values are satisfied (no points are awarded if the tolerance values are exceeded). The criteria evaluated are as follows:

1. **Grey balance (max. 30 points):** Neutral grey printing is a fundamental element of colour printing.
2. **Colour space (max. 11 points):** The gamut (range of colours obtained) must be integrated into that defined by the ISO to guarantee a good impression quality.
3. **Colour conformity (DeltaE) (max. 49 points):** The printed colour must respect a minimum tolerance threshold.
4. **News-Shade (max. 30 points):** The paper shade, defined in the ISO standard, impacts the target values.
5. **Mid-tone spread (max. 10 points):** This criterion strongly influences the colour quality of a newspaper.
6. **Tonal Value Increase (TVI):** A constant TVI is essential for a good colour balance
    - 6.1. TVI gain at 40% (max. 10 points)
    - 6.2. TVI gain at 70% (max. 10 points).
7. **Colour register (max. 30 points):** The quality of the register influences printing quality.

The summary comments by WAN-IFRA for Printers 1-3 using MOF inks:



The Cuboid was developed for the WAN-IFRA International Color Quality Club (IQCC) competition to promote publication printing to a consistent high-quality. The target (42 x 28 mm) is printed under standardised conditions as part of regular production and is used to evaluate Coldset, Heatset and UV offset printing on newsprint and coated papers.

- No major trend can be identified. If the MOF ink used by printer 1 shows better results than the MO ink, it is not the case for printer 2. Finally, none of the prints obtained the minimum number of points defined by the IQCC on all the criteria.
- The performance of MO and MOF inks are very close and the totals comparable. There is no evidence that MOF inks do not meet ISO standards*.
- The grey balances of the MOF inks printed at sites 2 and 3 are within specification and better than some of the MO samples measured at the same sites.
- Colour compliance, especially of the Black MOF ink, was much more consistent and well within limits compared to the CMY inks. Some MOF colours were outside the target specification, but the same was observed in the case of MO inks. This should not be a particular problem.*
- Some MO and MOF ink samples did not meet the ISO-specified colour space overlap (75%), but the MO and MOF inks at site 3 met the target value.
- No particular problems were observed with the MOF inks.
- These tests used unchanged TVI curves, print quality will improve if they are optimised.

Cuboid trial printed using MO & MOF inks & waterless process

	Maximum points/ criteria	*Min. IQCC* points/ criteria*	Printer 1	Midi Libre	Printer 2	Le Progress	Printer 3	La VdN	Printer 4	Riccobono	Printer 5	ICP
			MO ink	MOF ink	MO ink	MOF ink	MO ink	MOF ink	MO ink	Low MOH	MO ink	Low MOH
Primary criteria			points	points	points	points	points	points	points	points	points	points
1: Grey balance	*30*	*≥ 24*	10.0	20.0	20.0	30.0	30.0	30.0	26.0	17.7	27.3	28.7
2: Color space in %	*11*	*≥ 7*	0.0	0.0	0.0	0.0	11.0	11.0	5.5	5.5	11.0	11.0
3: Color conformity Delta E	*49*	*≥ 40*	28.0	28.0	42.0	21.0	35.0	28.0	31.5	31.5	24.5	28.0
Sub total points	*90*	*71*	38.0	48.0	62.0	51.0	76.0	69.0	63.0	54.7	62.8	67.7
Other criteria												
4: Newsshade	30	≥ 30	30.0	30.0	20.0	20.0	20.0	20.0	25.0	25.0	30.0	30.0
5: Mid-tone spread	10	≥ 6	0.0	0.0	0.0	10.0	0.0	0.0	4.1	3.0	10.0	2.5
6.1: TVI 40%	10	≥ 7	2.5	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
6.2: TVI 70%	10	≥ 7	7.5	7.5	0.0	5.0	0.0	0.0	0.8	0.0	0.0	5.8
7: Color register	30	30	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Sub total points	90	30	70.0	72.5	50.0	65.0	50.0	50.0	59.9	58.0	70.0	69.2
TOTAL	180		108.0	120.5	112.0	116.0	126.0	119.0	122.9	112.8	132.8	136.9

The Cuboid results from five printers. For organisational reasons, the inks used by La Voix du Nord did not come from the same supplier. Printers 4 and 5 used Waterless Low MOH inks. Source WAN-IFRA.

Observations for Printers 4 and 5 using Waterless inks:

- The overall average result of these samples were similar to those printed using wet web offset (printers 1-3).
- There is no significance difference between the MO ink and Low MOH ink of both Waterless printers — the marginal difference is negligible.
- Overall, Printer 5 had better results for both MOH and Low MO compared to all the others (1-4).
- The comparisons of the criteria were more or less similar for all printers, except the grey balance from printer 4 on Low MO ink that shows a larger difference.

*WAN-IFRA observes that conformance of the ink formulation should be tested in the future with simulated conditions for Ink Film Thickness (IFT as per ISO 2846-2), which specifies the target standards for the news ink, using IGT printability tester for the ISO 2846-3 capabilities of the MOF inks. This testing will provide another dimension of the capabilities of the inks.

Summary MOF technical findings

The monitoring protocol used at all sites allowed each printer to make a structured evaluation of the overall printing performance of the MOF ink compared to their MO inks from the same supplier.

All the printers consider that the inks tested met their technical expectations. Their use was easy with only some occasional problems of misting, odour and the need to refine certain settings.

The ink suppliers consider the formulations that have been tested as successful and marketable as they are. The following positive points were identified by printers and ink suppliers:

1. Printing quality. This was deemed to be very good since the tests were carried out without modifying either the TVI (dot gain) or fount curves defined for the traditional MO inks. No reader or advertiser complained about the quality of the printing produced during these tests (all the printed products were sold as normal). Print quality was independently confirmed by the Cuboid analyses carried out by WAN-IFRA that no negative impact related to the use of MOF inks was observed.
2. No noticeable impact on the ink and dampening rollers. The presses can therefore be used as they are and no major modification is needed to switch to MOF inks.
3. Compatibility between traditional inks and MOF inks was observed, particularly at the end of the tests and the return to traditional inks (this point needs to be confirmed).
4. Ink consumption observations. One printer estimates this reduction as being of the order of 15 - 20% on Black (but no reduction on the process colours), another printer expresses a similar reduction. These anecdotal observations need to be confirmed by more precise measurements
5. Reduction of marking. Less ink transfer when the newspaper is rubbed after printing.
6. All printers considered that if MOF inks were available at the same price as traditional inks, they would consider their immediate adoption, subject to guaranteed availability.
7. The printers emphasised the interest of making a half-day pre-test to verify the printability of the alternative ink before the passage to full production.

There were comments from all printers on the much higher quality of the MOF Black ink compared to the MO. This is seemingly due to its ingredients being similar to that of process colours.

Conclusions on MOF tests

The MOF ink tests carried out under real production conditions for 6-8 weeks at three printing sites of various configurations confirmed the printability of these inks on both Classic and Waterless Coldset. No particular problem was identified, apart from the need to make a few adjustments considered as normal when changing inks or suppliers. The need to clean the whole ink supply network (including the mother tanks) needs to be reviewed.

The reduction of ink consumed per printed square metre may compensate for some of the additional cost of MOF inks. One solution, may be the reduction of Total Ink Coverage (TIC) as recommended in previous WAN-IFRA Reports as detailed in Section 3 page 55.

WAN-IFRA observes that conformance of the ink formulation should be tested in the future with simulated conditions (ink film thickness as per ISO 2846-2), which specifies the target standards using a IGT printability tester of ISO 2846-3 capabilities of the MOF inks. Testing of ink will provide information on mileage comparison and the colour shade reproduction potential of the inks.

It is important to emphasise the high motivation of the all the diverse participants in the tests — printers, ink suppliers, technical centres and associations. The will to find an alternative to mineral-based inks seems to be shared by the whole daily press sector.

French evaluation protocol — summary

	MOF ink evaluation during production testing					2021 CITEO / Ecograf
A	**PRECONDITIONS**					
		Status OK?			*How to evaluate*	*Who evaluates*
1	Ink < 1% de MOAH et < 1,5% de MOSH C20-C30 concentration				*Declaration*	*Ink supplier*
2	Deinking Ingede 11 confirmed, Citeo round robin OK accepted				*Document*	*Ink supplier*
3	Materials Handling Safety Sheet				Document	*Ink supplier*
4	Roller elastomères — var. vol. % pour **MO et MOF inks** utiliser				*Roller supplier*	*Ink supplier*
5	Roller dimensions — 1 inking & 1 dampening measure edges & centre				*Calibre & Shore hardness*	*Printer*
6	Check press conditions & control parameters				*Inspection*	*Printer / Ink supplier*

Ink evaluation on press

	EVALUATION			
Behaviour of MOF ink on press v MO	-			**Worse**
		=		**Same**
			+	**Better**

B	**TEST PREPARATION**					

a **Current printing status with conventional MO ink, warm press, print test forme before changing ink to MOF**

b **Bucket test of MOF on warm press, the same day using test forme**

					How to evaluate	*Who evaluates*
1	Colorimétrie : Measure (Gamut)	-	=	+	Measurement	Ink supplier / printer
2	Wet density to identify dry density after 24 h	-	=	+	Measurement	Ink supplier / printer
3	Calibration TVI - Dot gain	-	=	+	Measurement	Ink supplier / printer
4	Dampening curve adjustment	-	=	+	Adjustment	Printer
5	Ink-water balance (Toning edge/Damp values)	-	=	+	Observation	Ink supplier / printer
6	Trapping	-	=	+	Measurement	Ink supplier / printer
7	Image quality	-	=	+	Observation	Ink supplier / printer
8	Contrast	-	=	+	Measurement	Ink supplier / printer
9	Show-through	-	=	+	Observe & Measure	Ink supplier / printer
10	Set-off page à page par couleur	-	=	+	Observation	Ink supplier / printer

C	**WEEKLY PRODUCTION TEST REPORT**					
	Print quality				*How to evaluate*	*Who evaluates*
1	Printing stability	-	=	+	Observation	Printer
2	General image quality	-	=	+	Observation	Printer
3	WAN-IFRA Cuboid (run on both MO & MOF webs week 3 and week 6	-	=	+	Measurement	WAN-IFRA (via CITEO)
	Printability					
4	Printing speed	-	=	+	Observation	Printer
5	Trapping	-	=	+	Measurement	Printer
6	Ink-water balance (Toning edge/Damp values)	-	=	+	Observation	Printer
7	Behaviour when changing speed	-	=	+	Observation	Printer
8	Start-up sequence warm press	-	=	+	Observation	Printer
9	Start-up sequence warm press	-	=	+	Observation	Printer
9	Start-up sequence cold press	-	=	+	Observation	Printer
10	Blanket build-up & cleaning	-	=	+	Observation & Photo	Printer
11	Smearing - set-off - marking	-	=	+	Observation & Photo	Printer
12	Build-up on path rollers	-	=	+	Observation & Photo	Printer
13	Ink misting-splatter	-	=	+	Observation & Photo	Printer
14	Rheology no stiff ink in ducts	-	=	+	Observation	Printer
15	Autre comportement (précisez) / Other, specify	-	=	+	Observation	Printer

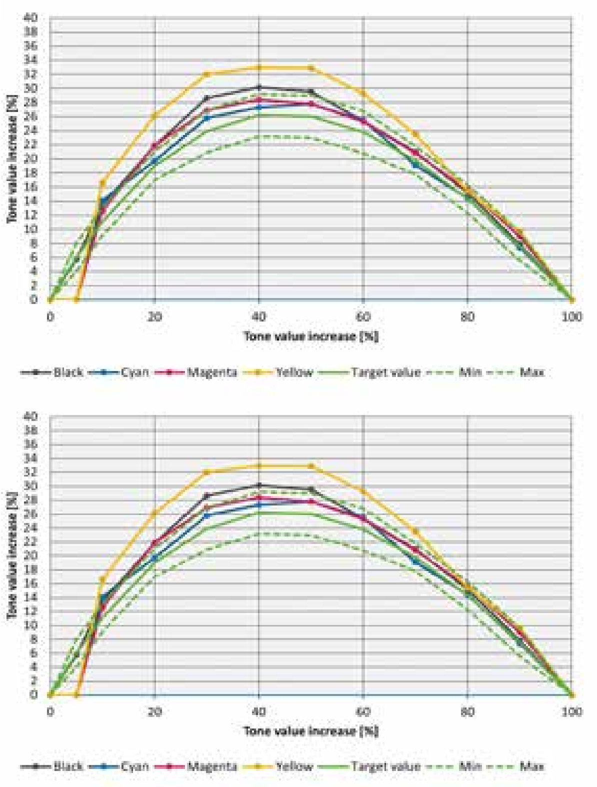
D	**END OF TEST**					
					How to evaluate	*Who evaluates*
1	Roller dimensions — 1 inking & 1 dampening measure edges & centre	-	=	+	Calibre & Shore hardness	Printer
2	Ink consumption	-	=	+	Measurement	Printer
3	Concluding report of test with synthesis of weekly reports					Printer

2.3: UBA - R&D testing of alpha inks Germany - 2015-2020

Trials at Frankfurter Societäts-Druckerei (FSD) printed 35 000 kg of inks from three manufacturers — Flint CPS Inks, Huber Group and Schuite & Schuite Druckfarben - over 22 months on their KBA Commander satellite newspaper press.

