MACE – XCi & Series II

The XCi is a modular metering system for the measurement of water flow in full pipe, partially filled pipe and an open channel.

The following requirements do not replace the XCi Product Manual or the FloSeries II Product Manual. The manuals are essential for the successful installation, commissioning, operation, and maintenance of these devices, and must always be used.

However, for use of these meters under this module of the standard the following requirements must be met, as a minimum, and have been formulated from recommendations/advice in the manual and where required with input from the manufacturer.

Requirements to be confirmed by validation type	
Post-installation - new meter installation **Existing meter installation – new logger and new sensor/s installed**	Table 2 applies – Full pipe meters larger than 600 millimetres only. Section 2.0, Section 3.0, Section 4.0, Section 5.0, Section 6.0, Section 7.0, Section 8.0, Section 9.0, and Section 10.0
Ongoing (revalidation) or Faulty meter (maintenance) – existing meter installation - new or replacement sensors only and no new logger	Section 2.0, Section 3.0, Section 4.0, Section 5.0, Section 6.0, Section 7.0, Section 8.0, Section 9.0, and Section 10.0
Ongoing (revalidation) or Faulty meter (maintenance) – existing meter installation - new logger only and no new or replacement sensors **Ongoing (revalidation) or Faulty meter (maintenance) – existing meter installation - no new or replacement logger and no new or replacement sensors**	Section 4.0, Section 5.0, Section 6.0, Section 8.0, Section 9.0, Section 10.0, and Section 11.0

Note: The requirements only reference the XCi but these requirements must also be met with any Series II. Where the requirements cannot be met with the Series II, this has been noted.

1.0 Key terms

Term	Definition
Area / velocity sensor	MACE Doppler ultrasonic strap mount area/velocity sensor
Depth sensor	As a component of the area / velocity sensor, or a stand-alone third-party sensor
Insert velocity sensor	MACE Doppler ultrasonic insert velocity sensor
Non-insert velocity sensor	MACE Doppler ultrasonic strap mount velocity-only sensor
XCi	The MACE AgriFlo XCi or FloPro XCi including connected sensors.
Logger	The controller/logger component of the XCi
Velocity sensor	Insert velocity sensor, non-insert velocity sensor, and area / velocity sensor

2.0 Authorised Meter Validator

From 1 December 2022, a CMI must have completed training by MACE for the XCi, within the previous 2 years to perform the activities in the following table. The training record/certificate must be provided with the validation certificate where a new sensor is installed.

Activity	CMI	Training by MACE
Installation of new sensors	✓	✓
Velocity sensor check for a new velocity sensor	✓	✓

3.0 Measurement assurance requirement B

3.1 Velocity sensor

New velocity sensors must be calibrated after manufacture and prior to installation, and the manufacturer must certify that the sensor will measure velocity within ±2.5% of true value across the velocity range.

The new sensor must be provided with a calibration certificate showing:

- date of the calibration test
- the serial number of the reference meter
- the sensor type, manufacturer part number, and the serial number for the sensor
- the velocity range over which the sensor was tested
- pass/fail.

With the installation of a new sensor a velocity sensor check (3.2) must also be completed.

A new velocity sensor must undergo a velocity sensor test (see 8.0 Velocity Sensor Test).

3.2 Velocity sensor check

Where a new sensor has been installed, a XCi must have a minimum of 10 real time graph measurements viewed and saved, while extraction is occurring.

The graphs must show an ‘ideal’ bell shape centred across the velocity range with the range set to double the average velocity.

If water extraction is occurring at the time that validation is being undertaken, a minimum of 10 graphs must be viewed, saved, and provided to the relevant person with the validation certificate.

If water extraction is not occurring at the time that validation is being undertaken, during the next extraction event a minimum of 10 graphs must be viewed, saved, and provided to the relevant person within 20 days of the extraction event.

The department will request another validation certificate if the real-time graphs are not provided to the department by the relevant person, within 40 business days of the next extraction event.

3.3 Depth sensor

New depth sensors must be calibrated after manufacture and prior to installation, and the manufacturer must certify that the sensor will measure depth within ±0.25% of true value across the depth range.

