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Tramex Skipper Plus Knowledgebase Document

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Introduction and Intended Uses:

The Tramex Skipper Plus (SMP) is a non-destructive electronic moisture meter primarily intended for use on Glass Reinforced Plastic (GRP) composites including sandwich construction composites with foam and balsa cores. The meter may also be used on timberwork and masonry.

The Skipper Plus is particularly useful for monitoring the moisture content of GRP boat hulls during pre-purchase surveys and by boat owners during winter lift out seasons. Excessive moisture is associated with gelcoat blistering (commonly known as 'Osmosis'). The Skipper Plus may also be used to monitor hull moisture content during osmosis treatments to verify that epoxy coatings may be applied without risk of further blistering.

This document applies specifically to the Tramex Skipper Plus moisture meter, but much of the information provided here is also relevant to the earlier Tramex Skipper meter, the new Skipper V and sister Tramex ME and ME Plus meters and other manufacturer's instruments.

History:

The Tramex Skipper Plus is the fourth generation of Skipper meters and was launched in 2004. The original Skipper meter was launched in 1987.

The Tramex Skipper Plus is derived from the Tramex Moisture Encounter (ME) and Moisture Encounter Plus (MEP) instruments which were designed for the construction industry.

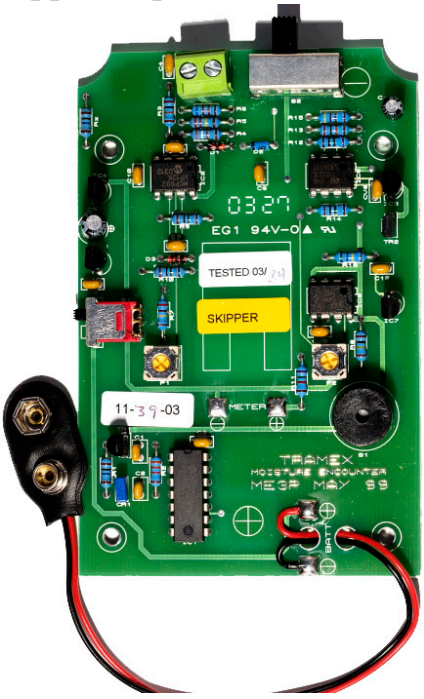
After sixteen years' service the Tramex Skipper Plus was superseded by the new Tramex Skipper V (SMM5) late in 2020 but continues in production for now.

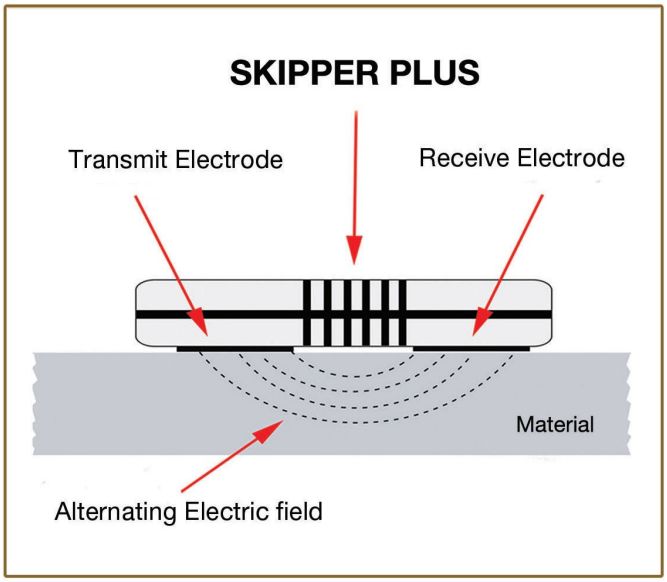
Design Concept and Principle of Operation (Skipper and ME Meters):
The electrical properties of timber and GRP change with their moisture content. The moisture content of timber and soft masonry can be determined directly by measuring the electrical resistance between two sharp metal pins pushed into the material. However, polyester boatbuilding resins have excellent electrical insulation properties so a different approach is required.

