How lube oil condition monitoring enables smarter maintenance

MAN Energy Solutions
Future in the making

A simple addition to preventive maintenance regimes – and a prerequisite for predictive maintenance – this future-proof diagnostic tool discovers small problems before they become big ones to reduce risk, unplanned downtime, and OPEX.

Key to risk management and smarter maintenance:

Condition monitoring is now more important than ever

Condition monitoring is essential to the successful operation of all mechanical systems. For high-value, mission-critical assets such as marine and power generation engines, it is a cornerstone of risk management and a precondition for maintenance regimes that can significantly improve operational reliability, prevent catastrophic failures and unplanned downtime, and lower OPEX.

Observing the parts and parameters that indicate the state of the engine enables remedial action and is thus at the core of even the most basic corrective or preventive maintenance strategies. When observation reveals that something is broken, we fix it.

However, condition monitoring can be much more than simple observation and quick fixes. When sensors in rotating equipment collect data which is analyzed over time to identify changes that indicate developing problems, operators can improve maintenance dramatically.

A HELPFUL ADDITION TO CORRECTIVE AND PREVENTIVE MAINTENANCE, AND A PREREQUISITE FOR CONDITIONAL AND PREDICTIVE MAINTENANCE STRATEGIES

As more operators move beyond traditional corrective and preventive maintenance regimes and begin to embrace the many benefits of conditional and predictive maintenance strategies, the importance of condition monitoring becomes even greater.

No matter how far they have progressed on their journey to predictive maintenance, the discovery of emerging anomalies as early as possible through condition monitoring vastly improves the ability of operators to prevent small problems from becoming big ones.

This not only reduces the operating expenditures and total cost of ownership throughout the lifetime of the engine. It also significantly reduces the risks of unplanned downtime and catastrophic failure.

Condition monitoring (CM) plays a role in all maintenance strategies

	CORRECTIVE MAINTENANCE **Run to failure**	PREVENTIVE MAINTENANCE **Maintain according to schedule**	CONDITIONAL MAINTENANCE **Detect & fix/maintain now**	PREDICTIVE MAINTENANCE **Detect, analyze, & plan optimal maintenance**
Scope of CM use	Low-cost assets; no safety issues; assets easy to fix or replace.	High-value, mission-critical assets; safety implications; unplanned downtime not acceptable.	High-value, mission-critical assets; safety implications; unplanned downtime not acceptable.	High-value, mission-critical assets; safety implications; unplanned downtime not acceptable.
How CM is used	Reactively: If CM reveals that something is broken, we fix it.	Reactively: Although maintenance primarily occurs according to predetermined schedules, CM can discover problems that need to be addressed before planned maintenance intervals.	Proactively and in real time: Maintenance is triggered when certain conditions & thresholds are met. Of course, CM can also be used reactively in conditional maintenance regimes.	Proactively, in real time, and with an eye to the future: CM enables trend analysis and predicts when maintenance is most cost-effective, allowing optimal scheduling of planned maintenance. Of course, CM can also be used reactively in predictive maintenance regimes.
CM architecture	Simple observation - but could be enhanced by sensors, algorithms and displays.	Simple observation - but could be enhanced by sensors, algorithms and displays.	Sensors, algorithms and displays - in addition to simple observation.	Sensors, algorithms and displays - in addition to simple observation.
Benefits of CM	CM enables better corrective maintenance. The quicker an anomaly is discovered, the quicker it can be remediated.	CM enhances preventive maintenance. If problems are detected, preventive schedules can be overridden when necessary.	CM is the precondition of conditional maintenance. It allows early detection of minor anomalies that can develop into major problems and enables timely maintenance and remediation.	CM is the precondition of predictive maintenance. It allows early detection of minor anomolies that can develop into major problems and enables timely remediation and optimally planned maintenance.

The lifeblood of the engine:

Lube oil opens a diagnostic window into engine health

Just as physicians rely on blood tests to identify human health issues, operators of mission-critical engines use lube oil tests to better understand the condition of the lubricant and the engine itself.

Lube oil is often referred to as the lifeblood of the engine. Not only does it keep engines healthy by lubricating moving parts, dispersing heat, cleansing impurities, and preventing corrosion. It also reveals the underlying condition of many critical engine and auxiliary components.