The new sensor must be provided with a calibration certificate showing the:

- date of the calibration test
- serial number of the reference device
- sensor type, manufacturer part number, and the serial number for the sensor

- depth range over which the sensor was tested
- calibration coefficients i.e., slope and offset, or, that the sensor has ‘passed’ the test.

4.0 Fit for purpose

4.1 General

A velocity sensor must only be used to measure extractions from stream flow with sufficient acoustically reflective particles such as sand, silt, dirt, leaves and/or air bubbles. The stream must contain at least 100 parts per million of acoustically reflective particles that are greater than 75 microns in size, noting most natural environments usually have sufficient reflective particles suspended.

A velocity sensor must not be:

- used in full pipe with a pressure greater than 25 meters head, at/on the sensor,
- used to measure velocities more than 8 metres per second,
- used for underground water measuring applications,
- installed within 25 meters of another acoustic flow meter in the same pipe/open channel.

4.2 Insert velocity sensor

The sensor must be:

- installed in a ball valve
- easily accessed on the outside of the pipe for servicing and maintenance (not buried).

The sensor must not be:

- installed in a round pipe with an internal diameter greater than 2.5 meters or where a pipe is not round with a cross-section area greater than 4.9 m2
- used for open channel metering.

4.3 Non-insert velocity sensor and Area / velocity sensor

These sensors must not be used in an open channel with a maximum width greater than 10 meters. For example, for a trapezoidal channel the maximum width of the channel during full flow must not exceed 10 meters.

These sensors must only be used with these regular channel geometries:

- concrete lined open channels
- concrete lined rectangular or trapezoidal culverts
- natural lined open channels with near-trapezoidal shape
- round and elliptical pipes.

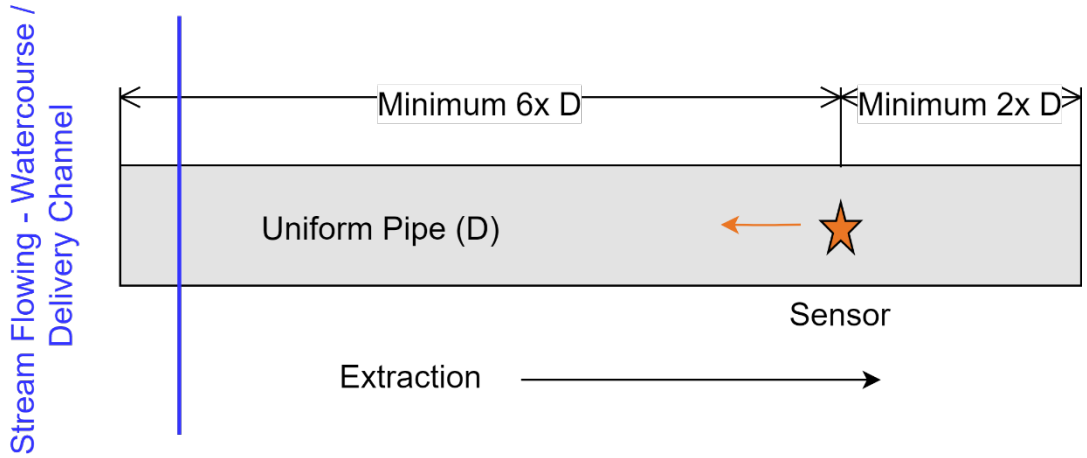
These sensors must not be used with:

- natural streams with complicated cross-sectional geometry
- complicated flow structures.