All Tramex Skipper meters have a pair of soft-faced electrodes fitted to the back of the instrument spaced a nominal 22 millimetres (⅞") apart. A high-audio frequency signal is applied to these electrodes and capacitive coupling used to measure the electrical impedance of the GRP sample.

At the heart of the instrument a crystal controlled oscillator generates a 1 MHz clock signal. This reference is unaffected by changes in temperature and supply voltage so no user calibration is needed or recommended. The clock signal drives a frequency divider circuit to provide a 32.25 KHz square wave output which is applied to the electrodes. The same frequency is used on all three ranges.

Using a bridge type circuit the current passing between the electrodes via the sample is amplified to provide an indication of moisture content. Three different levels of amplification are applied to provide three ranges, each calibrated for specific materials. Readings on the SMP and MEP meters are electronically mapped to provide a linear display throughout the measurement range.





The photograph on the left shows the circuit board from the third generation Tramex Skipper meter. The later Skipper Plus (fourth generation) uses much smaller surface mount components. The 1 MHz crystal controlled oscillator and frequency divider circuits are at the bottom left. The sounder is at the bottom right above the battery connector. Operational amplifiers will be seen towards the top and right. Cermet multi-turn trimming potentiometers allow fine calibration at the factory.

Perceptivity (Depth of Field):
All current marine moisture meters originate from the construction industry. Materials such as timber and masonry are homogenous in nature so any moisture tends to be evenly distributed throughout the sample being measured. By contrast, GRP and FRP composites are 'laminar' materials comprised of many layers, some of which may be wetter than others; therefore it is important to understand the limitations of individual moisture meters in this regard.

The depth of field (or 'perceptivity') provided by electronic moisture meters is governed by the spacing between their electrodes and cannot be increased or decreased by changing the circuitry. The useful depth of field is equal to half of the gap between electrodes. The nominal 22 mm (⅞") gap between the electrodes on the Skipper meters provides useful detection of moisture to a depth of approximately 11 mm beneath the surface, whilst moisture at greater depths will be detected with reduced sensitivity.

Calibration Standards:
By convention the 'Softwood' range on electronic moisture meters is calibrated against Sitka Spruce (*Picea sitchensis*) and Douglas Fir (*Pseudotsuga menziesii*) because these species are widely used in the construction industry. Remarkably, the properties of these timbers changes very little regardless of where they are grown in the world. Hardwood scales, where these are provided, will be calibrated to compensate for the density of the specified timber.

No scale exists for FRP or GRP composites because the makeup of these materials is so variable; even between seemingly identical hulls produced in the same mould. However, research carried out by EOLAS for Tramex and experimental data gathered during the development of the International Gelshield® scheme established that the true moisture content of GRP composites is very roughly 10% of the % H_2O values displayed on the Tramex Skipper set to Range 2 for GRP. In other words, a reading of 20% H_2O indicates a true moisture content of about 1.8 to 2.2% H_2O. This information may be of comfort to boat owners who worry that elevated moisture readings could result in a loss of buoyancy.

Repeatability:
Electronic moisture meters provide a great deal of useful information but the limitations of non-destructive moisture measurement dictate that the readings displayed are a close approximation rather than absolute values; especially when testing GRP composites. There are additional factors that can influence readings such as the depth of any moisture, the hand pressure applied and atmospheric conditions at the time of survey. The readings provided by a single meter from the same sample should be consistent, but may vary slightly if used by different operatives. Similarly, readings from different Skipper Plus meters may vary slightly on the same sample (typically ± 1% H_2O) even when used by the same operative.

The second generation Skipper meters built between C 1996 – 2000 were set for a lower sensitivity and will give lower readings compared with the Skipper Plus.