Short-term print trials

Several one-day print trials of MOF inks were made on FSD's press using 50 kg of ink per colour hand filled into the ducts to print 30 000 to 60 000 copies. Two test formes were used for quality control and to determine ink mileage. These trials focused on: ink/water balance, ink consumption, soiling evaluation and postpress behaviour. Differences in fountain solution requirements between conventional MO and MOF inks became apparent during these trials. Irrespective of speed, MOF inks generally



TVI of the final ink series of manufacturer 1(top) and manufacturer 3 (bottom). The dotted green lines indicate the limits of the TVI according to ISO 12647-3. Source UBA/Fogra

required a slightly higher metering volume of the fountain solution. The compensation curve in the press control system had to be adjusted to manage the damping quantity during speed changes. After adjustment of the fountain solution metering and further improvements to the inks, the final ink series from both manufacturers showed slightly elevated TVI increases. However, for most of the inks the TVI increases were within the limits for newspaper printing according to the ISO 12647-3.

Ink consumption

Ink consumption is a fundamental factor to evaluate the economic viability of using MOF inks and, consequently, was investigated in detail. The two accepted methods for measuring ink mileage are (1) after production at the ink factory, and (2) the gravimetric mileage evaluated by the printer (for more details see page 59). The results from the two methods were found to be very similar. In general, the measurements of ink consumption found that, for the same pigmentation, the MOF inks yield similar values to inks containing mineral oils.

Soiling and smearing

The transfer of ink from the substrate to parts of the press was observed on the idler rollers and the folder formers. The printed web makes direct contact with the metal idler rollers, whereas in the formers the printed paper moves over a rounded metal edge shielded by an air cushion. In both cases, the ink is subjected to mechanical stress that can partially separate it from the paper and soil the press. These components were cleaned at the start of the trial day and then checked for soiling at the end of the day. White paper sheets were placed at the ink units to check the spray and misting. Verification of the former and the idler bars, and the suspended sheets of paper, showed that the soiling behaviour of MOF inks is very low. Slight soiling is to be expected even with conventional inks.

Indirect ink drying tests were made for all inks by feeding printed products through FSD's FERAG finishing line. The results indicated no finishing problems with the MOF inks.

At the end of the short-term trials each ink manufacturer had one ink set ready for the long-term printing trials with:

- Tone values (ink/water balance) corresponding to Process Standard Offset.
- MOF ink consumption similar to conventional inks.
- Low soiling tendency.
- Problem-free finishing of printed products.

Long-term newspaper printing trials

Long-term print trials were made at FSD with each ink set. A dedicated tower was supplied with process CMY inks pumped from slip tanks (500 to 1000 kg) to the ink ducts. One of the two underground ink tanks was emptied and filled with 3000 kg of MOF Black that was then pumped to the ducts. It was not possible to fully clean this tank, which left residues of MO inks during the MOF print trials.

Because ageing effects may only manifest after a couple of weeks, a three-month trial was decided with the ink manufacturers to test the printing behaviour of both fresh and older ink. The time between an ink's production and its use for printing can be up to nine months.

During the long-term trials the roller nips in the press units running MOF inks were regularly checked for any changes in the roller materials. These measurements confirmed the swelling or shrinking rates for the elastomers measured in the laboratory. The long-term trials were subject to constant monitoring.

Although the inks had been optimised at FSD during the short-term print trials, the long-term trials had to be stopped on several occasions. It was not possible to achieve continuous use of CMY inks of manufacturer 1 and tests due to changes in the rheological properties and printing problems after a few weeks. In contrast, the Black ink printed continuously over three months. The primary reason was that the Black ink unit design is different (to CMY) and the ink was continuously circulated, which prevents problematic rheological effects. The printing inks from manufacturer 3 could be used over a period of three months.

Further refinement to the ink properties from both manufacturers towards the end of the project meant there were no further interruptions. This was a clear improvement over the start of the project when the quality standard was not achieved and the ink setting was too slow. The inks from manufacturer 3, which were used over a period of three months, did not then comply with the usual industry standards, as both TVI and ink consumption were too high. However, adjustment of the Cyan and Yellow inks significantly improved TVI and slightly improved consumption.

The FSD trials took 22 months, making it possible to investigate the behaviour of the inks over a long time. The initial changes in the inks generally only showed themselves after a couple of weeks. Ultimately, the two ink manufacturers were unable to bring a new generation of MOF inks to full production maturity. However, during the period when the inks had not aged too much, they showed the press operators that printing was practical.

The MOF ink mileage was similar to that of conventional inks for manufacturer 1. Only the Yellow had a higher consumption of about 15%. The consumption of CMY inks of manufacturer 3 was 15-30% higher than conventional inks. Only the MOF Black had a consumption similar to the requirements of the plant.

Waste and fountain solution consumption were not significantly different from that of conventional inks. Both the fountain solution and washing agents regularly used in the plant were continued to be used without change. The damping solution was a standard commercial product for Coldset that was not optimised for MOF newspaper inks.

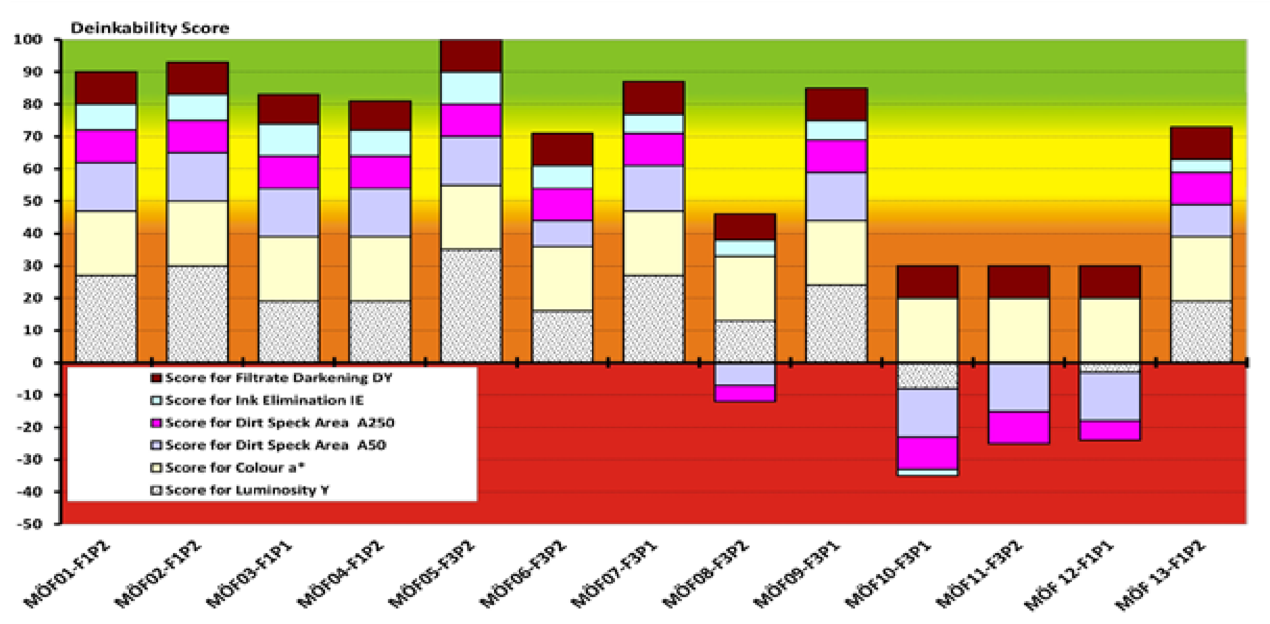
These print trials showed that in principle MOF inks work in newspaper printing. It was not possible to reach any conclusion about runability on other newspaper presses.

Deinking tests on specimens printed with MOF newspaper inks

Deinkability of print samples from both the short- and long-term trials was determined using INGEDE Method 11 (see page 23 for definition). In general, most of the products exhibited good or satisfactory deinkability. Four of the 13 print products produced with MOF inks were rated unsuitable for deinking because the dirt particle areas A50 and A250 did not meet the limits.

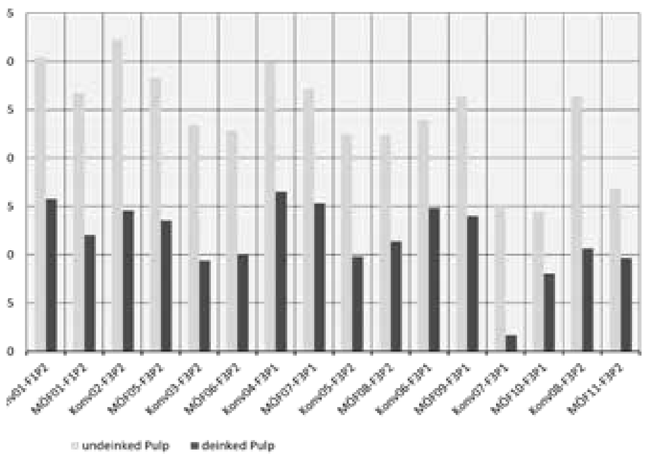
A total of 13 print products produced with MOF inks were tested for their deinking behaviour to the INGEDE 11 method. Nine samples were "good deinkable" and four "not suitable for deinking." The current MOF formulations of manufacturer 1 were not deinkable on paper with 50% DIP, while for manufacturer 3 the samples were not deinkable on both paper grades in the end. Further investigations on this subject was required.

The investigation also determined the fibre yield — the quantity of fibres still available after the deinking laboratory method. In most cases the fibre yield was lower with MOF inks. However, fibre yield in the industrial environment is higher than in the laboratory, since industrial-scale rejects from the first and second flotation stages are recovered from the skimmed volume flow by being returned to a secondary flotation stage. Nevertheless, switching from conventional to MOF newspaper inks may reduce the fibre yield and impact the waste paper streams.



Deinking results for the tested printed products with MOF inks displayed as Deinkability Scores. (MÖF: mineral oil free ink, F: Ink manufacturer, P: paper grade). Source UBA/Fogra

A total of 13 print products produced with MOF inks were tested for their deinking behaviour to the INGEDE 11 method. Nine samples were "good deinkable" and four "not suitable for deinking." The latest MOF formulations of manufacturer 1 in this project were not deinkable on paper with 50% DIP, while for manufacturer 3 the samples were not deinkable on both paper grades in the end. Further investigation on this subject was still required.



