

INTEGRISTICK™ Dynamic Curvature Sensor



INTEGRISTICK™ strain sensor

The Pulse **INTEGRISTICK™** is a unique patented dynamic strain sensor specifically suited for riser fatigue monitoring where response is dynamic bending dominated. Typical applications include fatigue monitoring in the touch down section of an SCR and the taper joint of a top tensioned riser.

The stick sensor is 19 mm outer diameter and 0.5 meter in length and it is attached to the outside surface of a riser. It changes in sympathy with the riser pipe and measures the change in riser curvature in 2 planes allowing local dynamic bending stress to be determined and hence the fatigue damage rate to be calculated.

The sensor has a typical 2 micro-strain resolution. This makes the sensor sensitive enough to capture lowest sea states. This capability is essential for measuring response under day to day current profiles and waves that contribute significantly to damage accumulation.

Uniquely the **INTEGRISTICK™** is sealed, oil-filled and pressure balanced allowing application at depths up to 3000m. It is manufactured from corrosion resistant materials. The strain measurement system is compact, ultra lightweight and can be fitted to the riser in a matter of minutes. When fitted with a compact GRP fairing the arrangement provides a highly reliable and robust method for measuring riser bending stresses.



INTEGRISTICK™ strapped to a riser

SYSTEM CONFIGURATION

The sensor has ultra low power consumption and designed to interface directly to an **INTEGRIPOD™** ⁽¹⁾ for battery-powered (standalone) or online data logging. The connection between the **INTEGRISTICK™** and **INTEGRIPOD™** is a dry-mate connector. The connection type will depend on the project specification.

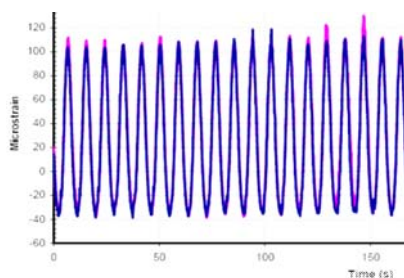
MOUNTING METHODS

The **INTEGRISTICK™** is mounted on the outside diameter of the riser or over the outside diameter of the coating of the riser via four mounting blocks. The blocks are made from Titanium material. The blocks are strapped to the riser pipe using smart band straps. The installation can be carried above water only.

The logger pod is mounted on the outside diameter of the riser using various proven mounting methods.

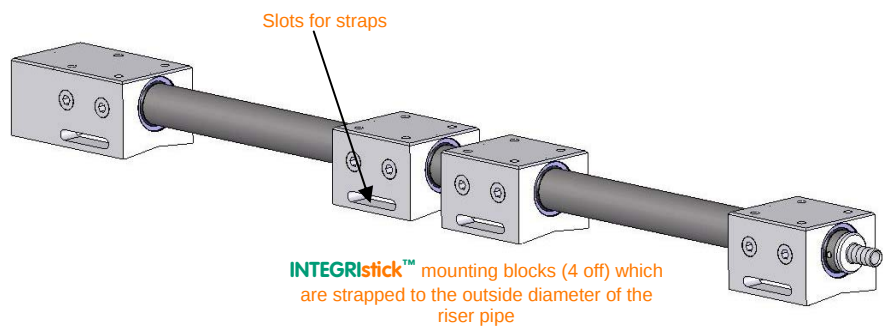
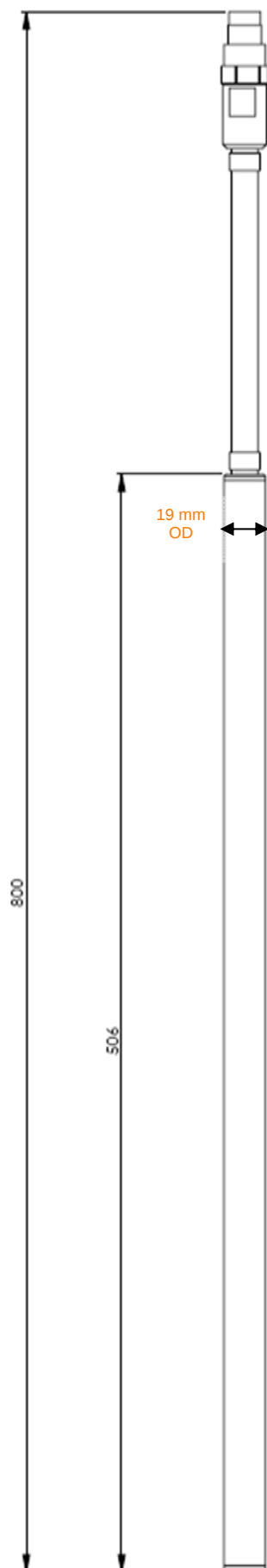
SPECIFICATIONS