4.4 Installation conditions

4.4.1 Full pipe and partially filled pipe

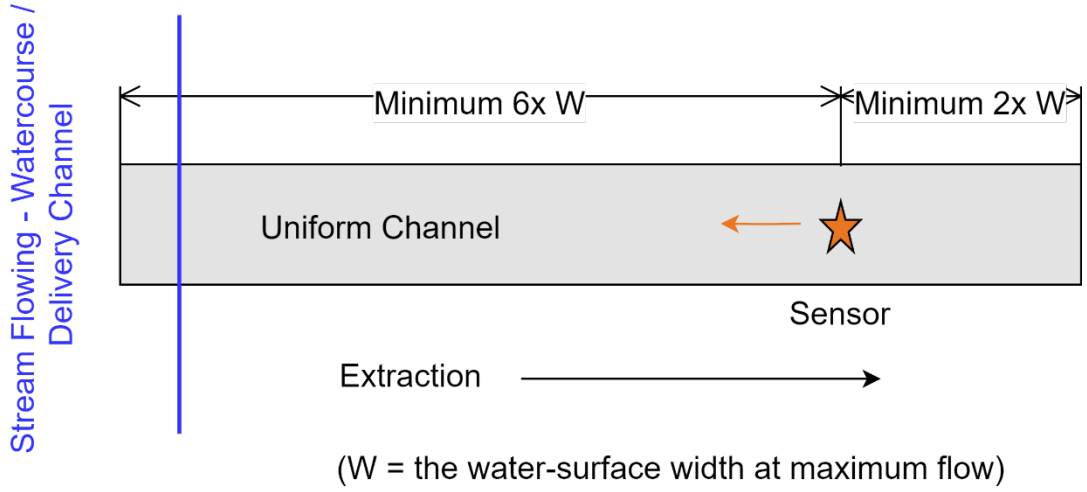
For a uniform pipe with no upstream disturbance (for example no valves/bends/pumps upstream) the velocity sensor must be installed to these minimum straight length requirements.



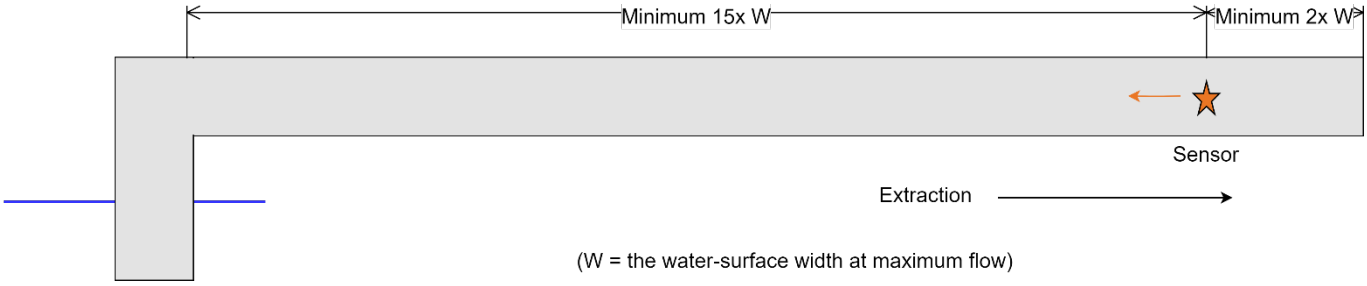
For all other installation scenarios, the velocity sensor must be installed with the upstream and downstream lengths specified in the Meter Installation Plans in Appendix D – as a minimum.

4.4.2 Open channel

For a uniform channel with no upstream disturbance (i.e., no sharp bends/angled undershot gate) the velocity sensor must be installed to these minimum straight length requirements.



Where there is upstream disturbance (i.e., high velocity flow via a sharp bend/there is an angled sluice gate) upstream, the velocity sensor must be installed to these minimum straight length requirements.



4.4.3 Depth sensor – stand-alone

Note: Series II does not have this functionality.

Where required, a depth sensor can be a third-party sensor.

Any third-party sensor must:

- connect to the XCi, where measurements must be logged
- obtain power from the XCi.

