



DIGI+

Digi Cell Plus - Digital Oil Test Cell

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Wilhelmsen

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Overview

Introduction

Digi Cell Plus (DIGI+) is a Digital Oil Test Cell with USB storage and charging. DIGI+ provides an accurate means of detecting and measuring the quantity of water (H_2O) in oil and / or the residual Base Number (BN) of oil. This battery-operated, rugged and compact mobile instrument provides easily retrievable data to ensure fast, accurate and consistent management of lubricating oil samples.

Condition monitoring of the health of lubricants is an established method of predicting issues, prolonging machinery life and avoiding impending machinery breakdown thus optimising operating costs. Lubricant condition can be identified before any serious damage occurs so that production can be maintained, machinery life extended and return on capital investment increased.

DIGI+ is available in three variants:

- **DIGI+ Water** (H_2O) only
- **DIGI+ Base Number** (BN) only
- **DIGI+ Combined** - H_2O and BN

Smart Setup, Data Storage & Rechargeable Battery

DIGI+ provides a refreshed, but familiar, interface with the addition of smart features to enhance the user experience over previous versions of the product. DIGI+ can continue to function as an offline instrument for single measurements and is able to be operated without smart features until the user chooses to do so.

DIGI+ can be configured when connected to most personal computers (PC) – Windows and Mac. Sample points and test locations are labelled as Sample Point Identification (SPID). This creates structure to measurements and ensures no data is accidentally missed. Results are saved to DIGI+ and can then be imported into a PC. The SPID approach creates an easily retrievable sample point and test history. Setup can include real-time feedback and alarms for optimal monitoring.

Key Features:

- USB-rechargeable battery with indication of tests remaining before charge
- Oil reference list for BN measurement may be configured via PC rather than entered manually via DIGI+ keypad, saving time and effort

Safety Information

DIGI+ and reagents should be operated by persons trained in the use and handling of hydrocarbon products, including new and used lubricants. Persons should also be familiar with basic laboratory or workshop environments and associated hazard awareness.

Prior to operating, DIGI+ should be inspected for damage. If any damage is found, consult with the supplier of DIGI+ accordingly.



CAUTION

A Caution notice is used to emphasise that particular care is required to avoid the danger of personal injury or other hazard.



CHECK

Notes call attention to information that is especially significant to understanding and operating the equipment. There may be a need to check the orientation or tightness of connections, for example.



SAFETY EQUIPMENT

Some operations require special attention to safety, such as the use of safety glasses and / or protective gloves.

General

- this information guide should be read in full before operating DIGI+
- appropriate safety measures must be taken when handling both combustible and flammable liquids
- no liquids outside of those defined in the [technical specification](#) should be used

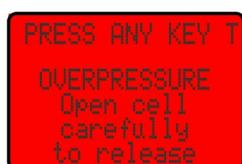
Environment

- DIGI+ must only be operated in well-ventilated areas
- DIGI+ has not been approved for use in an explosive atmosphere

Handling

- the USB socket cover must be fitted unless a micro-USB charging cable is plugged in
- DIGI+ must be kept upright when adding reagents and oils
- care must be taken to be a safe distance away from people and objects when shaking DIGI+

Operating



Only oil that contains < 20% water must be tested. DIGI+ warns of overpressure at 1.3 bar (18.8 psi): DIGI+ should be put down immediately and care taken when opening.

- any spills should be immediately wiped from the surface of DIGI+ and surrounding work area using a soft cloth or tissue
- safety protection may be impaired if DIGI+ is used in a manner, or for a purpose, other than that described in this information guide

Test by-product (H_2)



Hydrogen gas (H_2)
build-up risk

Use in well ventilated areas.



No open flames, smoking or sources of ignition.

Never add water instead of oil samples.

Dispose of waste carefully.

The water in oil test reagents react rapidly with water. In normal operation up to 70 ml H_2 is generated. Test waste can continue to react with water and moisture from the atmosphere. Test waste must not be poured into a closed container or lidded slops bucket where H_2 can accumulate. Adequate ventilation must be ensured to avoid H_2 build-up in a confined space. H_2 gas is explosive at concentration levels above 4%.

Conformity

This equipment is CE marked (approved for the EEA market) and UKCA marked (UK Conformity Assessed). See [Contact, consumables and spares information sheet](#) for conformity documentation.

Exclusion of Liability

Every endeavour has been made to ensure the accuracy of the content of this information guide however errors cannot be ruled out. Consequently, no liability is accepted for such errors as may exist or for any damage or loss whatsoever which may arise as a result of such errors. All details are subject to technical modifications. Technical specifications are subject to change without notice.

Principle of Operation

DIGI+ measures the pressure generated by a chemical reaction that takes place inside the closed sample cup. An oil sample and reagents are put into the sample cup and DIGI+ is closed and shaken to aid the chemical reaction. The pressure is proportional to the parameter to be measured. A very sensitive high-resolution pressure transducer is used to convert pressure to an electrical signal which is then processed and displayed to the user.

Water (H_2O) in Oil Measurement

Gas is generated from a chemical that reacts with available water in the sample. The water content is calculated from the gas pressure in the sample cup.

Base Number of Oil Measurement

Gas is generated from a chemical that reacts with available (remaining) BN additive in the sample. Gas pressure in the sample cup from used oil is compared to new oil as a ratio:

$$BN_{used\ oil} = BN_{new\ oil} \times \frac{P_{used\ oil}}{P_{new\ oil}}$$

DIGI+ stores the value of pressure generated by new oil which is measured once and saved as a reference. DIGI+ can save values for multiple new oils in its memory as OIL TYPES. Before used oil is measured, the new OIL TYPE must be measured and stored as a calibration value.

- DIGI+ holds calibration data for up to 8 different OIL TYPES
- when using smart mode, DIGI+ holds calibration data separately for up to 10 different OIL TYPES

Technical Specification

Water	BN
Measurement Range (v/v)	Measurement Range (mg KOH/g)
0.1 % to 20.0 % 0.1 % to 10.0 % 0.02 % to 1.00 % 200 ppm to 10000 ppm 100 ppm to 3000 ppm	1 to 150
Water Range Resolution	BN Resolution
0.1 % to 20.0 % 0.1 % to 10.0 % 0.02 % to 1.00 % 200 ppm to 10000 ppm 100 ppm to 3000 ppm	1 BN 0.1 % 0.1 % 0.1 % 50 ppm 10 ppm
Water Accuracy	BN Accuracy
100 ppm to 10000 ppm > 1 %	Typically \pm 1000 ppm Typically \pm 1 %
Test Time	Test Time
180 seconds	120 seconds
Power (from USB)	
Micro-USB: 5 V 100 mA minimum	
Tests Per Charge	
50 tests or 5 hours	
Minimum Battery Charge Cycles	
500	
Maximum Storage Time From Full Battery	
6 months (stored between -5 °C to 35 °C)	
Operating Temperature *	
10 °C to 45 °C	
Storage Temperature **	
-20 °C to 60 °C	
Material Compatibility	
Mineral and synthetic fluids compatible with FKM (Viton(tm)) elastomer seals. Lubricant oils, hydraulic oils, distillate fuels, and Bio-based fuels.	
Unit Dimensions	
112 mm maximum height x 76 mm diameter	
Mass	
200 g	

*EasySHIP reagent must be >18 °C before use.