- | | |
|---------------------|---|
| • Stick size | 19 mm OD and 506 mm length. Hose length varies |
| • Strain Resolution | 2 μ strain RMS (for Pipes between 6" to 12") |
| • Strain Accuracy | 6% of riser strain on the surface (for Pipes between 6" to 12") |
| • Temperature range | -5°C to 80°C (storage) 0°C to 65°C (operation) |
| • Stick Weight | 1 kg approx. in air |
| • Design pressure | 3000 meters water depth |



INTEGRISTICK™ dynamic strain measurement
— example of signal output from the stick

Note (1): **INTEGRIPOD™** is the generic name for Pulse subsea logger assembly to acquire data from sensors, to store data into memories and to transmit data in different communication schemes

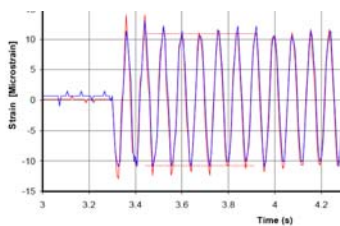


INTEGRISTICK™ and INTEGRIPOD™ deployed on a steel catenary riser with protective cage

INTEGRICollar™ Subsea Strain Sensor



INTEGRICollar™ installed on a pipe



INTEGRICollar™ dynamic strain measurement – example of signal output from the sensor

The Pulse **INTEGRICollar™** is a strain sensor for measuring axial and bending stresses of a pipe structures. It uses the proven and robust displacement sensor technology widely used in the industries. The typical application for **INTEGRICollar™** includes SLOR air can up-thrust tension measurement, drilling riser tension measurement and tendon tension measurement.

This device is attached to the pipe with two rigid collars that are securely installed around the pipe. The collars are either bolted or welded to the pipe. Four linear displacement sensors are installed between the collars, allowing the pipe axial strain to be measured. The sensors require tiny force to operate, hence they will not impose heavy load to the collars.

The device relies on the high accuracy, stability and robustness of the non-contact displacement sensors, which are extensively qualified in marine applications. The sensors are hermitically sealed in corrosion resistant alloy materials and are rated to 3000 meters underwater. The robust design coupled with pressure-balanced oil-filling technologies ensures that the **INTEGRICollar™** can reliably operate for many years without intervention.

The collar design accommodates a wide range of dimensional tolerances and surface finishes typical of riser pipes. The two collars are designed either to be retrofitted or welded to the structure by operators in dry areas. The displacement sensor modules are designed to be installable by divers.

SYSTEM CONFIGURATION

The **INTEGRICollar™** can be interface permanently to the Pulse standard **INTEGRIPod™** data logging pods for standalone or online recording operations. The **INTEGRICollar™** may be also connected to an ROV retrievable **INTEGRIPod™** using a wet mate ROV connection allowing the **INTEGRIPod™** to be removed and replaced whilst leaving the **INTEGRICollar™** connected to the structure.

INTEGRIPod™ LOGGER PODS

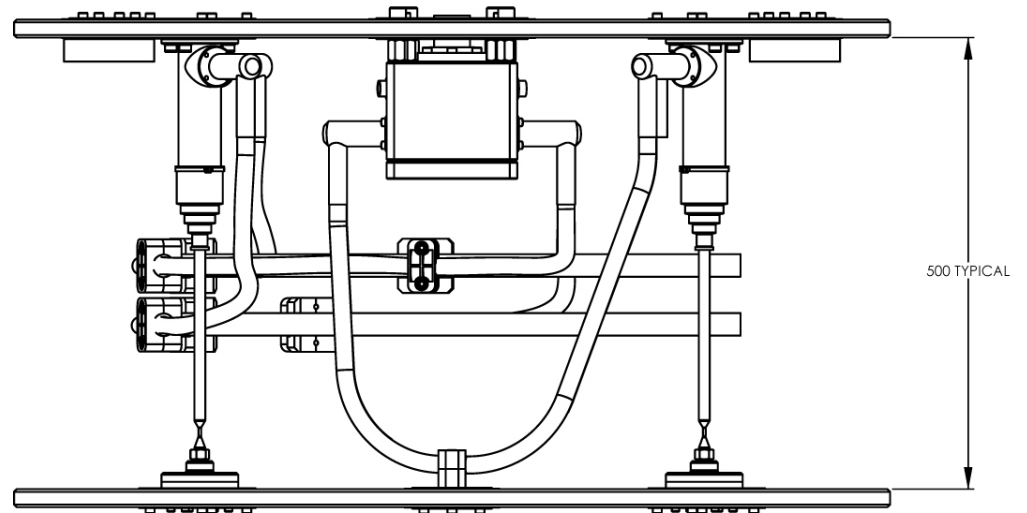
For battery-powered standalone monitoring applications, the standard **INTEGRIPod™** has 114mm OD and 600 to 900 mm length to accommodate the number of batteries required for a logger. For acoustically-linked battery-powered on-line monitoring applications, the standard **INTEGRIPod™** has 114mm OD and 1000 mm length. For hardwired on-line monitoring application, the standard **INTEGRIPod™** has 114mm OD and 450 mm length. No battery shall be used for this configuration.