Luminosity of comparable print samples, produced on the same paper with conventional and MOF inks of the same ink manufacturer (MÖF: mineral oil free ink, Konv: conventional ink, F: Ink manufacturer, P: paper grade). Source UBA/Fogra

Adherence to the specifications for the absence of mineral oil

Ink samples from the FSD short-term trials and at the beginning of the long-term trials showed no significant differences in the measured MOSH and MOAH content between the inks containing mineral oils and those of MOF, although, according to the ink manufacturers, no mineral oils were present as constitutional components of the inks.

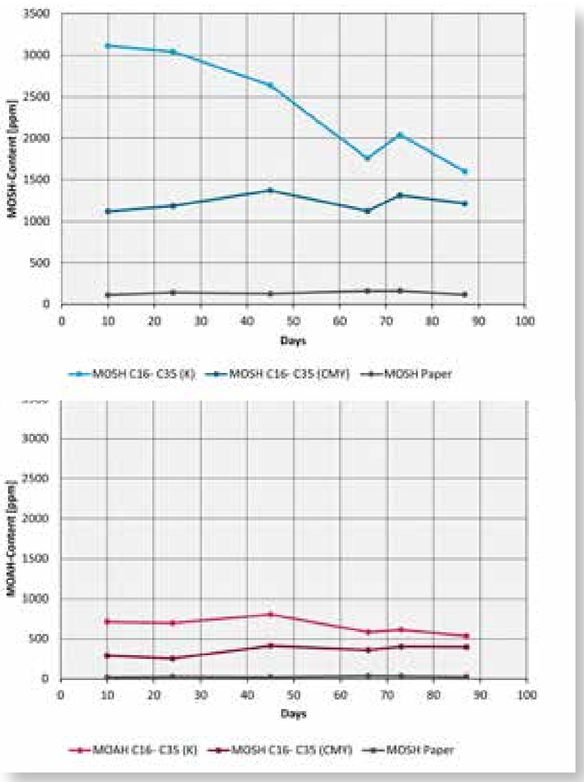
MOF inks were produced in small quantities < 3 tonnes and significant contamination in their manufacturing is probable. The ink makers confirmed that although their systems had been cleaned, there was certainly residual contamination from the previously produced MO inks.

Periodic measurements of the mineral oil content on different areas of a printed product were made during the 15-week period when only MOF inks from manufacturer 3 were used, including areas that were printed in equal parts with all four printing inks and areas that were printed in one colour. The mineral oil content of the chromatic inks were comparable in all measurements; therefore, a mean value for the three chromatic inks was used to allow a clearer presentation. The temporal behaviour of the Black ink differed greatly from that of the chromatic inks where a clear decrease in the mineral oil content was observed. This series of tests proved the postulated contamination in the press. The mineral oil content of the printed products decreased over the test period . The main difference in Black could be identified as the primary source of contamination.

Conclusions

The project enabled far-reaching findings on MOF inks. The long-term trials used inks from two manufacturers in regular production. Continuous use of the chromatic inks over three months was possible with one manufacturer. For the second, there were problems from the rheological change caused by ageing. The Black inks from both manufacturers lasted longer than the required three months, which may be due to the different ink unit design. Almost all the initial printing problems with MOF newspaper inks were completely overcome (scumming, absorption too slow, rendering of colours insufficiently accurate in full colour advertisements).

The majority of the print products tested using the INGEDE 11 method exhibited satisfactory to good deinkability. The fibre yield after the deinking process from products with MOF inks was lower than for conventional inks in five out of eight pairings. The luminosity Y was rated as good when considered as one of the tested parameters that contributes to the Deinkability Score. However, the value for the printed products lay in the range from c. 53 to 58 whereas on an industrial scale the luminosity after deinking should be 65. Achieving the required luminosity may be a problem if there is a large switch to MOF printed newspapers within overall volume of recovered paper. This could lead to problems with the luminosity of the deinked pulp and may result in fibre being removed from circulation. The yields in laboratory trials were lower than for newspapers printed with conventional inks. However, on an industrial scale, this effect is significantly reduced by repeating the flotation stage, but any change in yield has not yet been quantified.



Mineral oil content of printed products as a development over a time period of 86 days. Shown here are the total MOSH and MOAH fractions of Black ink and the mean value of the chromatic inks in printed products and the contents of the reference values of unprinted paper (grey). Source UBA/Fogra

Overall, there was reduced contamination of printed products with mineral oil components through the use of new ink types. The MOAH content of newspapers printed with MOF inks fell to about 50% of comparable products printed with MO inks. Considerable quantities of mineral oil were found in all the inks and printed products tested using the BfR method in spite of the manufacturers stating that their new formulations contain no mineral oil components. The primary cause is the contamination of MOF inks from residues of conventional inks during manufacturing. Additionally, contamination on the press (pipes, pumps, elastomers, underground tanks) was observed. The roller elastomer testing of these inks has only received approval for use with the FSD press.

The formulations of the new inks should lead to a reduction in mineral oil residue in recycled paper once MOF inks are launched commercially. When the project ended there were no fully developed inks ready for industrial use. The ink sets required further optimisation. The time frame of around 22 months is a short one for the completely new development that MOF newspaper inks represent.

2.4: AGRAPA production testing beta inks Germany - 2020-2021

Trials at Heilbronner Stimme printed 25,5 tonnes of inks from Flint and Huber on their KBA Commander blanket-to-blanket newspaper press. This evaluation was a follow-up to the UBA project. The aim was to investigate the practical suitability of beta MOF printing inks on a different press cylinder and inker configuration.

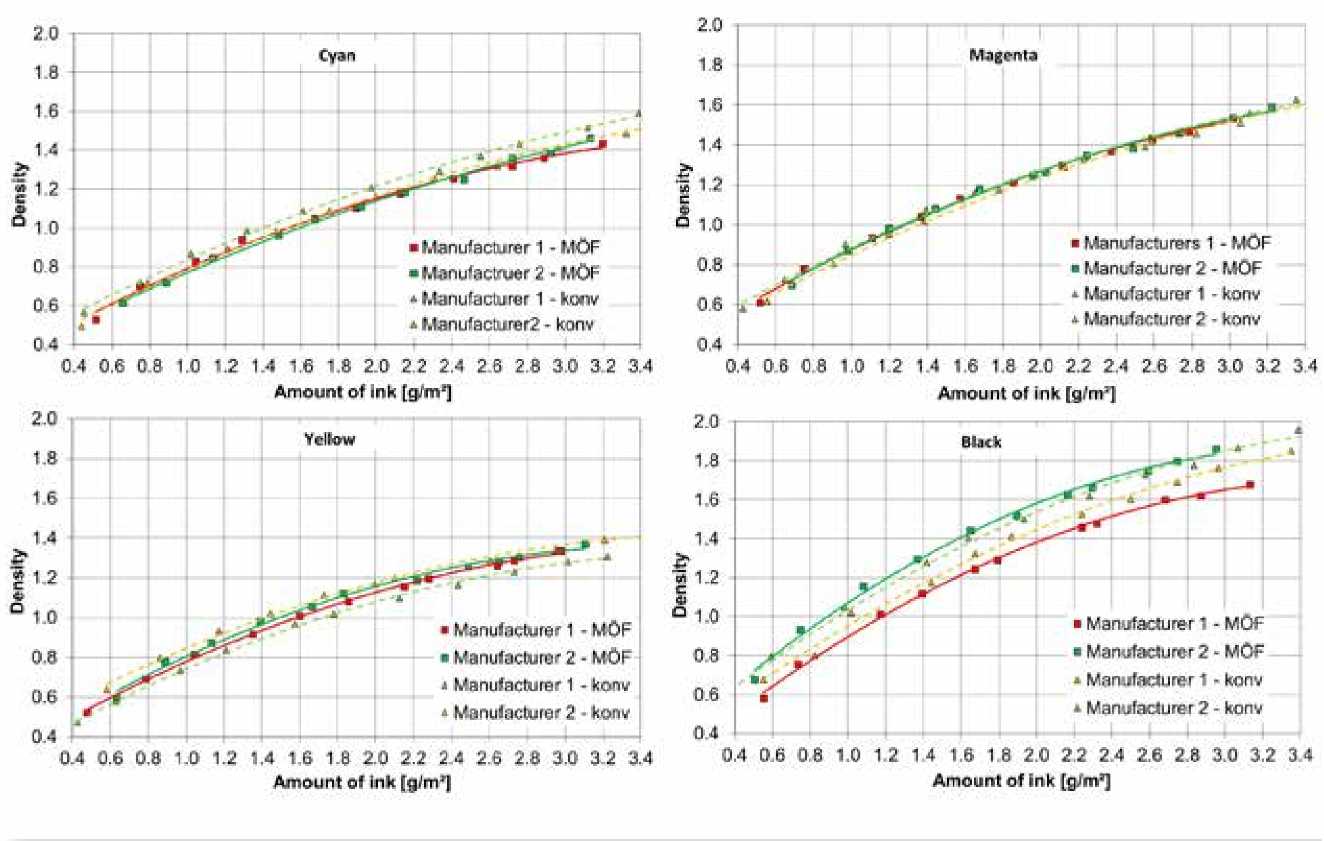
Short term trials

The inks had to be adapted to the different inker design (e.g. bottom-mounted doctor blades instead of top-mounted). These changes made printing tests necessary to ensure the general usability of the inks for the long-term tests and to avoid damage or product failure. The test procedure was similar for the UBA project using inks from two suppliers and two different types of newsprint.

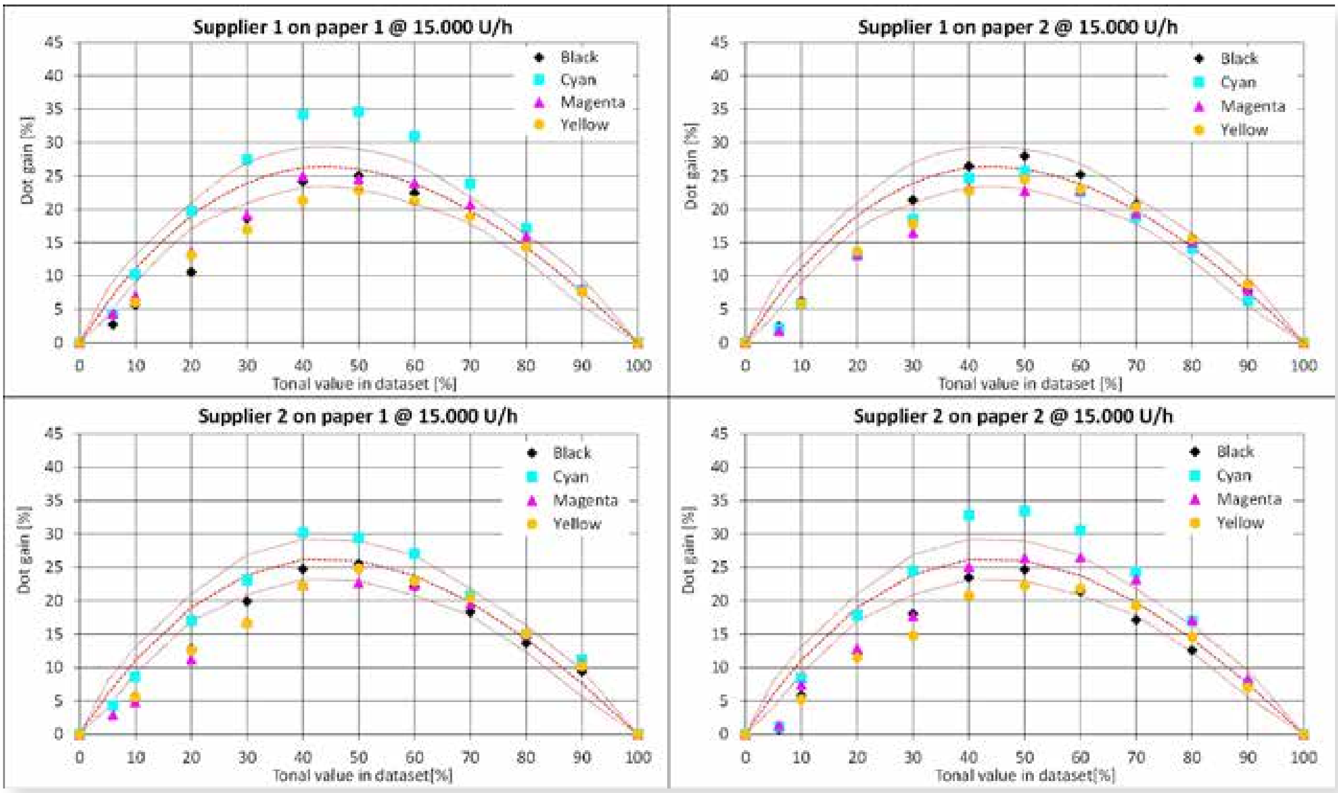
Printing properties

The printing properties were assessed by the printers on the basis of the printed copies. Particular attention was paid to the solid areas of the individual colour tones (CMYK).