**Extremes of temperature will reduce battery life.

Before Starting

Contents

NOTE: Original packaging must not be disposed of as this is required to return the DIGI+ safely to the supplier for maintenance and / or servicing.

Accessories: PPE, reagents, syringes and consumables



DIGI+



Agitator – DIGI+ Water (H_2O) and DIGI+ Combined variants



Micro-USB charging cable



Quick Test Guide
– printed copy



Contact, consumables and spares information sheet - printed copy



Scan QR code on Contact, consumables and spares information sheet to access online versions of support documentation, how-to videos, an example DIGI_CFG.csv file and DIGI Utility (Set-up Software).



Manufacturer Information, Consumables & Spares

For service, please see the '[Contact, consumables and spares information sheet](#)'.

DIGI+ Instrument Overview & Operation



Charging

Charge fully with micro-USB cable before first use
DIGI+ requires a fully charged battery prior to initial use to accurately measure the remaining life

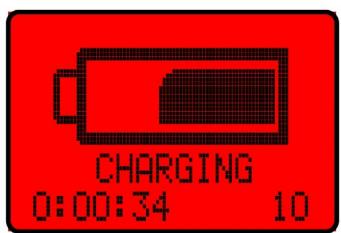


Refit USB socket cover

Fully charged battery run time: 50 tests

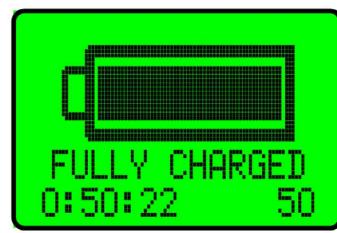


NOTE: If DIGI+ will not allow more than 10 tests, battery should be fully charged. Charge fully at least once every 6 months



Time on charge

number of tests available



Time on charge

number of tests available



Charge fully before storing. Storing DIGI+ for > 6 months and / or at high temperatures may reduce battery life and cause irreparable damage

Powering On & Off

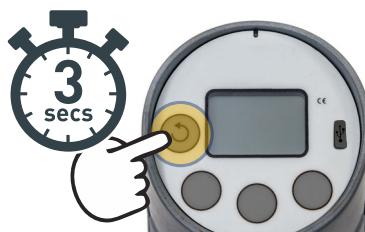
Powering On

Use Left (L), Middle (M) or Right (R) button to power on

Backlight turns off after 20 seconds. Press any button to re-activate



Powering Off



OR
AUTO-OFF
after
5 minutes

Opening & Closing DIGI+

Opening

Hold the sample cup and turn the upper counter-clockwise



Closing

Hold the sample cup and turn the upper clockwise

NOTE: DIGI+ should be closed to hand tight only (1/8 turn maximum)



Aborting a Test

To abort test



Sampling

Obtaining a representative sample is one of the most important parts of oil analysis. If a sample does not represent the true condition of the lubricant and component at the time of sampling, the reliability of both the test result, and the interpretation of it, is affected.

For maximum accuracy, the following is recommended to ensure that the measured sample is representative of the main body of oil:

Areas where oil flow is restricted, or where contaminants and wear products tend to settle or collect, should be avoided as sampling points. Lubricants should be sampled while the machinery is running, if it is safe to do so, or within 30 minutes after shut-down. This ensures that wear products and lubricant contaminants are thoroughly mixed with the lubricant and that the heavier wear particles have not settled out.

Once a proper sampling point and method is chosen for a particular component, oil samples from that component should always be taken from the same point with the same method. The following sampling points are recommended:

- petcock or other sampling valve installed prior to the oil filter
- oil dipstick tube or other service opening using a vacuum pump
- sump or reservoir drain

Sampling Interval

When beginning a routine oil analysis program, the usual practice is to sample the entire group of units / components to establish initial baseline data and quickly spot any components with serious problems. Once this process is complete, then it is possible to set an initial routine sampling interval. This interval is based on the results of the preliminary sampling, component manufacturer guidelines, customer maintenance procedures and personnel scheduling, plus experience with similar components and applications. When the program is fully established, the routine sampling interval may be adjusted. Once determined, routine sampling intervals should remain as constant as possible. On a ship, many users monitor key machinery once or twice a week, cylinder BN is measured every 3 days when the main engine is running, and the main engine system oil is measured every 7 days. See [Interpreting Results](#) section for frequency suggestions per application.

Oil Sample Preparation and Handling

The following will help reduce errors in testing the oil with DIGI+:

- containers used to store or collect the sample should be clean and free of contamination before use
- DIGI+ and the sample to be tested should both be at approximately the same temperature at the time of testing. Significant temperature differences can affect the measurement
- a clean bottle, such as those used for routine oil analysis, should be used to transfer a representative sample into the DIGI+ sample cup (pipettes are included with DIGI+ for this purpose)
- the main sample bottle should be shaken before taking a pipette sample to make sure the sample is evenly mixed

Setup Menu Navigation

Setting Date & Time

Power on
SETUP



> Date/Time <
OK → ▲▼ to select YEAR ►
▲▼ to select MONTH ►
▲▼ to select DAY **OK**
▲▼ to select HOUR (24H) ►
▲▼ to select MINUTES **OK**

BN Calibration

Gas is generated from a chemical that reacts with available (remaining) BN additive in the sample. Gas pressure from used oil is compared to new oil as a ratio:

$$BN_{used\ oil} = BN_{new\ oil} \times \frac{P_{used\ oil}}{P_{new\ oil}}$$

Pressure is generated in DIGI+ proportional to the remaining BN additive in the used oil sample and is compared to pressure from the new oil.

- the calibration can be checked by testing new oil in the BN, in place of used oil
- it is good practice to check and recalibrate BN, if necessary, every six months

Oil Types

DIGI+ stores the value of pressure generated by new oil as a reference. The pressure for new oil is measured once and saved. DIGI+ can save values for multiple new oils in its memory as *OIL TYPES*.

- DIGI+ holds calibration data for up to 8 different OIL TYPES
- when using smart mode, DIGI+ holds calibration data separately for up to 10 different OIL TYPES

*The OIL TYPE list can be edited by entering the oils list in set-up.