MOUNTING METHODS

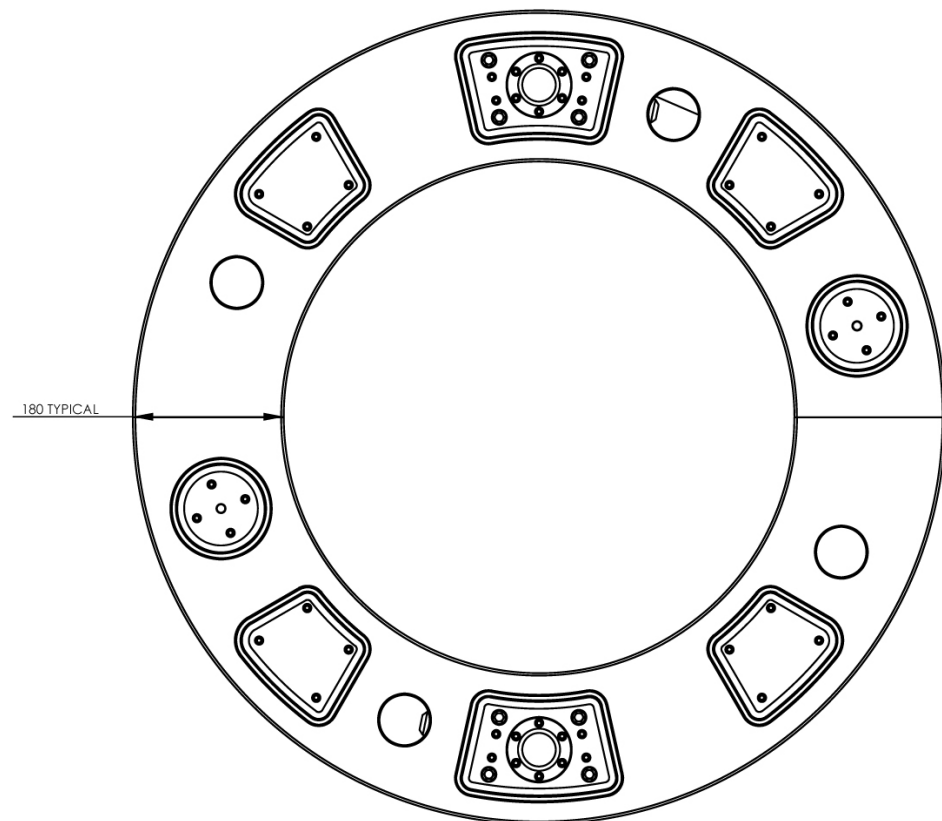
The two halves of the collars of the **INTEGRICollar™** can be clamped to the riser to anchor themselves to the structure pipe securely. The collars are made from corrosion resistant steel with cathodic protection or coating. The displacement sensor modules are fitted between the two collars. The collars may be also welded to the structure if it is allowed. Forged flanges or bossed collars may be also used if it is preferred. The data logger pods are mounted on the riser using various diver or ROV installable brackets.