5.0 Installation

5.1 General

The XCi must:

- Water damage – be mounted above known flood peak levels. The XCi must not be submerged.
- Sunlight - be mounted so that the LCD faces in a direction away from direct sunlight (i.e., LCD must face South).
- Cable damage – have all cables appropriately routed through electrical conduit when not enclosed in any mounting pole.
- Insects and moisture – have a non-curing sealing compound (e.g., duct-seal-putty) installed down the first 5 to 10 cm of electrical conduit or the mounting pole where cables are enclosed, to prevent insect/moisture ingress.
- Power – have an alternate DC source of 16-30V DV connected to the XCi power regulator to charge the internal battery (i.e., a solar panel). The cables from the solar panel to the XCi must be enclosed in electrical conduit when not enclosed in any mounting pole (see Insect and moisture requirement above).
- Solar panel - have tri-spikes installed on the top of the solar panel to reduce the accumulation of bird droppings on the front face of the panel; and the solar panel orientated to the North at the appropriate incline angle, and the panel must not be shaded by trees or structures.

5.2 Doppler ultrasonic velocity sensor

The sensor cable must not:

- be cut. Re-termination of the sensor is highly specialised and must be carried out at a MACE technical facility.
- have any connections between the sensor and the XCi (so the sensor cannot be disconnected inadvertently or to facilitate fraud).

5.3 ZX SnapStrap

A correctly sized ZX SnapStrap must be used (see the XCi - Product Manual).

In round pipe the strap must be permanently affixed to the inside of the pipe.

5.4 Bespoke strap mount

The CMI can choose to use a bespoke strap mount in a pipe.

The sensor must mount through countersunk holes in the strap (using the same principles as for mounting of a sensor in a ZX SnapStrap)

The strap must be permanently affixed to the inside of the pipe (e.g., bolted/screwed through/to the pipe wall or mounted using adhesive (or equivalent)).

5.5 Mounting plate

The MACE mounting plate must be used in pipe greater than DN800 (or equivalent), and for open channel installations.

It must be permanently affixed (e.g., bolted/screwed through/to the pipe wall, bolted/screwed to a concrete pad or mounted using adhesive (or similar product)).

‘Or equivalent’ in this instance means, in round pipe with an internal diameter greater than 800mm or a non-round pipe with a cross-section area exceeding 0.503m2.

5.6 Depth sensor – stand-alone

Note: Series II does not have this functionality.

The sensor cable must not have any connections between the sensor and the logger (so the sensor cannot be disconnected inadvertently or to facilitate fraud).

6.0 Configuration

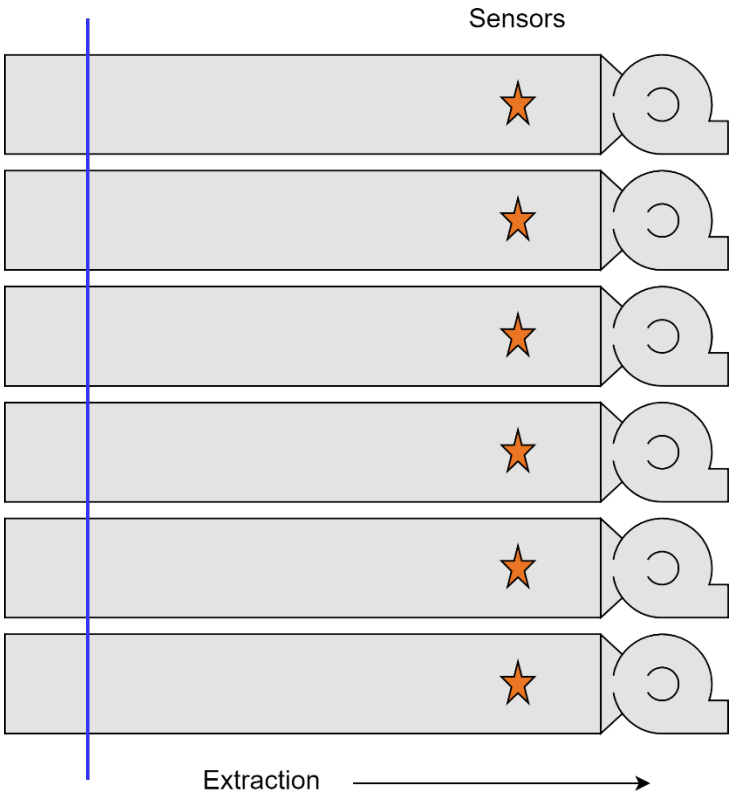
6.1 Site ID

Must be the logger serial number.