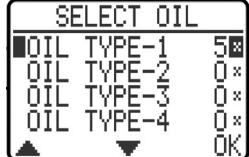
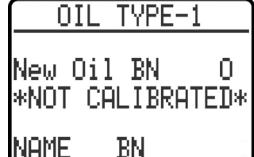
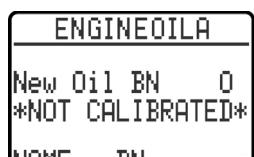
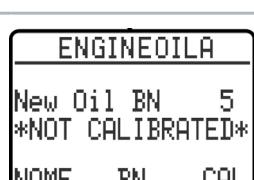
The OIL TYPE is structured in DIGI+ into separate lists as below:

	[Name]	[New BN]	[Low BN]	[High BN]	
1	SUPERLUBE	40 x			NON-SMART MODE MANUALLY ENTERED Edit on DIGI+ via SETUP
2	HS%CYLGARD	150 x			
3	LS%CYLGARD	40			
4	SYS LUBE_Y	20			
5	ENGINEOILW	15 x			
6	ENGINEOILA	30 x			
7	EP GEAR	10 x			
8	ULTRA_OIL	30			
1	SUPERLUBE	40	20	40	= NOT EDITABLE
2	HS%CYLGARD	150 x	70		
3	LS%CYLGARD	40 x	15		
4	HS%CY+TEST	100 x	40		
5	ENGINEOILW	15 x	6		
6	ENGINEOILA	30 x	15		
7	EP GEAR	10	4		
8	ULTRA_OIL	30	10		
9	SYS LUBE_Y	40	20	40	
10	HS%CY+TEST	30	20		

BN OIL TYPE List Name, BN Value & Calibration

DIGI+ stores calibration data for up to 8 different *OIL TYPES*. In Smart DIGI+ mode stores calibration data separately for up to 10 different *OIL TYPES* (these can only be edited in DIGI_CFG.csv file on USB drive)

NOTE: It is recommended to use the oil grade or name as the “Name” during DIGI+ setup process

Action	Visual	Description
To assign a name to OILs	 	<p>> OILs <</p> <p>OK → ▲▼ to select OIL TYPE OK</p> <p>NAME</p> <p>►▼ to select character NEXT</p> <p>Repeat steps above and when finished press NEXT repeatedly until OIL TYPE NAME VALID → OK</p> <p>*NOT CALIBRATED*</p> <p>NOTE: OIL TYPE needs a value of BN before calibration is possible.</p>
To edit OILs list		<p>> OILs <</p> <p>OK → ▲▼ to select OIL TYPE to edit OK</p> <p>NAME ►▼ to select character NEXT</p> <p>Repeat steps above and when finished press NEXT repeatedly until OIL TYPE NAME VALID → OK</p> <p>*NOT CALIBRATED*</p> <p>NOTE: OIL TYPE needs a value of BN before calibration is possible.</p>
To assign a BN value to OILs		<p>> OILs <</p> <p>OK → ▲▼ to select OIL TYPE to edit OK</p> <p>BN ▲▼ to scroll through numbers OK</p> <p>Repeat steps above and when finished press NEXT repeatedly until OIL TYPE NAME VALID → OK</p> <p>*NOT CALIBRATED*</p> <p>NOTE: OIL TYPE needs a value of BN before calibration is possible.</p>
To calibrate or re-calibrate OILs		<p>> OILs <</p> <p>OK → ▲▼ to select OIL TYPE to calibrate OK</p> <p>CAL</p> <p>Follow on-screen instructions → START</p> <p>Shake cell</p> <p>SAVE (or DISCARD to repeat or abort calibration)</p> <p>Clean cell → DONE</p> <p>Repeat for all OIL TYPES to be calibrated</p> <p>OK</p> <p>SHAKE CELL FOR x MINUTES</p> <p>TO ABORT TEST PRESS ⌂ FOR 5 SECONDS</p>

Cleaning



Cleaning is required following each oil calibration and each test.

The following steps should be taken to ensure safety:

1. Contents should be disposed of carefully.
2. DIGI+ body upper and sample cup (including agitator for H₂O testing) should be thoroughly cleaned. Attention should be paid to ensuring no reagent residue is left in the O-ring and threaded surfaces.
3. To clean the exterior and keypad, a lint-free cloth should be used (with a mild solvent if necessary, for example, isopropyl alcohol). Water, water-based cleaning products or other solvents must not be used as these may cause damage.



Testing

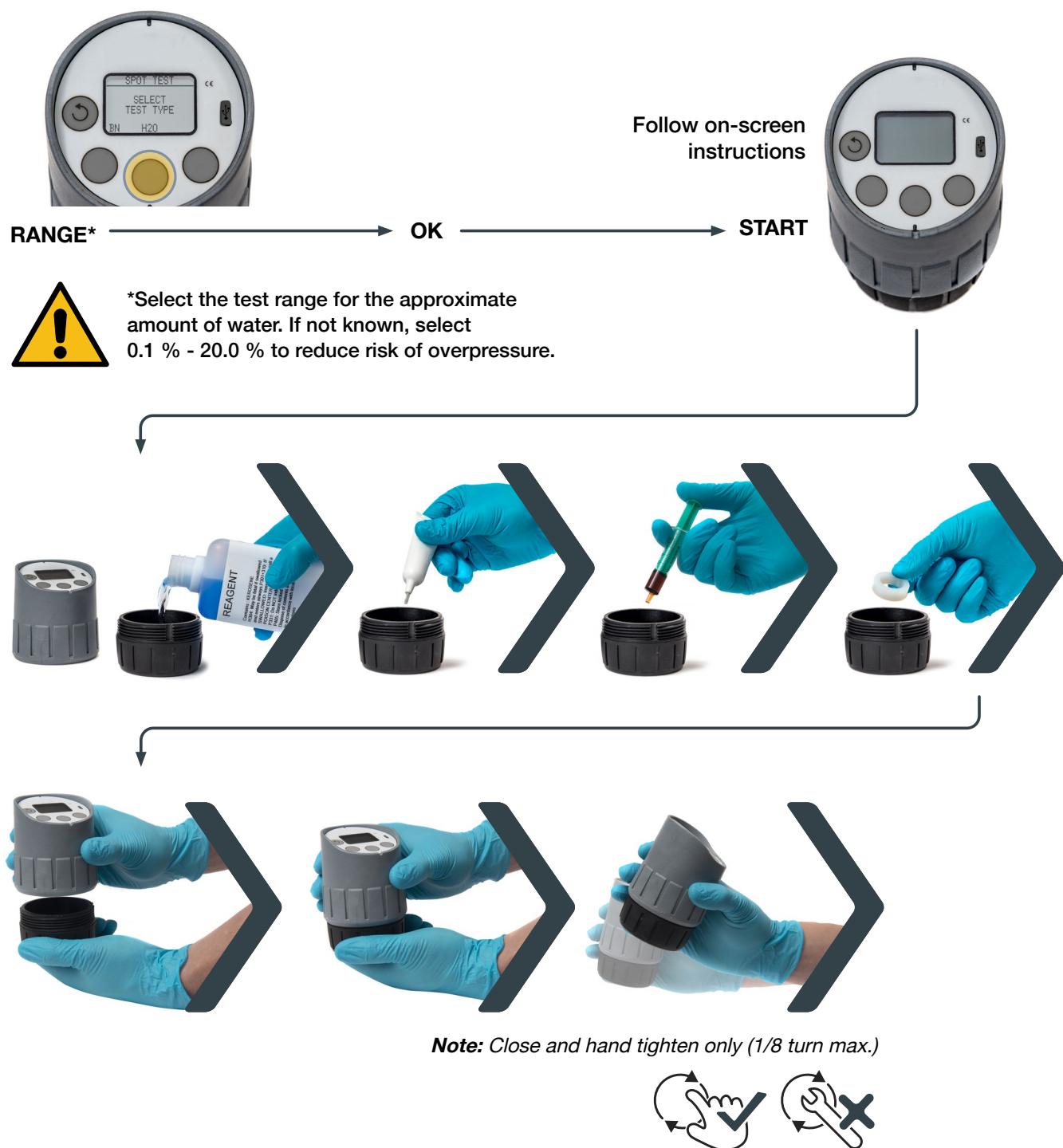
Before starting the test:



- DIGI+ should be clean and dry (particular attention should be paid to the seal). See [Cleaning](#)
- EasySHIP reagent must be above 18 °C and should be shaken thoroughly

Test Menu Navigation

Water (H₂O) - Single Test



Base Number (BN) - Single Test



See [BN Calibration](#)

Measure Used Oil

Select Oil using ▲▼

OK → (Follow on-screen instructions)



Note: Close and hand tighten only (1/8 turn max.)