SPECIFICATIONS

Collar internal diameter	To suit riser pipe outside diameters
Collar gap distance	1 m nominal
INTEGRIPod™ size	114 mm OD, various length
Strain measurement resolution	2 μ strain, typical
Strain measurement accuracy	5 μ strain, typical
Temperature range	-5°C to 70°C storage, 0°C to 35°C operation
Collar and pod weight	100 kg approx. in air
Design pressure	3000 meter water depth
Calibration certificates	Provided for calculating strain with temperature and external pressure correction



SIDE VIEW



TOP VIEW - OUT OF POSITION



London

1-7 Cherry Street
Surrey, GU21 6EE, UK
Tel: +44 1483 774910

Aberdeen

Tern Place House, Tern Place,
Bridge of Don
Aberdeen, AB23 8JX, UK
Tel: +44 1224 452285

Houston

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Centro, RJ, 20031-924, Brazil
Tel: +55 21 2510 7323

INTEGRipod™ SM

Stand-alone Motion Data Logger



Stand-alone motion data logger



Data logger installed on BOP frame



Software to initialise the data logger

INTEGRipod™ SM is a stand-alone device that measures motion of structures. The device measures dynamic response and stores data on its on-board memory. Data is downloaded into a computer for subsequent post data processing. The device measures 6DOF motion using:

- Tri axial accelerometers
- Tri plane angular rate sensors

From the measurements, various other parameters can be derived:

- Linear displacement
- Acceleration due to motion
- Inclination variations
- Harmonics

Typical applications are:

- Riser VIV monitoring
- BOP motion and displacement monitoring
- Subsea structures vibration monitoring
- Platform motion monitoring

A Pulse proprietary data viewing software called INTEGRiview™ is also supplied with the device for users to view the collected data in time domain; the software shows statistical data history and allows post processing data. A dedicated kit including laptop pre-installed with software, memory card reader and cables are provided with this device.

DEPLOYMENT OF LOGGERS

The data logger contains all electronics, batteries and sensors enclosed in a rugged subsea casing. After initialization using a computer, loggers can be deployed to the designated locations. This may simply involve strapping directly to the structure using bands or design of tailor-made interfaces to suit (available for diver or ROV operation for subsea use).

MOUNTING METHOD

- Strapped using suitable bands
- Retrofit diver and ROV friendly cradles or magnetic holder

ANALOGUE SIGNAL INPUTS

- | | |
|-----------------------------|--------------|
| • Number of inputs channels | 2, 4, 6 or 8 |
| • Input range | 0 – 2.5V |
| • Resolution | 12bit ADC |

DOWNLOADED DATA FILES

- Excel compatible time stamp files
- Raw voltages for all sensors inputs

MAXIMUM LOGGING PERIODS (EXAMPLES)

- | | |
|--|---------|
| • Continuous logging @ 10Hz | 23 days |
| • 10 minutes logging every 0.5 hours @10Hz | 48 days |
| • 10 minutes logging every 2 hours @10Hz | 81 days |

SPECIFICATION

Tri-axial accelerometers

Sensor direction	X, Y and Z
Range	± 1.2g
Cut-off response	4.7 Hz
Dynamic acceleration measurement accuracy	± 3.0% of measured acceleration or ± 2mg (whichever is greater)
RMS Noise	< 1mg RMS@10sec
Sensor calibration	Use static gravity @ 20° C $g = 9.812\text{m/s}^2$ (London, UK)

Tri-plane angular rate sensors

Sensing direction	X-Z, Y-Z and X-Y
Range	± 4 deg/s
Cut-off response	4.7 Hz
Angular rate measurement accuracy	± 3.5% of measured angular rate or ± 0.05 deg/s (whichever is greater)
Noise	< 0.01deg/s RMS @ 10sec
Sensor calibration	Use a motion simulation rig (@ 3 & 6 RPM speed @ 20° C)

Logging program

Frequency [Hz]	2, 5, 10, 15, 30, 60, 150
Logging mode	Continuous and intermittent
Log on period [min]	5, 10, 15, 20 and 30 (for intermittent)
Cycle period [hour]	0.5, 1, 1.5, 2, 2.5, 3, 4 (for intermittent)

Communication port

Port	1 x RS232 port
Connection method	Standard RS232/USB cable

On-board memory

Memory media	512 Mb memory (Flash memory)
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Software

Operating system	Windows 7 and all previous versions
Functions	- Diagnostic check of loggers - Initialise loggers - Download data from loggers - On-line logging - Battery/memory life calculation - Data processing (Statistics, FFT)

Power supply

Batteries	2 D-size 3.7V lithium batteries
Battery capacity	>12.5Ah @ 7.4V nominal
Current during logging	< 23 mA
Current during standby	< 5 mA

Casing

Material	Superduplex stainless steel
Size [mm]	60 diameter x 316 length
Weight in air	3.5kg (with batteries)
Weight in water	2.0kg (with batteries)
Direction of X Axis	Polarisation slot on base

Environmental

Operating	2° C to 30° C
Storage	-5° C to 50° C
Pressure rating	3,000 m water depth
Seals	3 'O-rings' on cap

DIMENSIONS

(all in mm)