Routine Calibration Checks (all meters):
The 1 MHz clock signal in the Tramex Skipper meter is crystal controlled to ensure that readings remain consistent irrespective of ambient temperature and battery voltage. Under normal circumstances factory calibration is maintained throughout the life of the instrument, therefore user calibration is neither required nor recommended.

However, if the electrodes on the reverse of the instrument become worn sensitivity may be reduced. Readings may also be affected by mechanical damage to the moving coil display. We therefore recommend that the meter is checked for correct operation on a regular basis.

Tramex produces specific Calibration Check Boxes for each of the Skipper meters which allow correct operation to be verified quickly and easily in the field. Alternatively a piece of hardwood kept in a sealed bag will provide a handy reference. Please note that the ME Plus, earlier Skipper and ME meters require different calibration check boxes.

Limitations (Abnormal readings):
In common with other electronic moisture meters the Tramex Skipper Plus may give abnormally 'high' or 'off scale' readings if used on composites incorporating metals or electrically conductive materials including carbon fibre reinforcement and sandwich structures where aluminium honeycomb is used.

Kevlar reinforcements are not themselves conductive but some types of Kevlar fibre are treated with graphite which may result in abnormally high moisture meter readings.

Metal reinforcements and fastenings inside GRP structures and chains inside chain lockers will result in abnormally high readings if within range of the meter. Moisture, bilge water and conductive materials will be detected to a depth of 30 mm (1¼") or more which may result in misleading readings where boats are wet inside.

Antifouling Paints:
There is generally no need to remove antifouling paints before taking moisture meter readings.

Granular copper antifouling systems such as Coppebott and Copper Coat will result in higher readings depending on the thickness applied. Graphite based

antifouling paints such as Graphspeed will also result in abnormally high moisture meter readings.

Readings should not be taken in sub-zero temperatures because the conductivity of moisture falls rapidly in freezing conditions. Low temperatures also increase the risk of surface condensation.

Battery (SMP and MEP):
The Tramex Skipper and Skipper Plus meters are fitted with 9 Volt PP3 (6LR61) type batteries. These are readily available from chandleries, newsagents, supermarkets and DIY stores. Any type of PP3 battery may be fitted, including zinc-carbon and NiMh rechargeable batteries, but alkaline and lithium batteries will provide the longest battery life.

Under normal circumstances an alkaline battery will provide six to nine month's service. However, the soft switching circuitry continues to draw a small current (typically less than 20 µA) even when the meter is switched off. We therefore recommend that the battery is disconnected and ideally removed if the meter is not likely to be used for an extended period. Always carry a spare PP3 battery!

Automatic Switch Off (SMP and MEP):
The Tramex Skipper Plus (and ME Plus) meters use 'soft switching' circuitry to switch the instrument off if it has not taken any new readings for approximately ten minutes, and to retain 'held' readings. The alarm will sound twice just before the instrument switches off. Later instruments may be switched off manually by pressing the On/Off button. If the meter switches off whilst in Hold mode, the held reading will be retained.

Alarm Sounder (SMP and MEP):
The alarm will sound to warn of high moisture readings whenever the meter reads more than approximately half scale on any range. This is particularly useful when taking readings in areas where the meter display cannot easily be seen. To turn this feature off, press and hold the On button, then press the Hold button. Repeat this procedure to turn the sounder back on.

Which Range should I Use for GRP?
In the first instance readings from GRP composites should always be taken with the Tramex Skipper or Skipper Plus set to Range two (2) for GRP. This is the most sensitive range on the meter.

The guideline readings in the table below all refer to Range two. If the composite is very wet, or if monitoring water ingress into sandwich structures it may be necessary to switch to a less sensitive scale.

Range One is provided for hardwoods. Range 3 is a very low sensitivity scale which can be used when ranges one and two are too sensitive such as when tracing deckhead leaks. Range three can also be used where surface moisture is present and moisture in the composite is not important.