The inks of both manufacturers showed a slightly increased water absorption. However, the ink/water balance of the MOF inks was within the usual range for Coldset inks. The printers rated the printing properties of both inks as good, and the run clean of the plates showed no problems. The solid areas of both inks showed no, to very little, cloudiness (or mottling) — an unintentionally uneven, cloudy or patchy appearance in the print. Only the second version of the Black ink from manufacturer 2 had to be readjusted before it was used in the long-term test.



Ink yield of the conventional (konv) and mineral oil free (MÖF) inks. Source AGRAPA/Fogra



TVI of MOF inks from supplier 1 (top) and supplier 2 (bottom) on both papers with the target values from ISO 12647-3 (red dotted lines). Source AGRAPA/Fogra

Ink consumption and soiling

Both the ink consumption and the soiling behaviour were examined as the UBA project. Soiling was rated uncritical by the printers and the consumption of the MOF inks is comparable to conventional printing inks from both ink manufacturers

TVI (dot gain)

The results (below) show TVI curves together with the target values and tolerated deviations (red lines) defined in ISO 12647-3. The measurements were made on prints produced at a speed of 15000 rph. TVI conformed to ISO 12647-3 over a wide range, except for some low dot gains but there were no problems in printing colours correctly. The platesetter curves were not adapted for the new inks and are therefore not optimal, adapted curves would bring a significant improvement in TVI curves.

Swelling properties

The qualified inks of both manufacturers showed no noticeable swelling or shrinkage effects on the roller materials. The change in hardness was inconspicuous. From the point of view of the elastomer manufacturer, the printing inks could also be approved for the production tests.

Long-term production printing evaluation

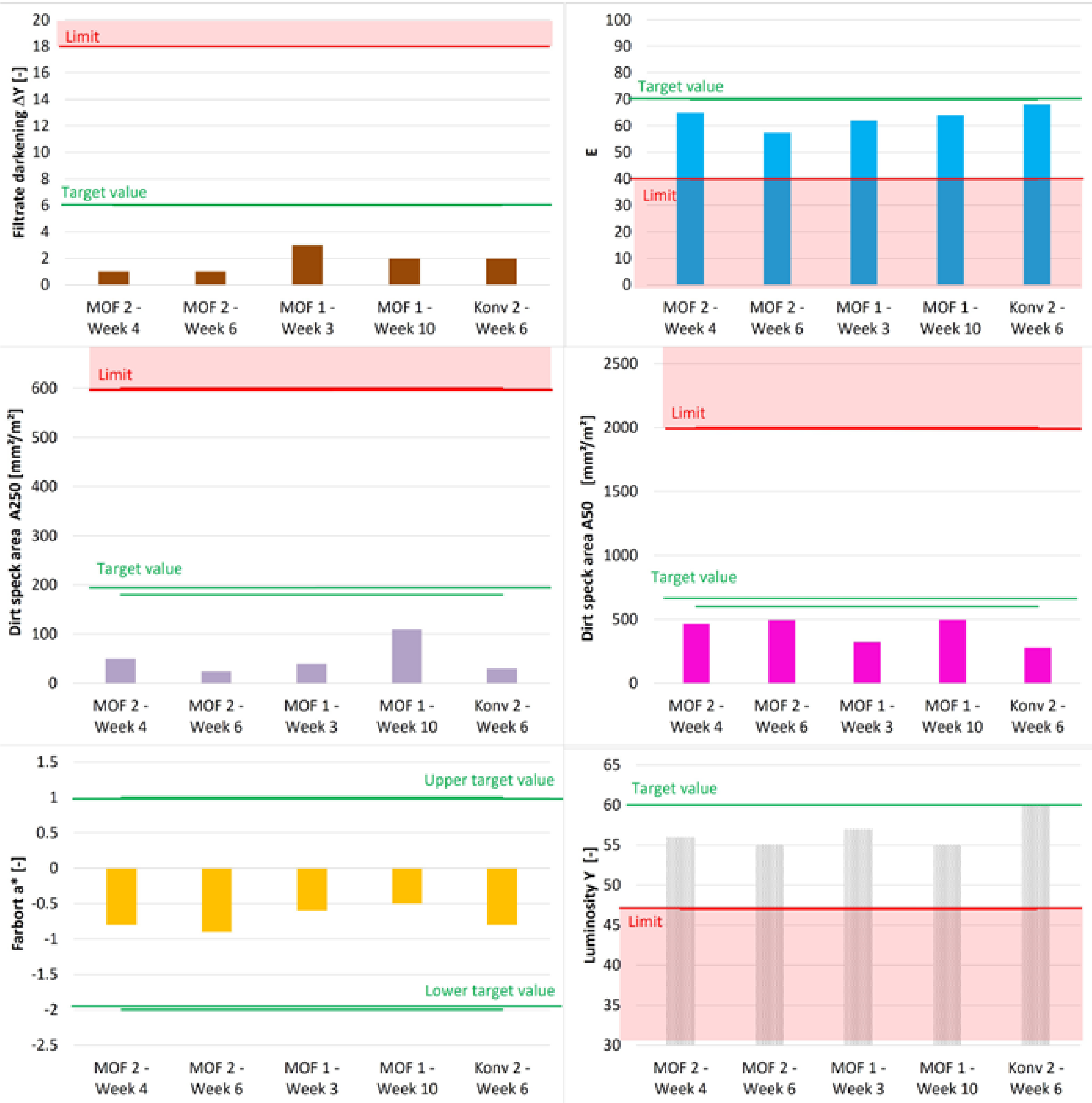
MOF inks were used to print sales copies of the newspapers over a period of about three months using inks from both suppliers. Standard production parameters of the printing plant were followed with a printing speed of up to 40 000 rph. The weekly production volume was around 500 000 copies. These tests used a total of 25,5 tonnes of ink (4,5 t of Black of both suppliers, and 7,5 t, and 9 t of CMY from suppliers 1 and 2 respectively). Test formes were also printed to determine the mineral oil content of the individual inks. Samples of sales copies were taken at comparable times and examined for their deinking behaviour to the INGEDE 11 method.

Deinking behaviour

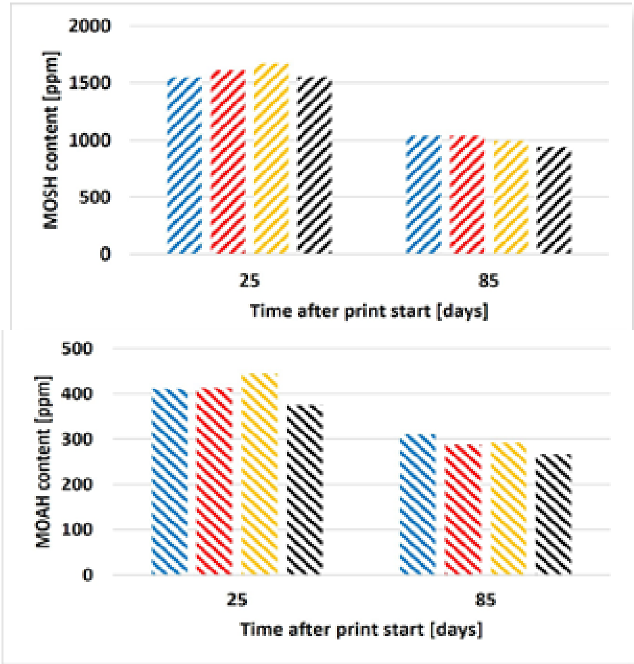
Tests were made at the same times as the print tests to assess recyclability using the INGEDE 11 method to determine the deinkability of printed products on a laboratory scale.

In general, the deinkability of the MOF ink printed products is good. To make better comparisons between the inks requires not only to look at the deinkability scores but also the absolute measured values as shown in the tables. Overall, the somewhat poorer deinking results are mainly due to the lower brightness of the samples with MOF inks, as it was the case of the CITEO-Fogra round robin tests.

The individual absolute measured values are mostly better than the deinking results from the earlier UBA project. Above all, the dirt specs are lower and also the ink elimination is more comprehensive with the ink-paper combination tested in this project.



Measured values from the deinkability tests for the printed products with MOF printing inks from supplier 2 (MÖF2) and supplier 1 (MÖF2). For comparison, the measured value for a printed product with conventional printing ink from supplier 2 is shown in each case. Source AGRAPA/Fogra



MOSH (top) and MOAH (bottom) contents of the individual solid prints of each ink from supplier 2; samples taken from a test print form printed at different times during the long-term tests. Source AGRAPA/Fogra

Mineral oil content of the printed products

The mineral oil content of the printed products was tested at the beginning and end of the print tests. Between the tests with the ink series of the two ink manufacturers there was a gap of about five months. (During this time, the press ink supply system was filled with conventional inks so that the second test period with the inks from manufacturer 1 started under similar conditions to those with the inks from manufacturer 2.) The mineral oil content was measured individually for each ink. The samples were taken from the solid surfaces of the test formes. The determination was carried out in accordance with the method recommended by BfR.

The table shows the measured mineral oil content of the printed products with the inks from manufacturer 2. At the beginning of the printing tests, the ink tanks were not completely emptied so that, initially, residues of the conventional printing ink were still present. This manifested in increased levels of both MOSH and MOAH components. Over the duration of the test these MO contaminants were discharged from the press, which is shown in the decreasing amounts of mineral oil — MOSH decreases by approx. 40% and MOAH by approx. 30% over 60 days.

New generation printing ink experiences

In general, the press makeready copy is slightly cloudy, especially in larger solid areas with high ink coverage, in the MOF ink series. This is especially true for Black ink. The ink-water balance differs significantly for both MOF ink series to that of conventional inks. This means a higher amount of fountain solution must be used during the makeready to keep the printing plates free of ink. However, during the production run the amount of fount solution needs to be reduced to avoid emulsification of ink and fount solution and the effect of toning. This change in water flow is probably also responsible for the slightly increased waste of about 30% at the first makeready copy compared to conventional inks.

The colour reproduction when printing with MOF inks was comparable to conventional inks. The printing company's house colours could be printed colour-fast. No significant additional ink consumption was detected.

The soiling behaviour of ink from manufacturer 1 was somewhat more pronounced and required more frequent cleaning of the folder formers and bars. The ink from this manufacturer had a stronger tendency to mist, especially at higher printing speeds, particularly in Yellow. However, the Heilbronner Stimme printers rated this as non-critical.

Conclusions

The three-month production tests used around 4500 kg of black and between 2000 to 3000 kg for each colour (CMY) at press speeds up to 42 000 rph.