Where more than one logger are required at the metering location, use the lowest serial number, and record the other logger serial number(s) on the validation certificate.

Note: the Series II does not have the following functionality.

The following example describes where more than one logger could be required for the XCi. In this example, there are six velocity sensors. For each of these sensors a Doppler card is required to be installed in the logger to convert the signal received from the sensor to a velocity measurement. One logger has five card slots only, with one of these devoted to data output (refer to 12.0 Output) – leaving four card slots for Doppler cards to be installed. Therefore, a second logger would be required for the remaining two Doppler cards.



When a validation certificate is provided for the XCi, it must link:

- the logger serial number (Site ID), to the
- water resource extraction authorisation number(s), to the
- works number(s) for extraction occurring against an authorisation, to the
- latitude and longitude for the meter location
- the serial number/s for the sensor/s connected to the logger/s.

Where the controller card is replaced, the serial number for the new card must be linked to the metering site with a validation certificate. The new serial number must be permanently recorded inside the logger using a label or tag.

6.2 The XCi channels

The XCi uses channels to enable various measurements to be made and other parameters to be calculated. There are three types of channels:

- Connected sensor channels – these channels output the measured value based on the signal received from physically connected sensors wired to the logger.
- Calculated channels – these channels use the measured values (connected sensor channels) and apply an algorithm(s) to output calculated values.
- System channels – these channels use system values direct from the logger.

6.2.1 XCi – water meter

There are two primary measurement configurations where the XCi is used as a water meter.

CONFIGURATION 1: Measurement of velocity, with flowrate calculated by multiplying by a fixed cross-sectional area of flow (full pipe).

- A Doppler ultrasonic velocity sensor signal is converted to a velocity output by the logger using a ‘velocity channel’.
- The velocity output is then used to calculate flowrate via a ‘flowrate channel’ by multiplying by a fixed cross-sectional area of flow.

CONFIGURATION 2: Measurement of velocity and depth of flow, with flowrate calculated by multiplying by a calculated cross-section area of the flow (partially filled pipe and open channel).

- A Doppler ultrasonic velocity sensor signal is converted to a velocity output by the logger using a 'velocity channel'.
- A depth sensor signal is converted to a depth output by the logger using a 'depth channel'.
- The velocity output is then used to calculate flowrate via a 'flowrate channel' by multiplying by a calculated cross-sectional area of flow.

Following are minimum requirements for 'Channels' to be configured and confirmed for the meter installation. The requirements are based on the two basic measurement configurations for the XCi (described above) as a water meter.

Channels	Channel type	Configuration 1	Configuration 2
Velocity	Connected sensor	✓	✓
		The 'monitor status' checkbox must be ticked.[#] / [##]	
Doppler stream index	System	✓	✓
Depth	Connected sensor	×	✓
Flowrate (using velocity)	Calculated	✓	✓
Total flow	Calculated	✓	✓
		The 'non-resettable' check box must be ticked.[##] The 'total positive flow' check box must be ticked.	
Net flow total	Calculated	✓	✓
		The 'non-resettable' check box must be ticked.[##] The 'all values' check box must be ticked.	
Device battery voltage[#]	System	✓	✓
Device external voltage[#]	System	✓	✓

[#] Essential meter health elements, i) velocity sensor working, and ii) the XCi internal battery and alternate DC power source voltage, making it easier to identify if the meter is/when the meter became faulty.

[##] Essential tamper-evident/prevention elements, i) logging when a velocity sensor is disconnected or stops working, and ii) stopping unauthorised persons from resetting the XCi totals. Either inadvertently or to facilitate fraud.

7.0 Geometry

The cross-sectional area must be determined and/or confirmed at the sensor location whenever a new sensor is installed. A report on this activity, confirming completion, must be provided to the relevant person with the validation certificate.

7.1 Cross-sectional area – non-round or irregular shaped pipe, and open channel

The intervals for the measurement of depth must not be greater than 1/20 of the width when establishing the depth to cross-sectional area algorithm.