ABOUT BN TESTING AND CALIBRATION



- BN Calibration must take place for an OIL TYPE to be measured
- if the OIL TYPE is already calibrated, DIGI+ automatically selects measurement screen
- calibration takes place automatically if an uncalibrated OIL TYPE is selected
- see [BN Calibration](#) for further detail

Interpreting Results

Water

Water contamination may cause different problems in different types of lubricating oil, although corrosion is always directly associated with water ingress. Whatever the equipment, water can displace the oil at contacting surfaces, reducing the amount of lubrication and activating surfaces which may themselves act as catalysts for degradation of the oil.

This is a particular problem with synthetic ester-based oils (e.g. many turbine lubes) which also react with any water present (hydrolysis). Water in emulsified form can increase lubricant viscosity. On occasions it has caused gross instability and dropout of the additive package. Problems will occur, whether visible or not, in any system in the presence of more than about 0.2 % water (some systems are very intolerant to water contamination).

In highly loaded lubricated contacts, particularly where oil films are thin (for example on gear teeth), water contamination can result in rapid failure through localised or general breakdown of oil film conditions. Alternatively, the mode of failure could be progressive resulting from local or generalised corrosion of components within the systems and / or through effects which impact on the functionality of the lubricant itself.

Sources

There are many potential sources of water contamination in any system including:

- leakage from oil coolers and steam heating coils
- charge air coolers
- condensation of atmospheric humidity
- blow-by gases from engine combustion spaces or past compressor ring packs
- leakage at tank vents (especially those exposed to weather)
- coolant jacket leaks through cracks or seals
- contaminated top up oil (especially in systems with a low tolerance to water)

Effects

Water is an important contaminant in all lubrication systems because of its potential to cause system failure via a number of mechanisms. Water will:

- corrode unprotected metal surfaces
- attack bearing substrates
- cause instability of chemical additives in the lubricants
- encourage the formation of emulsions
- alter the lubricant vapour pressure

Water contamination within lubricating oil (especially crankcase and system oil) and in fuels can lead to microbiological growth, forming yeast, mould and bacteria that will clog filters and rapidly corrode fuel systems

Base Number

BN is only relevant to diesel engine lubricants and not relevant for gear oils or hydraulic oils. Alkaline additives are present to neutralise acids derived from both combustion (mainly strong sulphuric and nitric acids) and those weaker, organic acids resulting from oxidation of the oil as occurs during ageing. BN is a measurement of the capacity of engine oil for neutralising strong acids from combustion of fuel oil. It is not a measure of how alkaline an oil is (the alkalinity is more akin to soapiness than strong alkali) but it instead measures the alkaline reserve of the oil or its ability to neutralise acids.

The BN of trunk piston diesel engines (high and medium speed) will fall due to exposure to combustion products but generally reaches a stable level as consumption of BN by neutralisation is matched with replenishment by fresh oil top-up.

BN of system oils in large 2 stroke cross head type engines may rise due to contamination of the oil with very high BN cylinder oil draining, via the stuffing boxes or from top-up with incorrect oil grades.

A drop of around 50 % of fresh oil BN indicates that the oil is almost at the end of its useful life. Another useful indication is a minimum BN equal to 7 times the sulphur content of the fuel in use. Oil suppliers usually recommend a change or partial replacement at this level in order to optimise the acid neutralising properties of the oil. This recommendation is mostly based on engine manufacturers' advice.

Put simply, the governing factor for the rate of decay of BN is the fuel sulphur level and the initial sump volume. The governing factor for the stable final BN level is the oil consumption rate and the fuel sulphur level.

Rapid BN decrease is caused by:

- low oil consumption
- small sump volumes
- high fuel sulphur levels

Low BN reserves provide insufficient neutralisation capacity leading to corrosion of engine components particularly around the piston ring pack, piston ring lands and top end bearing. Fouling of the engine internals and under piston cooling ways may also increase.

BN in gas-fuelled engines is often achieved using a very low ash additive pack. Additives are often based on automotive practice using magnesium in preference to calcium salts. Low ash properties are specified, as hot ash on combustion components can result in pre-ignition of the gas during the induction or compression strokes. BN in these applications can fall very rapidly due to high operating temperatures and, if using landfill gas, contaminants in the fuel itself.

Target Levels

In most cases there will be a value specified by the Original Equipment Manufacturer (OEM) which should be used. Check the latest guidelines and service letters from OEMs which are regularly updated in response to new operating regimes as determined by market conditions, such as engine load and vessel steaming speeds. The following is a general guide for target levels in given applications:

Diesel Engine Oils

Type	Fuel	Water % Maximum	New Oil BN (Typical)	BN value (% Change)	Typical Measurement Frequency in days
Automotive	Distillate	0.5 %	5	Minimum 1 (-60 %)	30
High Speed	Distillate	0.3 %	10	Minimum 2 (-50 %)	14
Medium Speed	Distillate	0.2 %	15	Minimum 5 (-50 %)	7
Medium Speed	Residual	0.2 %	30 to 50	Minimum 10 (-50 %)	7
Slow Speed (Cylinder Oil)	Residual LS (< 0.1 %)	-	15 to 40	Minimum 5 (-60 %)	5
Slow Speed (Cylinder Oil)	Residual HS	-	70 to 150	Minimum 20 (-70 %)	3
Slow Speed (System Oil)	Residual	0.2 %	5	Increase to 12 (+50 %)	7

Gas Engine Oils

Type	Water % Maximum	BN value (% Change)	Typical Measurement Frequency in days
Medium Speed Natural Gas 100 °C Lean Burn 40 °C	0.3 %	Minimum 2 (-50 %)	7

Other Applications

Type	OK	Warning	Exceeds limit	Notes	Typical Measurement Frequency in days
Enclosed Gear Oils	< 0.15 %	< 0.2 %	> 0.2 %	Check upper limit against OEM data.	30
Compressor Oil	< 0.1 %		> 0.1 %	Water can enter via compressor cylinders; always check inter-cooler drains are operating effectively. Refrigeration oil cannot tolerate any water.	7
Hydraulic Oils	< 0.15 %	< 0.2 %	> 0.2 %	Check upper limit against OEM data.	14
Turbine Oils	< 0.15 %	< 0.2 %	> 0.2 %	Check upper limit against OEM data.	7
Turbine Oils (synthetic)	< 0.1 %		> 0.1 %	Water can lead to hydrolysis of synthetic oils and rapid Acid Number increase.	7

SPID (Smart features)

– Overview and setup

Smart features are automatically launched when DIGI+ is connected to a PC (Windows and Mac), providing the ability to record results and to export for further analysis. The SPID structure provides a guided approach to measurements, ensuring all samples are measured in order. The smart capability of DIGI+ provides reassurance for the user by optimising data integrity and minimising missing test points, making it easier to spot out-of-range results. After taking measurements following the list of SPIDs, results are saved to DIGI+ internal drive (DIGI Drive). DIGI+ can then be connected to a PC and the SPID measurement data exported from DIGI Drive to the PC.