The inks could be used for production according to the printers and the shift supervisor. Only the soiling behaviour increased with one of the two ink series compared to the conventional inks. The printing of large solid areas with high ink coverage sometimes showed increased cloudiness. The ink/water balance of the new inks is different from that of the conventional inks, but this did not impair printability.

The deinking behaviour of the MOF inks according to INGEDE Method 11 was rated as good, and more positive than in the previous project.

The mineral oil content of the printed products was measured twice during the test period. A reduction of 30-40% was observed with the inks of one manufacturer.

With both ink series it was possible to carry out the long-term print production tests over three months without interruption. This showed that it is possible to use MOF printing inks in practical newspaper production at the current state of the art.

2.5: CITEO Heatset ink evaluations at eight sites - 2021

CITEO organised these Heatset printing tests with Low MOH inks reduced in mineral oils to meet the criteria of the 2021 French eco-modulation regulations. To encourage the early adoption of reduced mineral oil inks, a progressive malus was introduced in the eco-contribution (paid per tonne of all printed paper) in 2021 and was increased to 20% in 2022. This applied to printing with traditional Heatset inks containing more than 1% of MOAH and 1,5% of MOSH with carbon chains between 20 and 30 carbon atoms.

Prior to these tests, CITEO evaluated the availability and performance of Heatset inks that met the regulatory requirements of reduced MOSH and MOAH content, deinkability and printability. Alternative inks with reduced mineral oils that respect these limits were already widely used in Germany (conforming to the Blue Angel label) but were in limited use in France. Unlike MOF vegetable oil inks these inks can be described as "low MOH" as the ingredients are similar but their manufacturing is more complex. In Heatset, the MO are mostly evaporated and used as energy in the dryer, leaving only a low presence in the printed product.

The purpose of these trials was to evaluate the performance of alternative Heatset inks with reduced mineral oil content under real production conditions. The tests were carried out with eight printers using Blue Angel inks from Brancher, Flint and Sun Chemical.

Printers & presses

The participating printers are representative of the French Heatset offset sector's diversity of products, location, size and equipment. They cover the entire printing market: leaflets, flyers, magazines, catalogues, free newspapers, school books, etc. Their clients may be direct customers (publishers, industrialists, public players, real estate agencies, etc.) or production agencies. The print runs are generally between 5,000 and 500,000 copies.

These tests evaluated the impact of these inks on print production and their compatibility with existing equipment. One press was selected at each site to run alternative inks for one month. Each company selected three jobs typical of its normal work (product and paper types) to test print with alternative inks under standard production conditions for one month of continuous use. They were then compared with the equivalent jobs previously printed using traditional inks on the same press. This ensured that a wide variety of product types and papers were printed under full commercial printing conditions. All 24 jobs were printed with alternative inks and sold to customers.

Paper & Printed Products

As each printer had to print three different products, more than 20 different paper grades were tested, including newsprint, enhanced newsprint, SC (super-calendered), LWC (lightweight coated) and coated with a wide range of weights from 39 to 115 gsm. Papers were supplied by Holmen, Lecta, Leipa, Kabel, Norske Skog, Perlen, SAPPI, SCA, Stora Enso and UPM. Three printers carried out tests on papers containing between 50% and 100% recycled fibre.

The printed products varied greatly in nature (leaflets, free newspapers, magazines, catalogues, corporate communication, flyers), pagination (2 to 140 pages) and print run (10 000 to 6 900 000 copies with an average of 400 000 copies). Finishing was inline (glued, stitched, trimmed, varnished) or offline (stitched or perfect bound).

Printer	Location	Press	Size
FOT	Pusignan	GOSS M600	2 x 16 pages
IPS	Reyrieux	GOSS M600	16 pages
Imprimerie Cache	Balinghem	Komori S38	16 pages
La Galiote-Prenant	Vitry-sur-Seine	GOSS M600	16 pages
Mordaq	Aire-sur-la-Lys	Manroland Lithoman	48 pages
Newsprint	Lieusaint	Manroland Lithoman III S	64 pages
Rotofrance	Lognes	Manroland Lithoman	72 pages
SIB	Boulogne/Mer	KBA C818	72 pages

The presses used by participating Heatset printers.

Inks

The inks tested were supplied by three different suppliers. One of them supplied, in addition to the standard range (CMYK), a range of Black softened inks. One company also tested the application of an inline varnish. The ink suppliers confirmed that the inks tested had the same pigment concentration as the standard range used at the printers. The presses used were supplied from one-tonne containers, with the exception of one company which used a large bulk tank.

Test protocol

The presses were run continuously for more than a month with the alternative inks for these tests. Each printer selected three products that were representative of their activity and that provided a good variability (type/paper/run). Each printer made three comparative product evaluations (a total of 24).

The production data for the three products printed with the alternative inks were compared with the data for equivalent products printed with traditional inks. These tests were carried out under real production conditions as part of the company's normal production and were delivered to customers.

Following the tests, a report was provided by each site that included quantitative data, an evaluative matrix along and feedback from production staff. (Two printers called on PAGORA engineering university students, one of them carried out comparative laboratory tests between the two types of inks.)

Performance compared to traditional inks

Each printer made a structure evaluation of the printing performance of the alternative inks in comparison to their standard inks.

1. **Printing speed:** No significant change in print speed. While two printers noted a slight decrease in print speed, five other printers noted no change and the last printer noted a slight increase, which may be associated with better setting.
2. **Trapping:** The opinions were unanimous: no trapping deviation was observed.
3. **Press printability variations:** Two printers had to change their fount additive in order to recover good print stability. Otherwise, among the few modifications observed, three printers noted an increase in the transfer of Cyan, which can lead to a greening of the rendering for flesh tones. One printer also monitored the quality of Yellow coverage.
4. **Ink-water balance:** Three printers, including those who had to change their fount additive, saw a difference. None of the others noticed any difference. There was no correlation with the ink as none of the three printers used the same supplier. One reported a perceived difficulty, another that "more fine-tuning" was required.
5. **Behaviour at speed change:** No noticeable change was observed. The speed changes did not affect inking stability.

Printing characteristics

	Printing characteristics	*Heatset printers* 1	2	3	4	5	6	7	8
1	Printing speed	—	=	=	=	—	=	=	=
2	Trapping	=	=	=	=	=	=	=	=
3	Press printability variations	—	=	=	=	=	=	=	=
4	Ink-water balance	—	=	+	=	—	=	—	=
5	Behaviour at speed change	=	=	=	=	=	=	=	=
6	Start-up sequence	—	=	=	=	=	=	—	=
7	Blanket build-up & cleaning	=	=	=	=	=	=	=	—
8	Smearing / set-off / marking	—	=	=	=	=	=	+	—
9	Build-up on path rollers	—	=	=	=	=	=	=	=
10	Ink misting/splatter	=	=	=	=	=	=	=	—
11	Changes to heatset dryer settings	=	=	=	=	=	=	=	=
12	Web temperature at dryer exit	=	=	=	=	—	=	—	—
13	Comparative gas consumption	=	=	—	=	—	=	—	—
14	Other	+	=	=	=	=	=	=	=

Performance compared to traditional inks	Better	Same	Worse
	+	=	—

Average of the weekly performance assessment by the press crew at each site: + Better / — Worse / = Same. Source CITEO/Ecograf.

6. **Start-up sequence:** Two printers observed an increase in makeready time (one due to the difficulty of obtaining the right water/ink balance), which led to an increase in waste. A second reported a risk of paper curling at the blankets, especially for low grammages. This may be due to an increase in the tack of alternative inks. The others observed no difference. The use of softened ink did not change this sequence either.
7. **Smearing / set-off / marking:** Two printers noted an increase in roller splatter due to the lower viscosity of alternative inks. One printer also observed an increase in blanket deposit. No change was observed by the other printers, who did not change their wash-up frequency.
8. **Build-up on path rollers:** The same printer who noted an increase in misting observed an increase in the frequency of washing. The others did not notice any significant change.
9. **Ink misting/splatter:** One printer observed an increase in misting of the Magenta. Nothing was reported by the other printers.
10. **Changes to Heatset dryer settings / Web temperature at dryer exit:** Two printers reported a slight (+5°C) or significant (+10°C) increase in web exit temperature, another saw a decrease of 15-20°C. None of the other printers experienced any change using the alternate ink.
11. **Comparative gas consumption:** Two printers reported an increase in dryer temperature. This data is not readily available to all printers; however, one of them measured an increase for all three printed products (between +2,7% and +3,7%). This increase was observed even though the web exit temperature was constant. Another printer (who did not carry out a consumption measurement) expects a slight increase in consumption due to the higher output temperature.
12. **Other**

Ink odour: Two printers, not using the same ink, observed a decrease in odour.

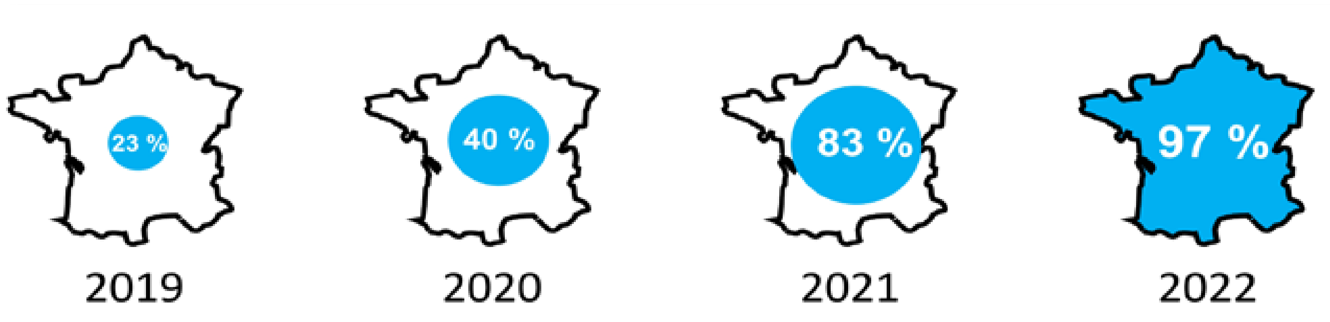
Ink consumption: Some printers noted slight variations, a decrease on some products and/or a slight increase on others. Two printers reported higher ink consumption more precisely (+3% and +10%) but this can be attributed either to the variation in the visuals of the publications compared or to the change of ink supplier (possible variation in pigment concentration). The other printers did not experience any change when changing the ink.

Longer term behaviour: One printer pointed out the need to evaluate the abrasiveness of the new ink over the long term. Another indicated that the Magenta may be more aggressive, which means that plate and blanket wear should be monitored. The impact on gas consumption needs to be better assessed.

Conclusion

At the end of the trials, the eight participating printers chose to continue to use these alternative inks on all their machines. These trials demonstrate the collective motivation of the printers to help improve the development of a circular economy. They have technically validated alternative inks from three different suppliers that are lower in mineral oils and more compatible with paper recycling.

Two of the printers experienced no noticeable change when switching to alternative inks, while for the other six only some minor modifications were required, which is consistent with any change of ink. Most of the counter-performance was relatively minor and not consistent across all participants. The consolidated test results showed limited changes or no change to performance.



Progression of French Heatset printers using low MO inks (estimation CITEO 2022 from a panel of 31 printers.)

The tests were carried out under real production conditions; the alternative inks demonstrated:

- Satisfactory printing of the selected products on all substrates including recycled papers (shorter fibres than virgin pulp).
- Paper weights from 39 to 115 gsm were validated.
- Productivity was maintained without any particular adjustment or modification of the usual work of the production staff. The most notable adjustment was the modification of the damping additive for two printers who changed the ink supplier for alternative inks.

Two points identified at the end of the trials are: the additional cost for printers to use these alternatives and the lack of visibility on gas consumption.

From a financial point of view, alternative inks represent an increase in the purchase price of 3-5%. This additional cost will tend to be diluted in general price increases.