Through a range of tests, lube oil monitoring and analysis reveal information about three important categories of anomalies that both affect the lubricant's performance and indicate engine and/or auxiliary issues that require maintenance: fluid properties, contamination, and wear debris.

Learn more about the importance of lube oil for four-stroke engines. →

50%
OF ALL ENGINE DAMAGE IS CAUSED BY LUBE OIL

70%
OF ALL ENGINE ANOMOLIES CAN BE DETECTED IN LUBE OIL

Fluid properties

As lube oil performs its job and ages, it deteriorates and its physical and chemical makeup changes.

Several fluid property tests expose such degradation so that operators can proactively change the oil or add additives to restore oil health:

- **Viscosity analysis:** Monitors and analyzes the lube oil's "thickness", or resistance to flow and shear, lube oil's single most important physical property impacting wear rate and fuel efficiency.
- **AN/BN:** More than a simple pH analysis, by determining oil's acid number (AN) and base number (BN), we understand its concentration of acidic components (organic acids created by oil oxidation and some additives) and basic components (e.g., some detergent additives).
- **FTIR:** Fourier transform infrared (FTIR) spectroscopy discovers and assesses multiple common contaminants, lube degradation byproducts, and additives.
- **Elemental analysis:** A fundamental test that reveals the presence of 15-25 different elements stemming from wear metals, contaminant metals, and oil additives.

Contamination

Over time, a variety of external impurities often make their way into lube oil. Fluids such as water and diesel fuel are one example, particle contaminants another.

A range of tests are used to determine the presence of these pollutants:

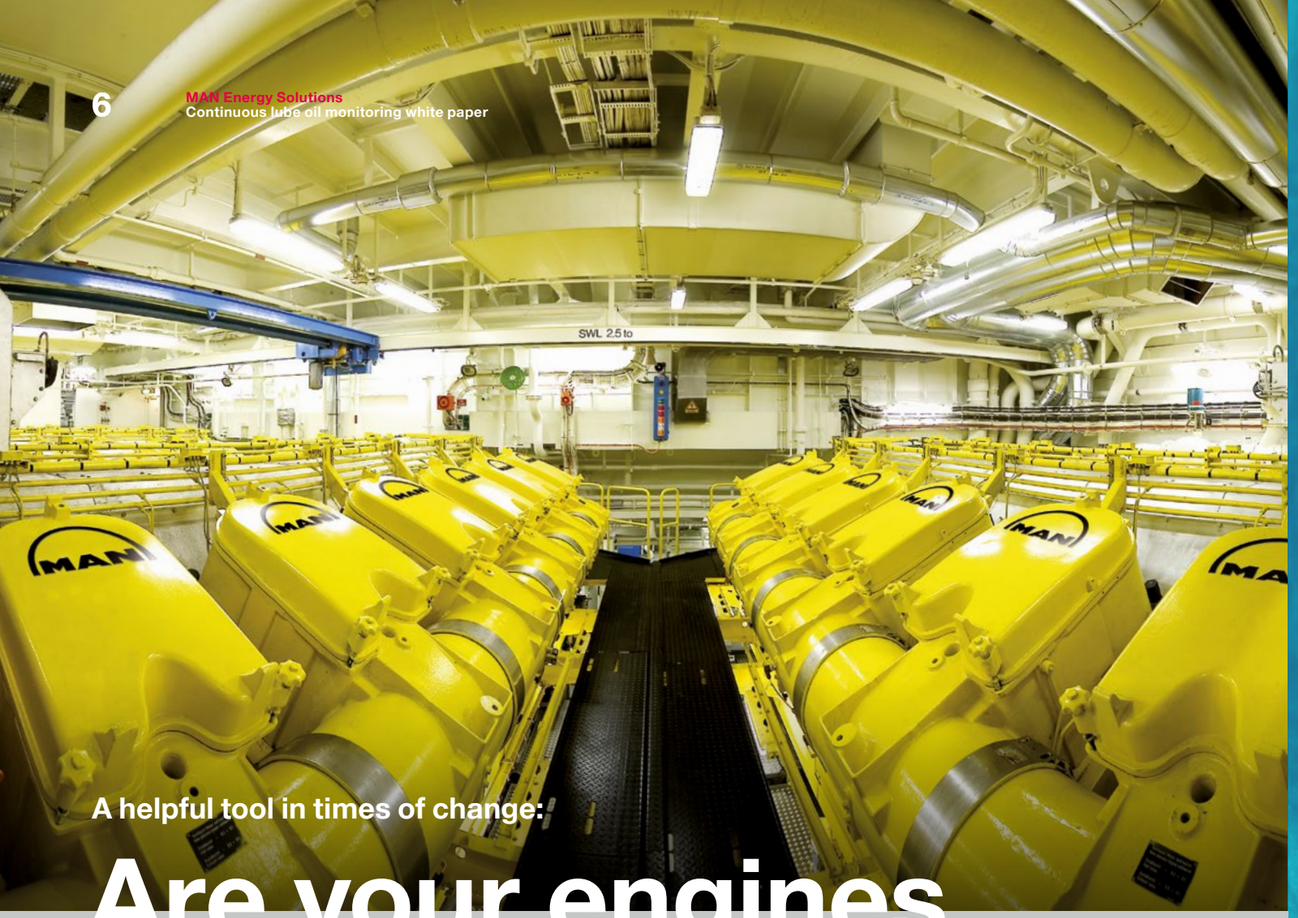
- **Particle counting:** A fundamental measure of oil's cleanliness, particle counting monitors and analyzes the number and size of contaminant particles so operators can better detect early signs of wear, evaluate filter performance, and assess the need for oil service.
- **Moisture analysis:** Water in oil – whether free, emulsified, or dissolved – corrodes and can cause irreparable damage. When moisture is combined with other contaminants its effects are even worse. Moisture analysis can catch this early on.
- **Patch test:** Patch microscopy can quickly reveal oil contamination by comparing in-line oil samples with a catalog of standard patches. Visual examination of particle morphology can also reveal the source of observed particles.
- **Flash point:** An oil sample's flash point is the lowest temperature at which its vapors will ignite under specified conditions. Oil diluted during long use by fuel or water has a lower flash point than non-diluted oil and can reveal contamination from solvents and antifreezes, thermal failure, and mixed or wrong oils.