Interpreting Moisture Meter Readings:

There is no direct correlation between moisture readings and hull condition; however, many years of experience have shown a clear link between persistently high moisture readings and an increased risk of gelcoat blistering (osmosis) and other problems. High moisture content will also increase weight very slightly and may reduce stiffness; which could be an issue for some racing craft.

It must be stressed that there are many variable factors that can affect moisture meter readings including the thickness of the hull laminate, water and humidity in bilges, nearby tanks and metal fittings, outdoor atmospheric conditions and the length of time since lifting out. Readings should always be backed up by thorough visual examination before any conclusions are drawn or treatment prescribed.

The table below provides some outline guidance when examining GRP hulls and describes the three stages of the osmotic process. The colour scale to the left of the table correlates with the scale on the Tramex Skipper Plus and Skipper V meters. Older Skipper meters used a slightly different scale but the same comments apply.

Please take the time to read and understand these notes before taking readings.

1. Ensure that all surfaces are visibly dry, and that bilges are dry and well ventilated before taking moisture readings.
2. Moisture readings should not usually be taken within seven days of lifting out unless the vessel was built after C1993 and is known to have been laid up with Isophthalic or vinyl ester gelcoat and lay-up resins.

   (Isophthalic resins were not widely used in production boat building until the 1990s. Vinyl ester resins are a more recent development, and are less widely used than Isophthalic resins).
3. If readings are unexpectedly high, further readings should ideally be taken a week or two later to see if readings have fallen significantly.
4. Readings given by moisture meters are relative to timber, and do not indicate absolute moisture content in GRP. Furthermore, readings given by different instruments of the same type may vary. The true moisture content of GRP is very roughly 10% of the value given for timber.
5. Moisture readings taken from laminates prepared for full osmosis treatment should fall quickly as soon as the washing phase has been completed (see *The Shorter Guide to Osmosis and its Treatment*). Persistently high readings indicate that hygroscopic solutes are still present, and must be removed by further washing.
6. As a general rule, moisture readings from GRP composites in sound condition should be no higher than from a piece of clean, dry timber (ideally a hardwood) kept in the same atmospheric conditions. Significantly higher readings indicate the presence of hygroscopic solutes.

	Stage/Reading	Interpretation
	Stage 1	**'Dry' hull effectively in new condition. No evidence of blistering.**
	0 ~ 20 Comparative 0 ~ 10% H_2O	Readings expected from newbuilds, very dry laminates and repairs, etc,. Thin laminates may also give readings in this range when dry. An epoxy osmosis prevention scheme may be beneficial at this stage.
	21 ~ 38 Comp. 10 ~ 14% H_2O	Typical readings expected from in-service boats after a period ashore. Usual target range specified for application of epoxies for osmosis prevention and treatment. An epoxy osmosis prevention scheme may be beneficial at this stage.
	39 ~ 52 Comp. 14 ~ 18% H_2O	Typical readings expected from in-service boats at survey if not dried ashore. An epoxy osmosis prevention scheme may be beneficial at this stage.
	Stage 2:	**<u>Persistently</u> high moisture readings but no blistering evident.**
	53 ~ 80 Comp. 18 ~ 25% H_2O	Some evidence of moisture absorption. Hull may be Stage 2 Osmotic but is unlikely to blister in the short to medium term. Wintering ashore will help to delay any further deterioration. The application of protective epoxy coatings (for osmosis prevention) is not recommended at this stage unless readings fall significantly after a period on hardstanding.
	80 ~100+ Comp. 25 ~ 30%+ H_2O	Clear evidence of moisture absorption. Hull may be Stage 2 Osmotic and is likely to blister within a few seasons. Localised blistering may be found on close examination. The vessel may remain in service but annual monitoring is advised. Wintering ashore will help to delay any further deterioration. Osmosis treatment or the application of protective epoxy coatings (for osmosis prevention) is not recommended at this stage owing to the risk of blistering.
	Stage 3:	**High moisture readings accompanied by visible blistering**
	60 ~ 100+ Comp. 20 ~ 30%+ H_2O	High moisture readings coupled with visible blistering indicate an osmotic hull and may indicate some physical degradation. Provided the hull is otherwise 'sound' the vessel may remain in service with regular monitoring. Wintering ashore will help to delay any further deterioration. The application of protective epoxy coatings (for osmosis prevention) is not recommended at this stage owing to the high risk of blistering. A full osmosis treatment should be considered but is best delayed until the hull shows significant evidence of blistering over at least half of the underwater hull area. Any treatment should be started as soon as possible after lifting out at the end of a sailing season. Vessels which have been on hardstanding for extended periods are not good candidates for osmosis treatment owing to the lack of mobility of the solutes responsible for blistering.