Gas consumption is difficult to measure by the printers on individual machines. The consumption should be evaluated more precisely over time to ensure its stability.

All the printers who participated in the tests consider the experimentation as "a positive feedback" and that "the change was successful" or "went smoothly". One of them considers that "the replacement of the inks had a very low impact" and therefore "encourages other printers to adopt this approach".

Epilogue

Prior to these trials the Blue Angel inks with reduced mineral oils were used by less than 20% of Heatset printers. A few months after completion of the evaluation their use increase to over 95% of French printers. The Blue Angel inks tested are a Low MOH series that comply to the current CITEO Recommendations but will not conform with French regulations in 2025. If they become MOF formulation their price will increase in a similar manner to Coldset MOF.

Chapter 3

Implications of changing to MOF inks

Implications of change

This section focuses on the implications of adopting the latest generation of Coldset MOF inks that were subject to large scale print trials in France and Germany. To a lesser extent it addresses Waterless and Heatset Low MOH inks.

1: Deinkability

The deinkability of MOF Coldset inks improved over the time of the different research projects. The different types of papers tested are now normally rated as "good" on the INGEDE deinkability score. Nevertheless, the deinking performance has not yet reached the level of conventional Coldset inks, mainly due to poorer luminosity values, the dirt speck areas and the fibre yield. The latter may not have a major impact because this laboratory parameter has no second fibre recovery step that is common in the paper making industry. However, a leading paper maker indicates that fibre loss over 5% will have a negative impact on efficiency and costs and should, therefore, be monitored.

Luminosity is a more critical parameter. It can already be difficult to obtain the required luminosity of papers made from recycled fibres. Newspapers are still an important source of recycled fibres and the introduction of MOF inks may increase this problem if no bleaching step is made. The dirt speck areas can have an impact depending on the ink manufacturer and paper used. As a rule, both values (A50 and A250) are slightly elevated compared to conventional inks but normally this does not affect the deinkability score.

There will be some impact of the new MOF inks on deinking but the process itself will not be disrupted or break down. The most recent results indicate that more optimisation will be needed to adjust the inks and the deinking process to attain a high quality of recycled paper. This may be an adaption of the ink formulations or the deinking.

Reducing the TIC of newspaper printing may improve brightness of recycled paper originally printed with Low MOH inks. An initial test with a reduction from 220 to 200% showed no tangible result. Further research may be required to better understand this relationship.

2: Roller coverings

One of the main problems at the beginning of the development of MOF Coldset inks was the interaction with the roller material. It took a long time to qualify the inks for the roller coverings used in the press used for the first alpha print trials.

Results from the most recent beta projects show that the common roller materials for both ink and fountain rollers can be used with the new generation of inks from the five ink manufacturers concerned. These inks did not show severe swelling or shrinking influences on the materials. It is useful to bear in mind that conventional inks will generally cause some change in diameter, so the results from an MOF test should be evaluated with this in mind and that the swelling/ shrinking is within the recommended limits. It is important that print plants check with their ink supplier that their roller materials have a good compatibility with the inks to be used before starting to print with them. As more pressrooms use these new inks more experience will be available to manufacturers to give reliable recommendations. Further ink developments will require additional roller material compatibility tests. However, sheetfed MOF inks have evolved in the same way and the roller compatibility is not a problem.

During the long-term printing trials in France and Germany, the roller nips in the press units were measured before and after using MOF inks (outside and centre diameters and Shore A hardness). The evolution of the circumferences of the dampening and inking rollers and of their hardness had no impact on the production conditions. When the circumference of the rollers varies, this evolution is always weak shrinkage. The evolution of Shore hardness is more complex, one printer having noted a small increase and another a small decrease.

Swelling properties

The two tables opposite show the results of the swelling tests with the limit values recommended by the manufacturer for the elastomers. The qualified inks of both manufacturers showed no noticeable swelling or shrinkage effects on the roller materials. From the point of view of the elastomer manufacturer, the printing inks could also be approved for the production tests.

3: Printability

The colour reproduction quality of MOF inks is now comparable to conventional inks. Only the tendency to show higher cloudiness in solid areas with high ink coverage may require some adaption by some of the ink manufacturers. Some printers noted an improvement in quality and consistency of the Black ink.

Evaluation of the printing behaviour of all print trials was carried out without modifying the TVI platesetter curves (defined for MO inks) and was, therefore, not optimal. However, no reader or advertiser complained about the quality of the printing produced during these tests. Adapted TVI curves should significantly improve reproduction performance; it is likely that a single new curve will fit all MOF inks as it is the case for conventional inks.

The first generation of MOF inks had problems with paper scumming, streaks on the plate edges and fogging on the printing plates. The viscosity of some inks changed after four to six weeks of production, creating printability problems. During the recent beta trials those problems were solved and they showed good print quality.

Printers commented after the recent AGRAPA trials that some printed copies from both MOF inks were slightly cloudier than with MO. This was visible in larger solid areas with high ink coverage and for Black. This change in water flow is probably responsible for the slight increase of waste but did not impair printability. One ink set was found to have soiling behaviour that was worse than with conventional inks and this increased cleaning of the folder formers and turner bars.

The feedback from printers in the research projects corresponds to those from the multiple short printing trials made in other German and French printing plants: that the overall printability with MOF Coldset inks is good and no problems are to be expected when introducing them to a printing plant.

	Ink	Ink-/Fountain roller	Fountain roller	Ink roller		
		Elastomer 1* DV [%]	Elastomer 2 DV [%]	Elastomer 3 DV [%]	Elastomer 4 DV [%]	Elastomer 5* DV [%]
Supplier 1	Cyan	0,8	3,6	2,9	2,5	3,6
	Magenta	0,5	2,6	2,4	2	2,6
	Yellow	1,4	3,3	3,4	2,8	3,5
	Black	-2	-1	-0,4	-1	0,1
Supplier 2	Cyan	-2,3	0,7	1,3	0,1	1,2
	Magenta	-3,0	-0,4	0	-0,7	0,4
	Yellow	-1,9	0,6	1,8	0,8	1,9
	Black	-0,2	-2,5	-1	-2,3	-0,9
	Limit value	+5 / -3	+5 / -3	+5 / -3	+5 / -3	+5 / -3

	Ink	Ink-/Fountain roller	Fountain roller	Ink roller		
		Elastomer 1* DH [ShA]	Elastomer 2 DH [ShA]	Elastomer 3 DH [ShA]	Elastomer 4 DH [ShA]	Elastomer 5* D H [ShA]
Supplier 1	Cyan	1	0	-1	-1	1
	Magenta	-1	1	0	-1	-2
	Yellow	-2	-2	-2	-2	-2
	Black	1	1	1	0	0
Supplier 2	Cyan	2	-1	1	1	-1
	Magenta	1	0	1	2	0
	Yellow	0	-1	0	1	0
	Black	-1	0	2	3	0
	Limit value	± 3	± 3	± 3	± 3	± 3

Upper table: Volume change (Delta V) caused by the printing inks qualified for the long-term test on different roller materials. Lower table: Change in the ShoreA Hardness (Delta ShA) caused by the printing inks qualified for the long-term test on different roller materials. Those marked with * are installed in the Heilbronner Stimme press. Source: AGRAPA/Fogra

4: Runability

Print stability: Judged to be equivalent or better than traditional inks.

Ink/water balance: This is different to conventional inks but does not impair printability. MOF ink may require a higher quantity of fountain solution during start-up to keep the plates ink free. In France, two printers observed a reduction in the need for dampening water, which is an improvement, while in Germany printers needed more to avoid emulsification and toning.

Fountain solution and washing agents: Current products can continue to be used without change. The damping solutions were standard commercial products for Coldset that were not optimised for MOF newspaper inks.

Printing speed: There were no reported impacts on maximum press speed, or speed change.

Start-up sequence: No significant changes were found with either a hot or cold press.

Blanket build-up: The impact of MOF inks can be considered as negligible or nil.

Soiling and smearing: One printer noted an increase in spray but this did not interfere with production. Another printer noted a decrease in soiling. The increased soiling did not increase press cleaning time. Checks of former and idler bars and the suspended sheets of paper for spray showed that the soiling behaviour of the MOF inks is very low. Tests of printed products after offline finishing did not indicate foreseeable postpress problems.

Marking: In France a reduction of marking was seen with less ink transfer when the newspaper was rubbed after printing. If the reduction is confirmed, it probably comes from the application of the ink on press and/or ink formulation specificity.

Rheology: These properties are now stable for the normal lifetime of unprinted ink, which could be several months.

Evolution of the ink over time: During the third week of testing, one printer observed mould on the surface of the ink in tanks, but this did not develop during the following weeks — its presence and origin remain to be explained. Another noted, during the first week, the cleanliness of the ink ducts and the maintenance of the freshness of the inks. At the end of the test, the weak presence of rigid ink in the ink fountains was noticed; on the other hand, the same printer notes a too strong viscosity of Black.

Other: One printer reported a strong and unpleasant odour of the inks tested — the filling of the ink ducts from buckets could have contributed to the diffusion of this odor.

5: Ink logistics & contamination

The MOF ink manufacturers stated that no mineral oils are present as constitutional components of their inks. However, the manufacturing processes, logistics and print site conditions are potential sources of MO contamination:

- Ink manufacturing systems currently produce batches of both conventional MO and MOF inks on the same line and it is not possible to completely clean all traces of mineral oils from them.
- Reusable transport tanks and bulk tankers used for both MO and MOF inks risks contamination.
- Contamination on the press from underground tanks, pipes, pumps and elastomers.

The first two causes will only be eliminated with the use of dedicated MOF manufacturing and logistics. However, none of the suppliers can today envisage dedicating a line to the production of MOF inks until the market is sufficiently developed at a European level.

When the printer decides to completely change to MOF ink there will be an initial period of contamination that will normally disappear over several weeks..

Questions concerning the necessity or not of purging and cleaning the whole ink supply network or the possibility of mixing a remainder of MO ink with MOF inks needs to be better understood. However, MO and MOF inks appear to be compatible. One printer at the end of the test progressively replaced the MOF inks as they ran out by MO inks without washing the ducts or pipes. This period lasted one month and the use of MO and MOF inks simultaneously on the same tower did not disturb printing stability and quality. The experiences in both France and Germany were similar.

The decontamination of bulk ink tanks will need to be reviewed between the printer and their ink supplier. Even after the MO ink has been pumped out of the tank there will remain important residues that will contaminate the incoming MOF inks. To avoid this requires thorough cleaning that can be expensive and needs to be well planned.

6: Ink consumption

Along with price, ink consumption is a fundamental factor in evaluating the economic viability of using MOF inks. In general, the measurement of ink consumption found that for the same pigmentation and TIC, the MOF inks yield similar values to MO inks. The printers generally confirmed these results, although one reported a reduction of ink consumption of around 15-20% on Black, but no reduction on the process colours; this was for a single MOF ink and needs to be confirmed by more measurement. Consumption is also influenced by different parameters for the ink, press and paper surface.

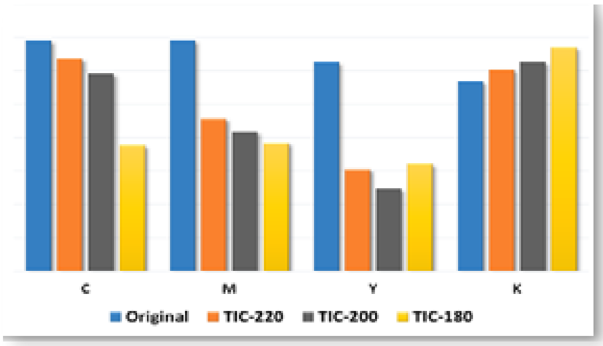
There are two accepted methods for measuring ink mileage. In the first, inks are tested at their site of production, usually on the basis of ISO 2846-2, and the Bertholdt, Zins and Schless method for measuring the mileage. In the second, the mileage was evaluated at the printer (FSD) using its standard method of printing at reduced speed and applying solid ink at a defined colour density (1,1 for Black and 0,9 for CMY). The quantity of ink transferred to the paper is then weighed. The results from the two methods were so similar that they provided a good basis for communication between printers and ink makers.