For time-efficiency, the oil reference list for BN measurement may be configured via the PC rather than entered manually via the DIGI+ keypad.

The user connects DIGI+ to a PC to:

1	Create, edit and import an OIL TYPE list / Sample Point Identification (SPID) list	PC ► DIGI+
2	Export SPID measurement data	DIGI+ ► PC

DIGI+:

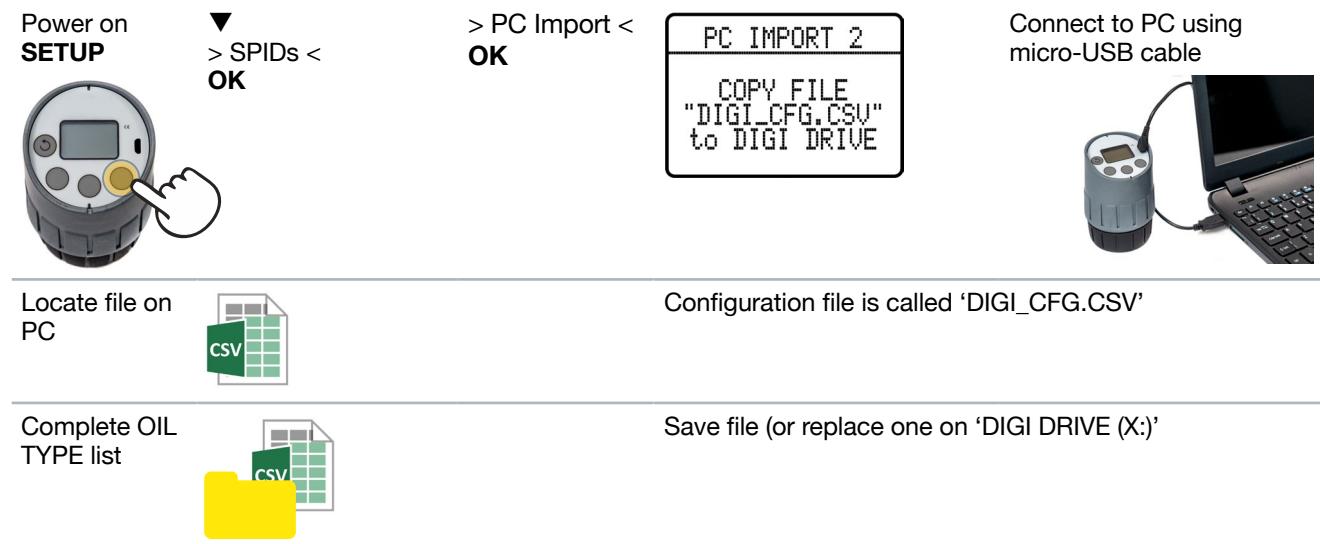
- can be configured manually with no special software
- works with any computer that supports MS-DOS (FAT12) – including MS Windows and Macintosh
- does not behave like a USB mass storage device but rather dynamically creates the csv files when connected to a PC
- file format is ‘Comma-Separated Values’.csv

It is only possible to drag and drop the DIGI_CFG file. Other files copied to the DIGI Drive are deleted. If files are deleted from the DIGI Drive, they are automatically recreated at next connection to a PC.

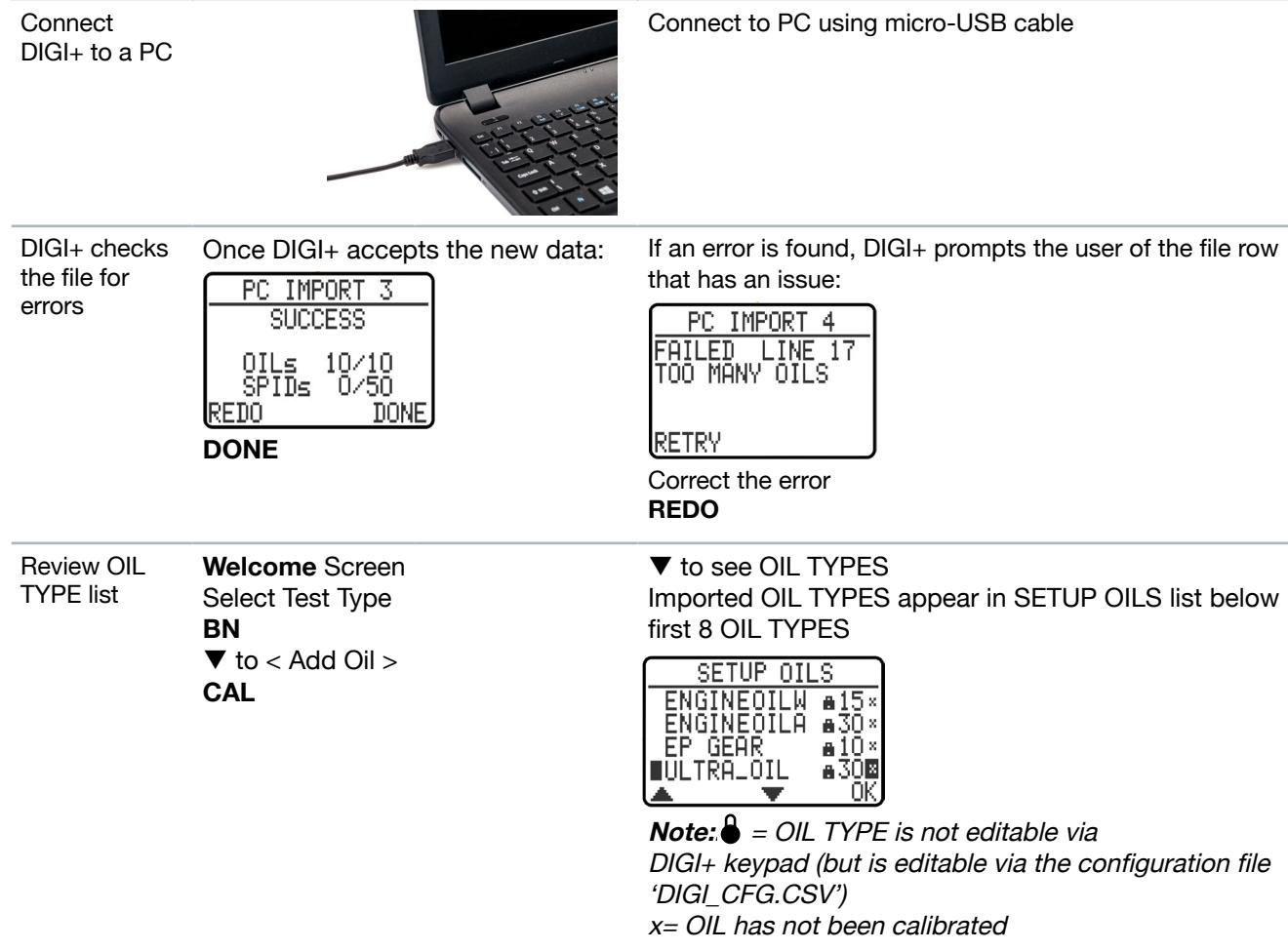
Creating & Editing an OIL TYPE List via a PC and & Importing to DIGI+ (BN measurement)