All of the readings in this table refer to Range 2 for GRP using the Tramex Skipper/Skipper Plus.

Known Problems:
The Tramex Skipper and Tramex Moisture Encounter family of meters has proved extremely reliable in service, with many of the original instruments built in the 1980's still in regular service. With the benefit of thirty years' experience of these venerable meters we have identified a handful of minor problems which are easily resolved:

Moving Coil Display (all meters):
The moving coil display is by far the most delicate component in the Tramex meters and is prone to damage from dropping and hard knocks. There are typically two types of problem that may be encountered with the meter movement.

1. Sometimes the needle will stick, or will fail to zero properly, even when the instrument is switched off and the battery removed. This may be caused by physical damage to the meter movement but is more often caused by a static charge on the meter face; especially on new meters. Placing the palm of your hand flat on the meter face may help to remove the charge but will not remove it altogether. A damp cloth (not wet) placed on the meter face for a minute should fully resolve the problem. If the needle remains stuck it is likely that the meter movement is damaged and is in need of replacement.
2. If the meter movement is not responding at all it is likely that one of the springs or fine wires has broken rendering the meter open circuit. This can be confirmed by switching the meter on, selecting Range 2 (GRP) and holding the back of the meter across the palm of your hand. If the LED's illuminate and the alarm sounds but the meter des not register then the movement has probably failed. However, if the alarm does not sound the fault will be found elsewhere. (See worn electrodes below.)

The moving coil display for the SMP and MEP is plugged into the circuit board and is easily replaced, but we would recommend that you purchase a Calibration Check Box at the same time to verify correct operation on completion. If you are not confident to replace the meter movement we can easily do this work for you.

Spurious (High) Readings (all meters):
We have seen a small number of meters which give spurious (high) readings at switch-on and during operation. These readings often change wildly as the meter is moved or handled. The meters concerned are usually older instruments which have travelled a lot, especially by air, have been exposed to high temperatures, and/or have been subject to vibration.

On investigation it was found that the four screws securing the circuit board into the case had become slightly loose. One of these fastening points provides a ground connection between the circuit board and a copper RF shield bonded into the back of the instrument. This shields the sensitive circuitry on the circuit board from the electrodes, but if the connection is lost the shield becomes inoperative.

This problem is resolved by opening the case and gently tightening the four screws retaining the circuit board. Please note that that the threads in the plastic case are easily damaged. If the threads become stripped apply a single drop of Superglue to the affected screws before refitting them.

Worn Electrodes (all meters):

The electrodes on the Skipper and ME meters are a co-planar design with self-adhesive backing, a foam core and a conductive rubber composite layer at their surface. The conductive layer has small 'tabs' which connect to the circuit board inside the instrument. The electrodes are quite hardwearing but with regular use the conductive layer will wear thin and lose some conductivity resulting in a slight, but measurable loss of sensitivity. This is typically about 2 or 3% H_2O on Range 2 for GRP at mid-scale. Dragging the meter across surfaces accelerates this wear. The electrodes have a distinct surface pattern when new which gradually wears away.[1] If the electrodes appear shiny and worn rather like old car tyres with no tread they should be replaced. Eventually the small 'tabs' connecting the electrodes to the circuit board will break rendering the meter inoperative, although the LED's will still be illuminated.