Minimising ink consumption

The reduction of ink consumed per printed square metre may compensate for some of the additional cost of MOF inks. One solution may be the reduction of total ink coverage (TIC) as recommended in previous WAN-IFRA Reports (2021 "Guide to printing using 40gsm newsprint" and 2018 "Implications of changing to lower grammage newsprint"):

"The reduction of TIC not only reduces the quality defects and improves the visual quality, but it also results in significant savings. The chart projects the savings by reducing TIC.

- As the graph shows, while the reduced TIC saves ink (reduces the consumption) in CMY, it simultaneously increases the consumption of Black, as the profile also applies some GCR that replaces neutral Black and greys (produced by near equal amount of CMY) with the single colour Black.
- While the reduction to TIC 220 brings 10,18% saving of coloured inks, it results in a minor rise of 1,78% in consumption of Black ink due to GCR application.



Ink coverage comparison 220 to 180 TIC Source WAN-IFRA

- Additionally, moving to TIC of 200 potentially saves 12,5% of coloured inks, and increases 2,89% in consumption of Black ink.
- And, further move to TIC of 180 saves 15,43% of coloured inks and leads to additional consumption of nearly 5% in Black ink.

"Even though the reduction of TIC saves on ink consumption, it's the roughness of the newsprint and the vehicles (solvents, etc.) of the ink that influence the consumption to a large extent. So, the percentage of savings might vary depending on the combined printability properties of the newsprint and ink." UCR/GCR can also modify ink consumption sometimes in an unpredictable manner and should be reviewed.

Other benefits from the reduction of newsprint from 42,5 to 40 gsm are 5,9% increased yield to reduce paper costs, roll changes, core and stripping waste, a lower shipping weight and carbon footprint. Reducing the TIC of newspaper printing may also improve brightness of recycled paper.

7: Economic evaluation

The price of MOF inks is higher than those of traditional inks. This is mainly due to the cost of petroleum solvents today (2023) that are lower than the cost of vegetable oils. The price volatility of these oils depend on diverse parameters linked to supply and demand, climatic and geopolitical conditions. It is not currently expected that the costs of vegetable oils will decrease.

MOF ink is currently a low volume niche market that requires suppliers to stop and clean their MO production lines. While a dedicated line for making MOF inks is not expected to reduce processing costs by much, it should reduce contamination substantially.

The relative importance of the economic impact of MOF has been evaluated on the indications and information from different printers and ink suppliers. As an example, the additional cost announced by one Coldset supplier indicates an increase of 100% for Black and 40% for the process colours. The variables between a specific ink supplier and a printer will need to be individually calculated to obtain a more precise estimate.

Web offset cost variables

The added supplier costs to produce MOF inks with different raw materials is subject to some variables that differ between the three web offset processes considered. The additional costs per kg are an indication of scale. However, a simple extra cost per kilogram does not provide printers and publishers with enough information to calculate their additional costs. Factors that need to be considered when calculating the influence of ink on the printing cost per square metre of paper include:

1. **Ink consumption:** The yield of the MOF inks is similar to those containing mineral oils if pigmentation and TIC is the same.
2. **Total Ink Coverage:** The lower the TIC, the lower the ink consumption. Coldset ranges from 180 to the 240% ISO standard. Heatset TIC tends to be <280%.
3. **Process:** Each web offset process uses different ink compositions, raw materials and manufacturing, which results in different purchase price levels:
    - **Heatset Blue Angel Low MOH*:** Ink cost is 2-5% above conventional formulations. Black is about 90% the price of a CMY colour. (As a generalisation, Heatset MO ink has a slightly lower price than Coldset MO.)
    - **Waterless Low MOH*:** CMY costs around 25% more than MO, while Black is about 80% price of a process colour. Hybrid Heatset uses the same ink as Coldset. These inks may include some vegetable oils. (As a generalisation, Waterless MO inks are about 25% more expensive than Coldset MO.)
    - *When these inks transition to full MOF vegetable oil-based ink, their prices are expected to increase by a similar proportion as Coldset MOF CMY.

- **Coldset classic MOF:** CMY costs 25-40% more, with Black about 100% more. This large difference is because Black MO inks currently use low-cost ingredients (e.g. black varnish and carbon black pigment) making them about 40-50% the price of a CMY ink. However, an MOF Black requires a clear varnish with pigment which is similar in composition and price to CMY. In addition, newspapers uses a much higher proportion of Black, which accounts for 30-50% of total CMYK ink volume.

These price levels are consistent with those of the US in 1995 when news inks converted from MO to soya with a 25-30% higher price for CMY and double for Black.

The impact of cost also depends upon its context:

1. **Purchasing:** Direct comparison of the cost of an MO vs an MOF ink.
2. **Production management:** Concerned by overall production cost including consumables (paper, ink, plates), energy, staff, along with efficiency of runability and printability.
3. **Publisher:** How much does an additional cost impact on sales cost of a newspaper and its margin? Concerns also include quality and environmental perception by readers, advertisers, staff and society generally.

Ink as a proportion of total publishing costs

Although the increase in ink cost is significant, the share of ink in total newspaper costs remains relatively low. Three examples provide an order of magnitude:

- One of the printers who participated in these tests estimates that the cost of producing a newspaper represents 55% of the total cost including editorial, administration and distribution. Ink represents 3% of this 55%, or about 1,5% of the total cost.
- In 2022, the French regional newspaper “Ouest France” gave its readers a breakdown of its total costs: Editorial, administration, digital services and distribution 80%, paper 10%, manufacturing 9% and ink about 1%.
- The Swiss newspaper publisher TaMedia AG with three printing sites stated publishing costs of 67% (editorial, marketing and other costs), print production about 33% of the total cost of publishing - 50% is logistics/distribution, 25% paper, 25% printing, with ink about 1,5% of the total cost. Source: Andreas Schaffer, World Printers Forum 2021.
- According to other printers interviewed, ink represents < 10% of manufacturing costs. This implies that ink is in the order of 1-2% of the total publishing costs.

While 1-2% of total publishing costs is modest, it is a dead loss to the press publisher, particularly if it difficult to increase the selling price of the newspaper.

The overall cost of ink depends on its purchase price and consumption. On the basis of a consumption common in France of 150 tonnes of ink per year, the additional cost for MOF inks would be about 200 000 €. This additional cost is a challenge to newspaper publishers experiencing a general increase in the cost of its consumables (paper, plates, inks, etc.) in a context of declining circulation.

Calculating additional MOF ink costs vs MO

To ascertain the exact cost impact, a newspaper printer should identify the proportion of Black ink to CMY — newspaper printers in the trials had a black ink proportion from 25-47%. This will then allow a simple calculation of the additional kg cost of CMYK in their plant.

8: Environmental considerations

The replacement of MO printing inks is an important step towards eliminating undesirable substances in paper recycling and providing benefits to consumers and the environment. The paper recycling cycle is essential for the circular economy. Direct and indirect food packaging material produced from recovered paper is significantly more resource-efficient with lower-emission production compared to the use of virgin fibres. However, several studies have found that mineral oils from recovered paper can migrate from packaging to food, even through intermediate packaging.

- Removing mineral oils from printed ink is an upstream improvement to the circular economy.
- Human health will be better protected from the ingestion of mineral oil via food from waste paper-based packaging.

These positive environmental improvements are seen to be of value to newspaper publishers, advertisers and readers, as well as to printing production staff. The adoption of MOF inks has social (health impact) and environmental (replacement of fossil resources by renewable resources) benefits and meet the objectives defined in CSR policies. For example, in France the printed WAN-IFRA cuboid targets were accompanied with an educational message for readers.

The ink suppliers agreed that the use of raw materials from coconut or palm oil is not permitted.

More attention to chemical assessment and management and consistent development and design for recycling is a prerequisite for circular economy.

Lower level of contamination will allow better barriers

The complete conversion of printing inks will not be sufficient to completely free the waste paper cycle from all mineral oil inputs as small amounts will continue to be contained in diverse inputs and through the import of contaminated printed products. However, the lower level of contamination from using MOF inks will allow barriers for food contact papers to be produced with less or alternative materials. Eventually, it may become feasible to produce food contact papers from recovered paper with a barrier function that contributes to climate, resource and biodiversity protection. While human health will be better protected against the ingestion of mineral oil via food from waste paper-based packaging, other components of printing inks are also moving into focus as possible contaminants, e.g. polytetrafluoroethylene PTFE.

Availability of raw materials

MOF inks are made from vegetable oils. The tested inks exclude raw materials from coconut or palm oil. The availability and price volatility of these oils are influenced by diverse parameters linked to supply and demand, climatic and geopolitical conditions, and the use of these oils for diverse applications. The exploitation of vegetable resources, deforestation, competition with human and animal food, etc. are important subjects that have not been considered in this evaluation. This dynamic is currently too complex to make credible assumptions about trends.

The adoption of MOF inks will require mid- to long-term planning between printers and their ink suppliers to identify expected volumes and will only be possible under the condition that the suppliers can commit themselves to produce the expected volumes on time.

9: Changeover best practices

There are a few simple best practice steps to make this transition as smooth as possible:

1. Talk to your ink supplier well in advance. Availability of new raw materials for these inks requires important changes to their supply chain.
2. Verify with your roller supplier that the inks you will use are compatible with your inking and dampening roller covers.
3. Plan your ink logistics with your ink supplier. Running out inks from underground tanks requires planning and thorough cleaning to avoid contamination of the incoming MOF inks. The use of 1-tonne slip tanks is simpler to manage.
4. MOF inks can generally run alongside MO inks during a changeover period to minimise ink waste.
5. Ensure your ink supplier sends MDS sheets.
6. Communicate to your colleagues why the change is being made and how this will be done.
7. If you are considering reducing your TIC to minimise ink consumption (and facilitate change to 40 gsm newsprint) do this early as a separate sub-project.
8. Arrange with your ink supplier a bucket test if your press allows you to hand feed ink ducts. Run 20-50 kg per colour and more if needed for Black. Use the plates of a job already on the press with the same paper; this will give you and your crews an indication of the MOF ink's comparative operating characteristics.
9. Recalculate the TVI (dot gain) curves to optimise MOF print performance. It is most likely that a single new curve will fit all MOF inks, as it is the case for conventional inks. The dampening curves should also be reviewed for MOF.
10. Some printers start by running a single tower with MOF if their ink supply system permits.
11. Make an environmental promotion/event from the changeover to MOF with staff, publishing team and clients. Promote with readers.

Conclusions

The transition to MOF inks is being driven by France and Germany, who represent about 35% of Coldset newsprint consumption in Western Europe. They are taking different paths to the same end: French regulations from 2023, and voluntary transition in Germany from 2025.

Both countries have the same objectives for the development of new MOF inks:

1. Conformity with MOF definitions of ink components.
2. Compatibility with existing press, rollers, consumables and papers.
3. Print quality equivalent to the existing quality of standard MO inks.
4. Newspapers printed with MOF inks should be deinkable.
5. Purchase and operational costs should be viable.

The first four parameters have been fully met, operational costs are unchanged but ink purchase price is higher. MOF inks are now fully developed and are fundamentally suitable for use in practice. All the printers and ink makers consider that the new inks tested met their technical expectations.

The replacement of MO inks in publication printing is an important step towards eliminating undesirable substances from the paper recycling cycle in Europe to provide benefits to both consumers and the environment. Companies will benefit from positive communication to their readers, advertisers, staff and shareholders.