Wear debris

In addition to the contaminants mentioned above, lube oil analysis can also identify wear caused by friction between moving parts in the engine or its auxiliaries.

Oil tests provide information about these wear debris particles which can be used to determine their source, and thus play a vital role in predictive maintenance.

- **Wear debris density:** Density analyses reveal the relative quantity of debris, such as ferrous and non-ferrous debris originating from wear.
- **Analytical ferrography:** Ferrous solids are separated from the lubricant and then analyzed by trained analysts to better understand their source and cause.
- **Elemental analysis:** A fundamental test that reveals the presence of 15-25 different elements stemming from wear metals, contaminant metals, and oil additives.

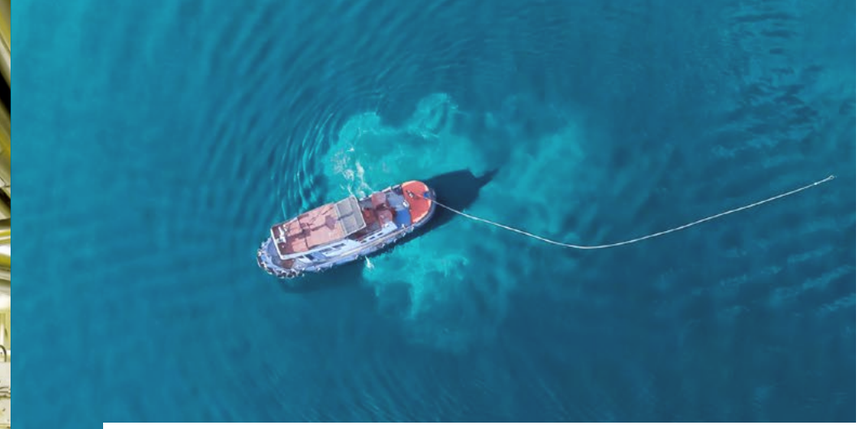


A helpful tool in times of change:

Are your engines ready for the future?

Engine condition monitoring will be increasingly important in coming years, and lube oil monitoring will be especially critical.

This smart technology will play an essential role in maintaining competitiveness and reducing OPEX as operators adapt to two mega-trends: decarbonization and digitalization.