For optimal efficiency, the oil reference list for BN measurement may be configured via a PC rather than entered manually via the DIGI+ keypad:

Creating an OIL TYPE List on PC (first time setup)



Importing OIL TYPE List to DIGI+



Editing an OIL TYPE List on PC

Locate file on
PC



Connect to PC using micro-USB cable.
File will be on the drive list as 'DIGI DRIVE (X:)'

Make changes
to OIL TYPE
list



Save file (or replace one on 'DIGI DRIVE (X:)')

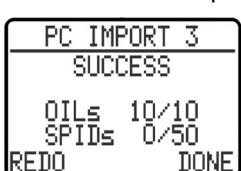
Importing edited OIL TYPE List to DIGI+

Connect
DIGI+ to a PC



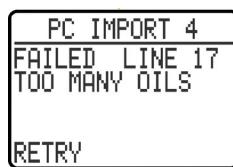
Connect to PC using micro-USB cable

DIGI+ checks
the file for
errors



DONE

If an error is found, DIGI+ prompts the user which file
row has an issue:



Correct the error
REDO

BN Measurement Visual Indicators

By connecting to a PC and using the DIGI+ smart functionality, cautionary alert limits can be entered for easy real-time result viewing.

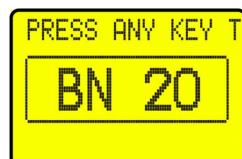
The user simply enters 'Low BN' and 'High BN' limits into columns C & D of the DIGI_CFG file.

Note: It is recommended to set these below target to give warning time.

See example below:

	[Name]	[New BN]	[Low BN]	[High BN]	
1	SUPERLUBE	40 x			NON-SMART MODE MANUALLY ENTERED Edit on DIGI+ via SETUP
2	HS%CYLGARD	150 x			
3	LS%CYLGARD	40			
4	SYS LUBE_Y	20			
5	ENGINEOILW	15 x			
6	ENGINEOILA	30 x			
7	EP GEAR	10 x			
8	ULTRA_OIL	30			
1	SUPERLUBE	40	20	40	NEEDS NEW OIL CALIBRATION
2	HS%CYLGARD	150 x	70		
3	LS%CYLGARD	40 x	15		
4	HS%CY+TEST	100 x	40		
5	ENGINEOILW	15 x	6		
6	ENGINEOILA	30 x	15		
7	EP GEAR	10	4		
8	ULTRA_OIL	30	10		
9	SYS LUBE_Y	40	20	40	
10	HS%CY+TEST	30	20		

DIGI+ uses these alert limits to dynamically backlight the screen providing a reassuring real-time result indication:



Result within pre-set alert limits

Result above pre-set alert limits

Result outside of range

Creating a Sample Point Identification (SPID) List via a PC and & Importing to DIGI+

Creating a SPID List on PC (first time setup)

Power on
SETUP
 ▼
 > SPIDs <
OK



> PC Import <
OK

Locate file on
PC



Locate File

Configuration file is called 'DIGI_CFG.CSV'.
File will be on the drive list as 'DIGI DRIVE (X:)'

Complete
SPID list



Save file (or replace one on 'DIGI DRIVE (X:)')

Importing SPID List to DIGI+

Connect
DIGI+ to a PC



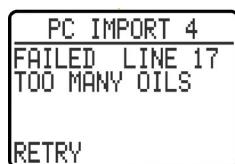
Connect to PC using micro-USB cable

DIGI+ checks
the file for
errors



DONE

Once DIGI+ accepts the new data:
If an error is found, DIGI+ prompts the user which file row has an issue:



Correct the error
REDO

Editing a SPID List on PC

Locate file on
PC



Locate File

Configuration file is called 'DIGI_CFG.CSV'
File will be on the drive list as 'DIGI DRIVE (X:)'

Make changes
to SPID list



Save file (or replace one on 'DIGI DRIVE (X:)')

Importing edited SPID List to DIGI+

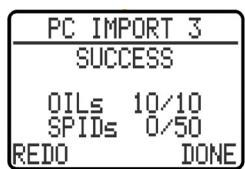
Connect
DIGI+ to a PC



Connect to PC using micro-USB cable

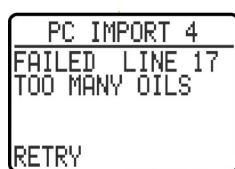
DIGI+ checks
the file for
errors

Once DIGI+ accepts the new data:



DONE

If an error is found, DIGI+ prompts the user which file row has an issue:



Correct the error
REDO

SPID Measurement & Storage



A SPID set is a batch of single tests. A new set is opened and then test results are collected.

Measurements can be repeated, for example, with an H₂O measurement, if the test is below the detection limit and a lower range is needed (from 0.1 % to 20.0 % to a 0.02 % to 1.00 % range on the same SPID).

Measurements can also be deleted.

A SPID set is kept open until closed – even if DIGI+ goes to sleep or if tests are performed over a period of a few days.

Once the user has completed all the tests, the batch is closed. The data set is then archived and is available to be imported into a PC as a results.csv file.

Range Detail



If a result is below the range used, the value stored is the minimum detectable limit for the range:

- either 0.1 %, 0.02 %, 200 ppm or 100 ppm

If a result is above the range used, the value stored is the maximum detectable limit for the range:

- either 10.0 %, 20.0 %, 10000 ppm or 3000 ppm

Only 3 archive files can be stored and displayed (new archive files replace the oldest file).

RESULTS.csv contains the in-progress SPID.

Exporting a Sample Point Identification (SPID) Results Measurement List from DIGI+ to PC

Connect DIGI+ to a PC



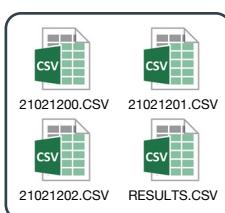
DIGI+ will automatically mount as 'DIGI DRIVE (X:)'

Locate file(s) on PC



DIGI Drive shows latest 3 archives and current in-progress set of SPID measurements as 'RESULTS'

Result files are dated when they were archived 'YYMMDD...'



View results in Excel / Notepad. Data can be archived or analysed for trend monitoring.

See [Interpreting Results](#) for further information.