Worn electrodes like these will reduce sensitivity.

New electrodes can be supplied for all Skipper and ME meters including the very first instruments in this series. However, fitting the new electrodes is a tricky operation because of the need for precise placement. The self-adhesive backing is also extremely sticky so there is little chance of repositioning the electrodes if they are not fitted in the correct position. We therefore recommend that your meter is returned for repair and a calibration check. Where possible we always record calibration results before and after repair.

Short Battery Life (SMP and MEP only):

With normal use a new alkaline battery should provide six to nine month's service in the SMP and ME meters. These instruments use 'soft switching' circuitry to switch the instrument off if it has not taken any new readings for approximately ten minutes, and to retain 'held' readings. However, the soft switching circuitry continues to draw a small current (typically less than 20 µA) when the meter is switched off.

If you find that your meter is discharging more quickly it is likely that it isn't switching off after use. Handling or constant movement will prevent the meter from switching off automatically. On later models it is possible to switch of

[1] Tramex Skipper Plus meters produced from late 2019 onwards are fitted with a smooth faced electrode which is much harder wearing.

manually by pressing and holding the On/Off button. For other instruments make sure they have switched off before placing them in their protective pouches.

The battery should be disconnected and ideally removed if the meter is not likely to be used for an extended period. Always carry a spare PP3 battery!

The older Skipper and Moisture Encounter instruments used physical switches and did not use any current whilst switched off.

Battery Compartment Cover (all meters):

The battery cover should be opened by inserting a screwdriver or key into the slot. Lift the cover by gently pressing on the securing tab whilst lifting the cover towards you. Take care when opening the compartment as the tab can be broken off. Spare covers are currently available for the SMP and MEP meters. A limited number of covers are available for older meters.

Immersion in Water (all meters):

The Tramex Skipper meter is not waterproof! If you are unfortunate enough to drop your meter into water very prompt action is needed to have any chance salvaging it. The first priority is to remove the battery to minimise electrolytic corrosion and to prevent other damage to the circuitry.

The greatest enemy of electronic equipment is salt, which is both conductive and corrosive. Worse still, salt is deliquescent, which means that it absorbs atmospheric moisture to maintain a permanently corrosive solution which will cause permanent damage to electronic components, especially if the battery remains connected.

The advice provided below applies to full immersion where water enters the meter casing. Superficial splashes should be wiped off with a clean cloth damped in clean water before placing the meter in a warm dry place and allowing it to dry.

Fresh Water Immersion:

Remove the battery immediately. If possible open the case to encourage removal of any water. Retain the lanyard, all screws and parts for refitting. Dry the instrument in a warm dry place such as an airing cupboard and then place into a sealed polythene bag with either a bag of silica gel or rice as a desiccant for a few days before reconnecting the battery. Calibration must be checked before any further use. In practice it is likely that the moving coil meter at least will need to be replaced.

Salt Water Immersion:

Remove the battery immediately and contact us for further advice.

Fault Finding Summary:

Fault	Check
Meter does not operate:	Check that battery is fitted and connected properly. A 9Volt PP3 (6LR61) type battery is required. Always carry a spare battery!
LED's cycle at switch on.	Battery is exhausted. Replace battery before using the meter.
LED's illuminated but meter does not respond.	1) Hold feature enabled. Press the Hold button to resume normal operation. 2) Electrodes worn or electrode tab broken. These are replaceable. 3) Moving coil meter broken. These are replaceable.
Meter does not zero.	The moving coil movement may be damaged or could be affected by static electricity. Apply a damp cloth over the meter movement to remove any static charge. Otherwise replace the meter movement.
Intermittent spurious (high) meter readings.	Intermittent connection between the circuit board and copper shielding foil inside the meter case. Resolved by tightening the four screws securing the main circuit board. This usually affects older meters that have travelled extensively.

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