DECARBONIZATION

Fuel oil change management is key to decarbonization, and condition monitoring is key to fuel oil change management. Already today, many alternatives to traditional heavy fuel oil are gaining momentum, including:

- **MGO, ULSFO, VLSFO**
- **LNG, SNG, biogas**
- **Ammonia**
- **Hydrogen**
- **Methanol**
- **Biofuels**
- **Electric**

As owners and operators worldwide transition to these future fuels with a lower carbon footprint, understanding the consequences of these new fuels for of both two-stroke and four-stroke engines will be critical.

Condition monitoring of key engine parameters – especially lube oil condition monitoring – provides an early warning system to enable discovery of any negative effects of these new fuels.

DIGITALIZATION

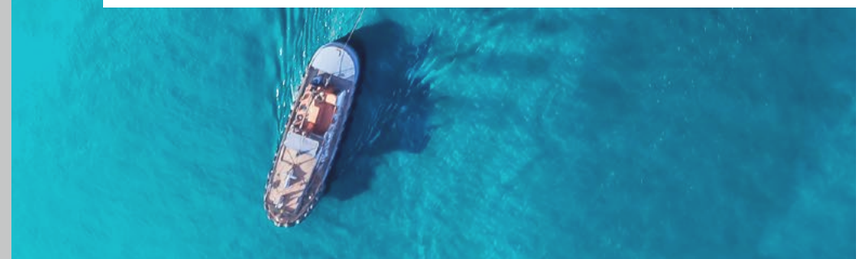
Operators of land-based high-value engines, such as power plants, have already digitalized many aspects of condition monitoring. Now, enabled by better connectivity, Industry 4.0 is also sailing into the maritime industry at full speed.

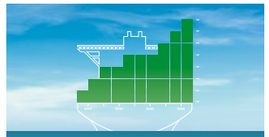
As engine owners and operators increasingly rely on the many benefits of digitalization and automation, smarter condition monitoring will be an essential part of many forward-thinking solutions.

Condition monitoring of some of the industry's most valuable assets – two and four-stroke engines – will be pivotal in successful digitalization strategies.

MAN experts are already ahead of the curve on the key issues facing owners who want to harness the power of lube oil condition monitoring to prepare for the future, now:

- **Increasing efficiency and lowering OPEX to improve competitiveness**
- **Smooth transition to predictive maintenance regimes**
- **Alarms and automations that compliment and support reduced staff levels**
- **Compliance with transnational and certification society standards**
- **Standalone and cloud-connected solutions**
- **Cybersecurity and data protection**





Learn more about decarbonization and future fuels here. →

EEXI 2023

Learn more about compliance with the Energy Efficiency eXisiting ship Index (EEXI) here. →

Learn more about how MAN is helping the maritime industry's digital transformation here. →

Always on, always vigilant:

Continuous lube oil monitoring is a powerful supplement to traditional periodic analysis

Operators that supplement periodic monitoring with real-time continuous monitoring achieve the best of both worlds.

Continuous lube oil analysis is a powerful way to detect small anomalies and nip emerging problems in the bud. It provides vital diagnostic information at all times, including during high-risk situations such as cold starts.

Periodic lube oil analysis compliments this non-stop vigilance with depper analyses that broaden operators' understanding of the oil's properties and what these reveal about the engine and its auxiliaries.

PERIODIC LUBE OIL ANALYSIS	CONTINUOUS LUBE OIL MONITORING
What: Intermittent analysis of the lubricant's physical and chemical properties, contamination, and wear debris	**What:** Non-stop monitoring of the lubricant's physical and chemical properties, contamination, and wear debris
How: Lube oil samples are tapped from the engine at fixed intervals or ad hoc, then sent to and analyzed in offsite labs.	**How:** Sensors installed in the engine collect data from the lube oil that is algorithmically analyzed to display always-up-to-date information and to trigger alarms if predetermined thresholds are met.
When: While engine operating recommendations vary, most recommend lube oil analysis every 500 running hours. For engines that only operate periodically, such as gen-sets, monthly lube oil analyses are normally prescribed.	**When:** Constantly
Strengths: Provides the broadest and deepest array of diagnostic tests	**Strengths:** Monitoring is continuous, so data always represent the current condition of the lube oil in real-time; monitoring also occurs in high-risk periods such as cold starts after maintenance; enables fast remedial reaction; diagnostic information paves the way to predictive maintenance regimes for the engine and its auxiliaries
Weaknesses: Monitoring is not constant, so samples do not necessarily represent the real-time condition of the lube oil; samples are not normally taken in higher-risk periods such as cold starts after maintenance; diagnostic information does not enable predictivemaintenance regimes for the engine or its auxiliaries.	**Weaknesses:** Provides a narrower array of diagnostic tests and less detail han periodic analyses. For example, periodic lube oil analyses detect smaller contaminant and debris particles than continuous lube oil monitoring.