The combined results from the French and German evaluation projects provide a deep and broad view. Overall, this process has created the scientific and technical basis for reducing the mineral oil contamination of the waste paper cycle from printing inks in the medium term.

The implications of changing to MOF inks are predominantly neutral to positive. Their higher purchase price is the only significant negative issue. There is some uncertainty over contamination, along with the availability and sustainability of some raw materials.

Operational use of MOF Coldset inks was confirmed by the evaluation of five different inks under real production conditions during 2-4 months at seven printing sites on presses with various configurations. Apart from a few adjustments that were considered as normal when changing ink, no particular problem was identified. The printers emphasised making a half-day pre-test to verify the printability of the ink before moving to full production.

	Evaluation
Conformity with MOF ink specifications	✓
Deinkability	✓
Compatability with roller coverings	✓
Printability	✓
Runability	✓
Ink logistics & contamination	?
Ink consumption (same pigmentation & TAC)	✓
Production cost efficiency	✓
Ink purchase costs	X
Origin & raw materials availability	?
Other environmental considerations	✓
Best practice for MOF ink changeover	✓

The implications of changing to MOF inks are predominantly positive. There is some uncertainty over contamination, and some raw materials. Their higher purchase price is the only significant negative issue.

Some observations:

1. Deinkability of different types of paper tested are normally rated as "good" on the INGEDE deinkability score. Reducing the TIC of newspaper printing may improve brightness of recycled paper originally printed with MOF inks. Further research may be required to better understand this relationship.
2. No noticeable impact on the ink and dampening rollers. The presses can therefore be used as they are and no major modification is needed to switch to MOF inks.
3. The colour reproduction quality of MOF inks is now comparable to conventional inks, and no problems are to be expected when introducing them to a printing plant. It is recommended to recalculate the TVI (dot gain) and dampening curves to optimise MOF print performance.
4. Runability is generally as good, if not better than MO. The ink/water balance of the new inks is different from that of conventional inks, but this did not impair printability. It is recommended to recalculate the dampening curves. Marking was noticeably reduced.
5. There are some contamination issues during ink manufacture that will only be permanently removed by using dedicated ink production lines. There will be passing contamination at printing sites when changing over, but the compatibility of running MO and MOF inks on the same press during the transition should reduce waste and cost. The decontamination of bulk ink tanks will need to be reviewed between the printer and their supplier.
6. MOF inks are made from vegetable oils. The availability and price volatility of these oils are influenced by diverse parameters linked to supply and demand, climatic and geopolitical conditions, and the use of vegetable oils for diverse applications. The inks tested in Germany exclude the use of raw materials from coconut or palm oil.
7. Along with price, ink consumption is a fundamental factor to evaluate the economic viability of using MOF inks. In general, the measurement of ink consumption found that for the same pigmentation and TIC, the MOF inks yield similar values to inks containing mineral oils. A TIC reduction from 240% to 200% leads to a potential 10% reduction of ink consumption.
8. If the price difference is excluded, the printers in the trials would be ready to adopt these new formulations immediately. This adoption would be subject to the ink suppliers committing themselves to provide MOF inks on a regular basis.
9. The adoption of MOF inks requires printers and ink suppliers to plan the transition to MOF to ensure their availability. Ink suppliers indicate a delay of 6-12 months to guarantee availability.

Proactive industry co-operation

The key to the success of this project was the proactive international co-operation between the diverse participants in these evaluations — printers, ink suppliers, technical centres and associations. Their motivation to find an alternative to mineral oil-based inks has been shared across the sector and will benefit the entire industry in Europe.

Possible further actions

1. Newspaper presses have a wide range of configurations and ink system designs. The available MOF inks were qualified on seven presses. However, more print trials will be needed to cover the entire range of press types and manufacturers.
2. Some optimisation of the deinkability of print products will be advisable to maintain the quality of recycled paper. Fibre yield in paper mill operations should be monitored for any impact from increased use of MOF products.
3. Better and broader understanding of ink consumption measurement for printers. Further ink developments will need their consumption to be reliably monitored.
4. Reduction of ink consumption is an important path to reducing cost impact, e.g. TIC reduction, and identify opportunities from alternative screening technologies.
5. Review the use of UCR and GCR in Coldset. Currently, higher priced CMY inks are substituted with lower cost Black ink (in dark, neutral areas of the reproduction and replaces (UCR) and CMY ink that has a greying effect (GCR). Are these techniques still valid for MOF inks when Black is almost the same cost as CMY colours?
6. WAN-IFRA recommends further tests with simulated printability to provide a better understanding of ISO conformance, mileage comparison and the colour shade reproduction potentials of the inks.
7. To accompany printers in this transition, it may be advisable to form an international cross-industry platform with organisations, printers, suppliers and technical bodies to follow the evolution of inks, the various parameters they influence, and to share experiences and best practices. The use of an appropriate environmental/sustainability label for vegetable materials is recommended.
8. The impact of France and Germany changing to newspaper MOF inks in the next 2-3 years will have an impact on other European countries. This suggests evaluation and discussions may be needed on the international implications of this web offset ink transition.
9. Heatset and Waterless inks will require new formulations to comply with stricter French regulation from January 2025. Two suppliers of Waterless inks have indicated that they will both have MOF inks available in 2024.

Other ink developments

Bio4inks PAGORA

A new research project launched in France in 2023 aims to limit the use of non-renewable resources. Its objective is to formulate fully bio-sourced offset inks. It is led by the Laboratoire des Génies de Procédés Papetiers (LGP2) and is funded by the French Ministry of Culture and CITEO.

The first stage involves studying the feasibility of using pigments of biological origin (plants, algae, etc.) on an industrial scale. Four main environmental issues have been identified:

- Reducing the carbon footprint of inks.
- Reducing the consumption of non-renewable resources and waste production through the use of renewable or recycled resources.
- Improving the recyclability of printed materials.
- Limiting the use of hazardous substances and reducing their presence in printed matter.

Life cycle analysis will be carried out in parallel with the laboratory research and the project is the subject of a doctoral thesis with the first results expected in 2026.

Blue Angel 195

To be awarded with the Blue Angel MOF inks that have to be used to produce printed matter. The exemptions for Coldset web offset printing in companies without a dual colour supply system ended in June 2023.

Heatset

The energy crisis of 2022 and 2023 led the major ink suppliers to develop Heatset inks to operate with lower drying temperatures. A reduction of 20-40°C has already been achieved by some suppliers, which automatically reduces related gas consumption.

What printers & ink makers say?

Printers:

"Our company was delighted to have taken part in the MOF inks test phase for six weeks printing three million copies including "Le Monde" and "Le Figaro". This represents around one hundred hours of printing and the results in terms of quality fully met our expectations."

- Apdenone Hassaine **Groupe Riccobono**

"For us it is important to always have our finger on the pulse of innovations. For this reason, when Fogra asked us, it was not a question of whether but when we could start testing the inks. The test results were consistently positive and suggest that there is an adequate alternative to conventional inks in the market already.

- Tobias Sobkowiak, **Heilbronner Stimme**

"This test was conclusive. There were no noticeable differences in setting and print results. A better black density was observed. If it wasn't for the extra cost and our concerns about the availability of these inks, we would have switched to using them straight away."

- Philippe Ceugniet, **La Voix du Nord**

"At the Dierichs newspaper printing plant in Kassel, some MOF inks are already being used. The intention is to increase this steadily in the future, with the aim of switching completely to these inks. Neither the tests nor production have shown any restrictions, so we assume that there will be no obstacles on the way to a complete changeover."

-Volker Hotop, **Frankfurter Societäts-Druckerei**

"At equal cost and subject to the guarantee of their availability over time, the Midi Libre would adopt these vegetable oil-based inks as of now."

-Bernard Porteix, **Midi Libre**

"The use of these alternative inks fits perfectly with our group's CSR policy. The economic obstacle remains to be overcome. From a technical point of view, no problems have been encountered, and we have even noted a real improvement in the quality of the black with a reduction, to be confirmed, in its consumption."

-Régis Caron, **Le Progrès**

Ink makers:

"Technically, everything is ready; however, for a market like France it will take a year to guarantee a regular supply."

- Huber

"It remains important to complete these tests in order to evaluate the behaviour of the inks on different press configurations, production habits and rheologies (medium and long flow). If the market demand is sufficient it will be possible to dedicate a production line to vegetable black. Using the same production line for both inks will automatically lead to contamination problems."

- Sun Chemical

"Once the volumes are set, the lead time for production is approximately three months. If these volumes are consistently set within this timeframe, Flint will be able to ensure consistent production. However, the absence of contamination cannot be guaranteed as long as MO and MOF production co-exist."

- Flint

Déjà vu from previous Reports:

"In general it can be concluded that the same newspaper print quality can be achieved in 4-colour printing with vegetable oil based news inks compared to mineral oil based news inks."

-Boris Fuchs, IFRA Research Director,
1991 Special Report 1.5 Vegetable oil based news inks and their printability properties

"The decision of the Los Angeles Times to change 100 % to soybean oil based inks is fully justified, both from the technical and marketing points of view."

-Bernard Bottomley, GM, Times Mirror Los Angeles
1995 Special Report 1.12 Why are soybean based news inks so successful in the USA?

Participants in projects for this report

Organisations commissioning research

Project and technical management

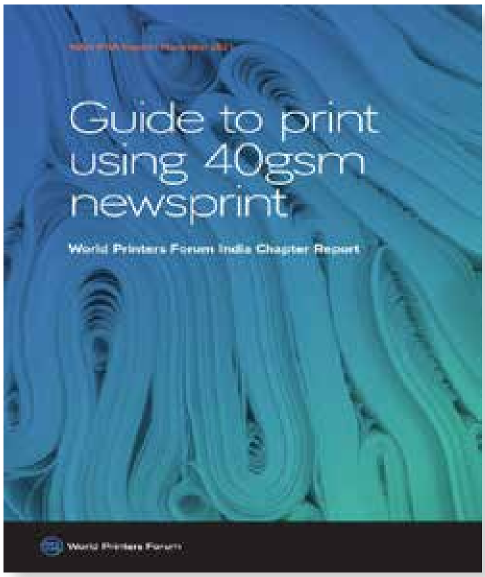
Coldset printers

Heatset printers

Suppliers

Other technical reports and guides from World Printers Forum

Guide to print using 40 gsm newsprint
The World Printers Forum India Chapter made this comprehensive report as a practical guide to printing with 40 gsm newsprint. It takes the reader through the various aspects that need to be considered. It includes a detailed analysis of lower grammage newsprint, supported by laboratory findings, and provides a step-by-step guide that can easily be followed. An important element of this report is the detailed evaluation of different TIC (Total Ink Coverage) parameters according to the grammage of the newsprint. This report is a follow-on from 'Implications of changing to lower grammage newsprint'.



Sustainability of Newspapers
This report jointly developed with Two Sides, examines the sustainability attributes of the key raw material for printed newspapers – paper – and discusses what those in the sector are doing to address their environmental impacts. The report shows that newspaper printing is a sustainable production method, that the important key data is developing in the right direction, but also that newspaper printers and publishers should do even more to develop their sustainable future prospects. It is important that paper is collected separately from other materials and sorted to allow its optimisation as renewable resource within the circular economy.

Optimised Paper Handling & Logistics
This cross-industry best practice guide brings together expertise from across the entire paper supply chain from the mill, through transport, storage, and handling, to printing. The 270-page guide offers a comprehensive view of a value chain that is both complex and global, which no single company or organisation can adequately address. Its goal is to reduce the risks of accidents, economic and environmental degradation. Its easy-to-read illustrated text shows how best practices are a tool to improve performance and trouble-shooting. Available as a FREE e-book from www.ophal.info or a printed version can be purchased

Implications of changing to Mineral Oil Free web offset inks

WAN-IFRA Report | October 2023

World Association of News Publishers