Examples

Spreadsheet

EXAMPLE.csv				
## DIGI+ COMBINED CELL #				
Vessel / Installation / Site				
IMO				
	JARAERIP			
	9044802			
# BN OIL TYPE LIST #				
[Name]	[New BN]	[Low BN]	[High BN]	
SUPERLUBE	40	20	40	
HSNCYLGARD	150	70		
L5NCYLGARD	40	15		
ENGINEOLW	15	6		
# SAMPLE POINT ID (SPID) LIST #				
[Name]	[Type]	[ID]	[Description]	
M/E CYL1	BN	H5NCYLGARD	HIGH SULPHUR MAIN ENGINE CYL DRAIN 1	
M/E CYL2	BN	HSNCYLGARD	HIGH SULPHUR MAIN ENGINE CYL DRAIN 2	
M/E CYL3	BN	HSNCYLGARD	HIGH SULPHUR MAIN ENGINE CYL DRAIN 3	
M/E CYL4	BN	HSNCYLGARD	HIGH SULPHUR MAIN ENGINE CYL DRAIN 4	
STERN-20%	H2O	AFT SEAL TEST LOC 2		
# END #				
; Vessel / Installation / Site name maximum 20 characters				
; IMO standard 7 digits or leave blank				
; Maximum number of OILs = 10				
; Maximum number of SPIDs = 50				
; OIL names maximum 20 characters				
; Names upper case 'A' to 'Z' '0' to '9' '-' '_' '/' '+' '%' with no leading or trailing spaces				
; New BN values in the range 1 to 150				
; The Low BN and High BN limit fields are optional,,,				
; SPID Type either 'BN' or 'H2O'				
; With SPID Type 'H2O' selected the associated OIL is optional,,,				
; Description maximum 40 characters (no commas)				

Text Editor

```
## DIGI+ COMBINED CELL #,,,
Vessel / Installation / Site,JARAERIP,,,
IMO,9044802,,,
# BN OIL TYPE LIST #,,,
[Name],[New BN],[Low BN],[High BN]
SUPERLUBE,40,20,40
HSNCYLGARD,150,70,
L5NCYLGARD,40,15,
ENGINEOLW,15,6,
# SAMPLE POINT ID (SPID) LIST #,,,
[Name],[Type],[ID],[Description]
M/E CYL1,BN,H5NCYLGARD,HIGH SULPHUR MAIN ENGINE CYL DRAIN 1
M/E CYL2,BN,HSNCYLGARD,HIGH SULPHUR MAIN ENGINE CYL DRAIN 2
M/E CYL3,BN,HSNCYLGARD,HIGH SULPHUR MAIN ENGINE CYL DRAIN 3
M/E CYL4,BN,HSNCYLGARD,HIGH SULPHUR MAIN ENGINE CYL DRAIN 4
STERN-20%,H2O,,AFT SEAL TEST LOC 2
## END #,,,
; Vessel / Installation / Site name maximum 20 characters,,,
; IMO standard 7 digits or leave blank,,,
; Maximum number of OILs = 10,,,
; Maximum number of SPIDs = 50,,,
; OIL names maximum 20 characters,,,
; Names upper case 'A' to 'Z' '0' to '9' '-' '_' '/' '+' '%' with no leading or trailing spaces,,,
; New BN values in the range 1 to 150,,,
; The Low BN and High BN limit fields are optional,,,
; SPID Type either 'BN' or 'H2O',,,
; With SPID Type 'H2O' selected the associated OIL is optional,,,
; Description maximum 40 characters (no commas),,,
```



Care must be taken to ensure comma formatting is maintained and correct columns are being edited. See online guidance on using .csv files

Measurement & Download Cycle

0/X SPIDs Done

New SET automatically opened

Download the archive SPID DATA file to a PC or wait until more SPID data collected

Select SPID to measure

Keep measuring SPID (repeat if necessary)

When finished,
CLOSE SET
(Not all SPIDs need to be measured)

DIGI DRIVE
connected to PC.
SPID Data
Archive saved

SPID Data
SET CLOSED
and archived

Measuring and Closing a SPID Set

Action	Visual	Description
From HOME screen	 <div style="border: 1px solid black; padding: 5px; display: inline-block;"> SHAKE CELL FOR x MINUTES TO ABORT TEST PRESS ⌂ FOR 5 SECONDS </div>	SPID TEST → ▲▼ to select SPID to be tested OK (RETEST if test data already exists) OK Follow on-screen instructions START Measurement. When completed press any key to continue

Saving, Repeating or Deleting Measurements

After performing a test in a SPID sequence the user can:

SAVE, REPLACE or **DISCARD** measurement

DELETE result or **RETEST**

To exit without making changes, press the **BACK** button to exit to SELECT SPID list.

Clean cell → **DONE**

Repeat until all required SPIDS have been measured

Closing SPID Set

Action	Visual	Description				
	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> 2020-11-09 14:43 2/5 SPIDs Done <table border="1" style="margin-top: 5px; border-collapse: collapse;"> <tr> <td style="padding: 2px;">SPIID</td> <td style="padding: 2px;">SPOT</td> </tr> <tr> <td style="padding: 2px;">TEST</td> <td style="padding: 2px;">TEST</td> </tr> </table> </div>	SPIID	SPOT	TEST	TEST	END → YES to close SET
SPIID	SPOT					
TEST	TEST					
	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> Archived as: "20121600.CSV" Timestamp: 2020-12-16 10:26 DONE </div>	Completed SPID set is archived: DONE				

NOTE: a maximum of 3 SPID sets can be archived.

- DIGI+ has a SPID set memory that is first in, first out (FIFO)

IMPORTANT: to stop data loss, copy files from DIGI+ to a PC before starting a 4th SPID SET

- until the SPID SET is closed, SPIDs can be measured and remeasured as necessary

Clearing DIGI+ Memory

To delete SPID data and disable smart functionality:

Visual	Description
	> SPIDs < OK → > Delete < OK Back to SETUP
! WARNING ! All SPIDs and associated OILs will be removed. Continue? NO YES	YES
!! WARNING !! SPIDs, SPID OILs and SPID Results to be removed? NO YES	YES

DIGI+ Reset

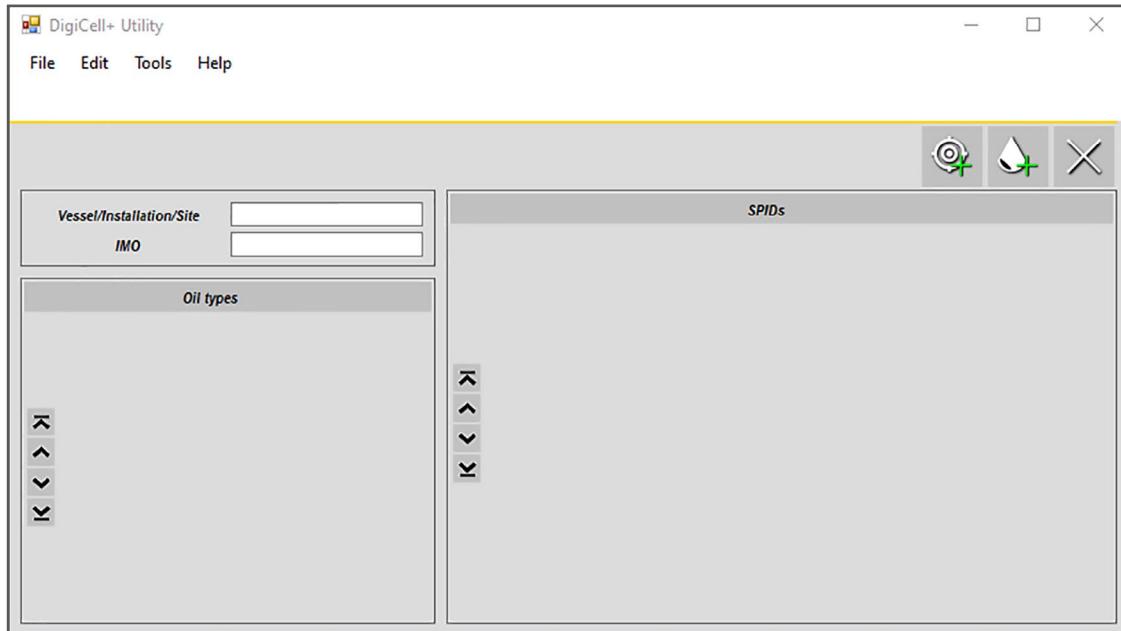
To remove all PC loaded data and stored data:

Visual	Description
	> Reset < OK Back to SETUP
! WARNING ! This DIGI+ will be reset to the factory default. Continue? NO YES	YES
!! WARNING !! All User data will be destroyed. Are you sure? NO YES	YES

DIGI+ Utility

A utility to configure DIGI+, download data and view trends in the SPIDs is available.

See the '[Contact, consumables and spares information sheet](#)' for links to these tools.



Maintenance & Servicing

No user-serviceable parts are contained within. DIGI+ must not be disassembled and will render warranty void.

For servicing, please see the '[Contact, consumables and spares information sheet](#)' on the USB drive supplied with DIGI+ kit or consult supplier.

DIGI+ has been designed with precision components for long term measurement accuracy therefore no periodic recalibration is necessary. Where quality systems require, or risk assessments indicate, that accuracy checking be performed DIGI+ can be sent to a service centre to be checked for accuracy and recalibrated if required.

Shipping Note

The original packaging must be used to return DIGI+ safely for maintenance, servicing and / or accuracy checking. The supplier will not be liable for damage to returned goods resulting from inadequate packaging.

Troubleshooting

Measurement

Symptom	Possible Cause	Possible explanation and Solutions
Over-pressure warning	Reaction with the oil	In very rare cases, the water test reagents may react with a component of the stock oil. If DIGI+ continuously over-pressurises, yet the water content is known to be in range, the water test will not be suitable for use with that stock oil.
	Incorrect volume of oil	All test ranges need different volumes of oil sample and reagents. Using too much oil can give too high pressure. Re-test and note volume of oil for the test. Ensure on-screen instructions are followed.
	Oil contains more water than range	Retest on 0.1 % – 20.0 % range.
	Possible gross water leak	Retest on 0.1 % – 20.0 % range.
Graph shows pressure loss	Leak	Dirt on seal. Seal should be removed, cleaned thoroughly and replaced before retesting.
		DIGI+ has not tightened properly. DIGI+ should be opened and re-closed, tightening by hand 1/8 turn only after the sample cup makes contact with the seal.
		 Tools should not be used to tighten DIGI+.
Screen does not: a) respond to button press or b) sleep after 5 minutes	Reset required	 should be pressed together for 8 seconds.

BN-specific Measurement

Symptom	Possible Cause	Possible explanation and Solutions
Unable to calibrate BN	Oil has 'non-Calcium' BN additive.	The BN reaction requires oils to have established and conventional Calcium carbonate additives. Ca ²⁺ alternatives do not react in the same way.
	Pressure leak	Before starting the calibration, the insides of DIGI+ and sample cup must be clean and dry (particular attention should be paid to the O-ring and threaded surfaces).
BN used oil is reading higher than new oil	Contamination of oil	Cylinder oil leaking into system oil on 2-stroke diesel engine.
	Wrong top-up oil used	Higher BN oil used to top up or incorrect oil added to system.
	Wrong amount of oil tested	On high BN, only 2 ml of sample is needed. Care should be taken to put exactly 2 ml into the sample cup.
		All test ranges need different volumes of oil sample and reagents. Using too much oil can result in too high pressure. Note volume of oil before re-testing.

Results

Symptom	Possible Cause	Possible explanation and Solutions
Results unrepeatable	Unclean instrument	Dirt or leftover reagents / oil from last test. Before starting testing, the insides of DIGI+ and sample cup must be clean and dry (particular attention should be paid to the O-ring and threaded surfaces).
	Contamination	
	Poor sampling	For consistent results, same sampling routine should be followed with same time period between taking the sample and measuring on DIGI+. The sample bottle should be shaken before taking a sample with a new pipette or syringe.
	Reuse of syringe	Use a new syringe for each test due to cross-contamination issues.
	Water used to clean DIGI+ inside	Water, water-based cleaning products or other solvents must not be used as these may cause damage.
Results lower than expected	Not enough reagent added	Ensure EasySHIP reagent is above 18 °C and entire tube is emptied into the sample cup.
	Sample oil and / or reagent volume incorrect	All test ranges need different volumes of oil sample and reagents. Using too much oil can give too high pressure. Note volume of oil before retesting.
	DIGI+ sensor fault	DIGI+ should be checked by conducting a test with no oil added. 1 drop of water should be added before starting the test. 200 ppm to 10000 ppm range should be selected and the result should be above 200 ppm.
		For DIGI+ BN only, new oil should be used for testing or calibration performed with a high BN oil, checking that DIGI+ records a pressure.
Results higher or lower than expected	Sample oil and / or reagent volume incorrect	On-screen instructions should be followed as the 100 ppm to 3000 ppm range needs 35 ml reagent and 15 ml oil whereas the 0.1 % to 20.0 % range needs 20 ml reagent and only 0.25 ml oil.
	Oil has changed significantly	Verify result by retesting.

Result Comparison

Symptom	Possible Cause	Possible explanation and Solutions
Results from DIGI+ are different than those from a laboratory test	Samples continue to age after being taken	A sample with water and / or low BN can continue to age such that the chemical composition of the oil is different to when it was tested.
	Differences within repeatability limit of DIGI+	All analytical methods, especially those requiring careful measurement of samples and reagents, can vary between tests. For maximum accuracy, a new pipette or syringe should be used, taking care when adding reagents to the sample cup.
	DIGI+ uses different measurement principles than laboratory tests	DIGI+ uses chemicals to react with components in the oil. Laboratory water tests such as Karl-Fischer or IR methods such as FTIR or NDIR can give different measurements and have their own non-repeat and accuracy issues. Laboratory methods also measure the total amount of water present. DIGI+ reagent reacts readily with free and emulsified water however dissolved water, and any held by the oil additive package, may not be accessed by the reagent. Laboratory methods such as IR do not discriminate what form the water is within the oil.

Connectivity, Battery & Power

Symptom	Possible Cause	Possible explanation and Solutions
DIGI+ will not turn on	Battery too discharged to turn on display.	DIGI+ should be charged via micro-USB cable until fully charged.
DIGI+ screen frozen	Processing error (crash)	DIGI+ needs resetting.  should be pressed together for 8 seconds.

DIGI_CFG.csv

Symptom	Possible Cause	Possible explanation and Solutions
DIGI+ will not connect to PC	Damaged USB	A different micro-USB cable should be used.
	Error 43 on PC	
	PC USB port not working	PC should be rebooted or another USB port should be used. Another PC should be used.