CONTINUOUS LUBE OIL MONITORING PROACTIVELY PREVENTS PROBLEMS BEFORE THEY OCCUR

- **Powerful diagnostics:** Monitors key lube oil parameters that reveal critical oil and rotating part anomalies
- **Always on:** Vigilant around the clock– especially helpful in critical periods such as cold starts
- **Real time:** Radically shortens the time between diagnostic insight and remedial action
- **Simple to install:** Easy to retrofit or integrate into new builds
- **Simple to use:** Easy to configure and calibrate, intuitive multi-lingual interface

Ideal for retrofits and new builds:

It’s simple to add continuous lube oil monitoring

Installation of continuous lube oil monitoring is easy for operators of four-stroke engines. For retrofits, installation and calibration typically take less than a day and require only a few simple connections that can usually be made without shutting down the engine.

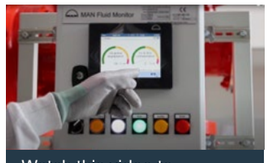
In fact, since installation is so simple – and because cold re-starts account for a full 50% of the damages that occur to high-value rotating equipment – MAN Energy Solutions utilizes it in testbeds when building new engines and MAN PrimeServ utilizes it during major maintenance operations that require engine re-starts.

Once installed, MAN Fluid Monitor is an easy-to-use digital system that allows operators to learn gradually how to make optimal use of powerful analytical data for smarter maintenance.

First, operators simply use a range of helpful, pre-set diagnostic codes that improve their ability to react to emerging problems in a timely manner.

As they become more familiar with the system and get better at understanding the trends that it reveals, operators can then use the diagnostic data more proactively and predictively.

WATCH OUR SHORT VIDEO TO LEARN MORE



Watch this video to discover MAN Fluid Monitor for lube oil in action →

How MAN lube oil monitoring works

1 COLLECT DATA DIRECTLY FROM CIRCULATING LUBE OIL

- Two simple hydraulic connections draw lube oil for condition monitoring
- Two powerful sensors – specially adapted to MAN specifications – analyze the oil and generate data on key condition parameters
  - o Sensor 1: Fluid properties and contamination
  - o Sensor 2: Debris from wear and pollutants
- One or multiple engines can be monitored on a stand-alone basis or connect to local and/or remote supervision systems

2 TRANSFORM DATA INTO DIAGNOSTIC INFORMATION

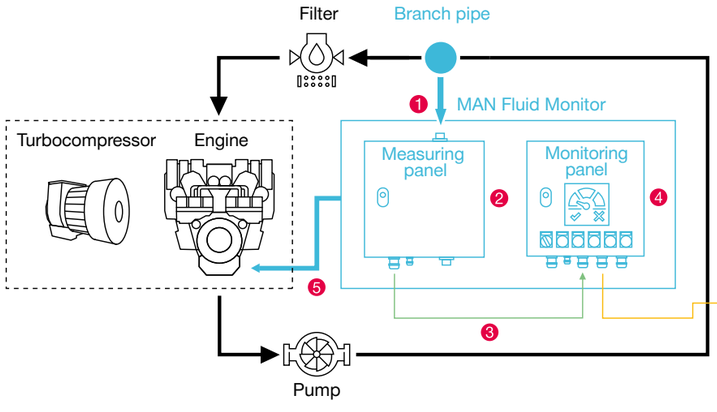
- Robust processing based on the CANopen communication protocol
- MAN’s patented algorithms compare the monitored data with historical and baseline data and asset-specific thresholds to provide insights into critical parameter status and trends
- The algorithms organize data into clear diagnostic codes that facilitate quick troubleshooting

3 COMMUNICATE CRUCIAL INFORMATION WITH SIMPLE, ACTIONABLE MESSAGES

- Information visualizations
- Daily, weekly, and monthly trend analyses
- Alarms and alerts based on configurable thresholds that can be delivered to any connected mobile device as well as the system’s primary display
- Stop recommendations based on configurable thresholds
- Automated stops based on configurable thresholds
- Onsite touchscreen display with configurable interface