Where the pipe/channel cross-section is uniform equal spacing between the vertical measurements is appropriate.

Where the pipe/channel cross-section is not uniform, the location of the verticals must be chosen so that the discharge in each segment is less than 5% of the total, in so far as possible and not exceed 10%.

8.0 Velocity sensor test

A MACE Doppler Sensor test kit must be used, and a digital multimeter capable of reading capacitance (<2nF range) and resistance (>20MΩ).

The sensor must produce capacitance and resistance values within the ranges specified in the AgriFlo XCi User Manual to remain in service.

Where a sensor fails the test, it must be replaced with a new sensor.

A report on this activity, confirming completion, is to be provided to the relevant person with the validation certificate.

9.0 Depth sensor check

The sensor “offset” must be confirmed and checked. The offset is the level that the sensor is positioned relative to the silt/sediment/bed level within a pipe or channel.

Where the water level is over the sensor, the reading must also be confirmed against another measurement device. For example, a tape or ruler.

Where the water level is not over the sensor, the sensor must be confirmed to be reading correctly against another measurement device. For example, submerging the sensor and confirming the level matches that of a tape or ruler.

Where the sensor fails the check, a new sensor must be installed.

A report on this activity, confirming completion, is to be provided to the relevant person with the validation certificate.

10.0 Output

Note: Series II does not have the following functionality, but it does provide a basic pulse output which must be confirmed to be operating.

Where the department requires meter health as an output from the meter:

The logger must have a FloSI card installed. To have a validation certificate issued, where an XCi:

- is installed after this document came into effect - it must have a card installed as part of validation post-installation
- was installed prior to the effect of this document - it must have a FloSI card installed as part of the next process of validation for the XCi.

The FloSI Card provides output from the logger for interface with third party transmission devices.

A WebComm card may be used where the department confirms this is possible. This card provides cellular output from the logger to the Department’s nominated data platform.

Where the department requires pulse output only:

The logger must have a Pulse I/O card installed. To have a validation certificate issued, where an XCi:

- is installed after this document came into effect - it must have a Pulse I/O card installed as part of the process of validation, post-installation
- was installed prior to the effect of this document - it must have a Pulse I/O card installed as part of the next process of validation for the XCi.

The Pulse I/O card provides output from the logger for interface with third party transmission devices.

11.0 Maintenance

11.1 Velocity sensor cleaning

The velocity sensor must be kept free of built-up debris, silt, or grease:

This is done using a stiff bristle brush (do not use steel bristle brushes) and carefully cleaning the sensor head and surrounding area

11.2 Battery replacement

Note: the Series II does not have a logger control panel battery.

The XCi internal battery must be replaced every 5 years, as a minimum, regardless of perceived battery status.

The logger control panel battery must be replaced when the internal battery is replaced, regardless of perceived battery status.

11.3 Area/velocity sensor

11.3.1 Reference filter

To keep the depth sensor component of this sensor working as required the vent tube must always remain free from moisture.

The silica gel crystals contained within the reference filter effectively entrap atmospheric moisture. However, these crystals require changing regularly to ensure that they are still effective.

The silica gel crystals used in the reference filter are an indicator type. When fresh they are a deep blue in colour and when exhausted they are light pink.

Inspect the crystals. Where the crystals indicate they are nearing exhaustion they must be replaced at the time of inspection.

11.3.2 Depth sensor

Due to the presence of silt, large gravel and debris, the depth sensor component of this sensor can be physically damaged through impact of large debris.

Inspect the depth sensor.

Where the depth sensor component is found to be damaged and/or not operating, it must be replaced with a new sensor.

11.4 Geometry – gravity diversion

From 31 October 2023, where gravity causes the water to flow past or through a XCi, the geometry of the pipe or channel must be remeasured between 1 April and 30 October, where extraction occurred during the preceding period of 1 November to 31 March. Reporting on this activity is to be included in the maintenance report, confirming completion, and must be provided to the relevant person with the validation certificate.

Note: requirements for non-round or irregular shaped pipe, and open channel are shown in 7.1.