Integration of MAN Fluid Monitor for lube oil

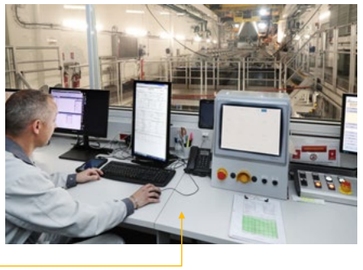
Learn more about the integration of MFM →



Main lube oil system
MAN Fluid Monitor for lube oil system
Electrical connection
Ethernet connection

1 The lube oil is oriented, before filtration, to the measuring panel through a branch pipe
2 The lube oil is measured permantly through sensors
3 The data is instantly transferred to the monitoring panel
4 The display screen constantly shows the levels of lube oil degradation and contamination and raises an alarm in the event of a deviation
5 The lube oil is returned to the equipment’s main lube oil system

Ideal for both onsite & remote supervision



Insight and expertise at your service:

You can count on MAN to do this right

MAN is a unique position to understand the significance of lube oil for high-value engines – and to develop innovative lube oil monitoring and other data-supported tools.

- We are an OEM that designs and manufactures engines, and have deep, decades-long insight into engine construction, operation, and maintenance.
- As a service provider, we maintain our own and third-party OEM engines through our MAN PrimeServ division, and have broad experience in corrective, preventive, conditional, and predictive maintenance regimes.
- MAN has extensive experience in fluid analysis, including periodic lube oil analysis, through MAN PrimeServ Lab.
- MAN has pioneered continuous lube oil monitoring through our proven MAN Fluid Monitor portfolio. Now available for four-stroke main and auxiliary engines, we are also developing solutions for two-stroke engines.
- R&D for our continuous lube oil analysis solution is based on close collaboration with our intra-company experts, customers using our own and third-party engines, and the world's leading manufacturers of high-quality sensors. MAN engineers are continuously developing integrated solutions based on sensors and AI to improve both preventive and predictive and maintenance.

Based on data from more than 30,000 events collected across the entire spectrum of our businesses, we are confident in emphasizing the significance of lube oil monitoring over the lifetime of high-value engines. Half of all the engine damage that we see can be directly attributed to the condition of lube oil, and more than two-thirds of all engine anomalies that we encounter can be detected in lube oil.

SEAMLESS INTEGRATION WITH OTHER MAN PRODUCTS AND SERVICES

Of course, MAN's Fluid Monitoring system can be fully integrated with other MAN products and services.

- MAN Fluid Monitoring works seamlessly with the MAN Multifunctional Monitoring System to integrate lube oil condition data with other crucial operating data such as crank pin lube oil temperature, main bearing and crankcase pressure, engine and turbocharger speeds, exhaust gas and fluid temperature and pressure, and more
- MAN Fluid Monitoring integrates effortlessly with MAN PrimeServ Assist for remote supervision and support via MAN CEON for secured-cloud operating data.

Learn more about our MAN Fluid Monitor solution →

Contact MAN to learn how continuous lube oil monitoring can work for you →

LEARN HOW CONTINUOUS LUBE OIL MONITORING PREVENTED MAJOR DAMAGE ABOARD *LA GIROLATA*

La Méridionale operates ferries between Marseilles, Corsica and Morocco. With four ships, 19 weekly routes, and nearly 200,000 annual passengers, reliability and efficiency are essential to the French company's success.

Always on the lookout for innovations that can improve operational efficiency, La Méridionale was an early adapter of MANs lube oil monitoring solution and installed it on one of it ferries, *La Girolata*.Just a few weeks after installation, the monitor proved its worth by discovering water leakage in one of ***La Girolata's*** two main engines.

According to La Méridionale's technical manager, Christophe Séguinot, continuous lube oil monitoring prevented major damage: "Thanks to detection in real time, the engine was immediately stopped, investigation was carried out, and the problem was solved. The cause was water leaking through a defect cylinder head gasket. Once that was fixed, we were able to restart the engine without any disturbance to the commercial operation of the ship."

Download and read the entire case here →

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No77_EN Sep. 2022 - Printed in France - GKM - FR

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