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EC-TD5325
MRI Safe
Gold Standard
Cradle Positioning System

Product Description

Document: 98-5325-01
Revision 3, Released 08/18/2016

Revision History

Date	Revision	Changes
04/23/2014	0	Initial Release, Author: Robert Rickenbach
06/23/2014	1	Added Performance Specifications
09/01/2014	2	Added Brake System Description
8/18/2016	3	Updated Micronor address and tel/fax

File Reference

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1. Description

The position of the patient cradle within an MRI system must be accurately measured and verified to the standard built-in position measuring system. This system is used to calibrate and verify the accuracy of the factory-installed system.

The system is based on the Micronor MR338 MRI compatible (non metallic) absolute position sensor which is coupled to a purpose-built accurate pull string mechanism.

In summary, the all-optical MRI safe position sensor (MR338) measures the pay-out of a film strip which is attached to the cradle. One end of the film is attached to the cradle while the far end of the string is wound up on a drum. When the cradle moves, the film is either pulled from the drum, or retracted onto the drum. The measurement is made by a precision pulley attached to the MR338 position sensor. The pulley is a sprocket wheel that engages into the sprocket holes of the film, preventing slippage over the measuring wheel. Any small minute change in film pay-out is registered as a change in distance to the cradle.

Key parameters are:

Maximum pay-out:	4000mm (4m)
Repeatability:	±0.05mm (Std Dev)
Accuracy:	±0.15mm (Std Dev)
Speed:	500mm/sec
Acceleration:	250mm/sec^2

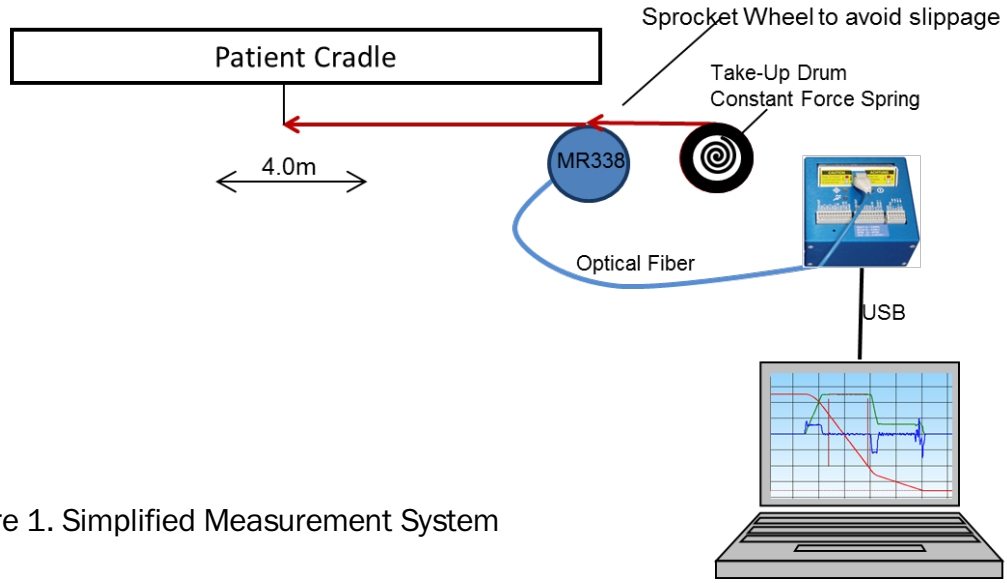

Figure 1. Simplified Measurement System

The length readout is via a USB interface connected to a PC computer running the purpose designed "Positioning Gold Standard" Software. The MR330 controller is a standard unit and includes other built-in interfaces such as analog voltage output, SSI and ModBus.

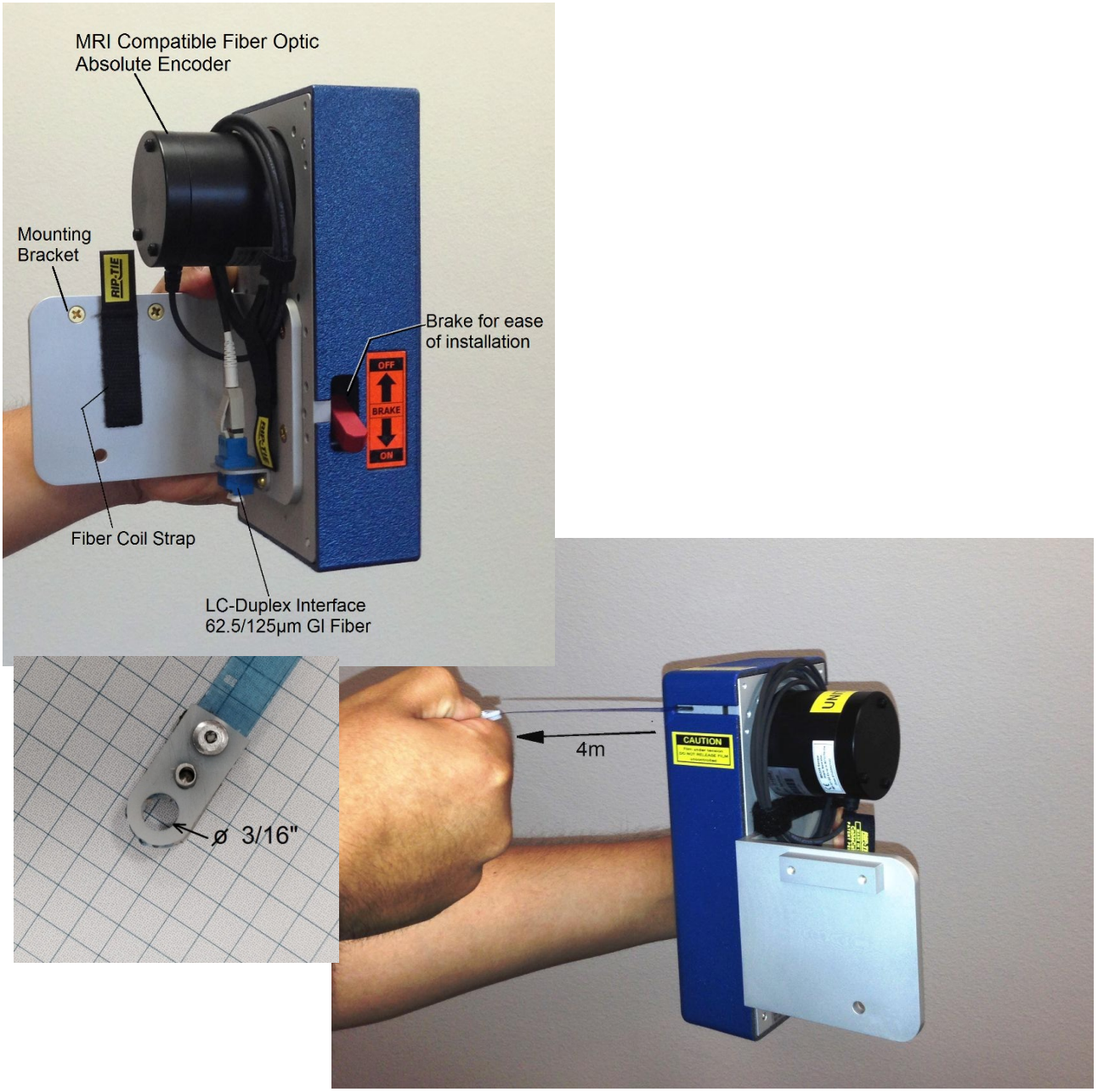

Figure 2. EC-TD5325-1 MRI Safe Pull-String Sensor

The EC-TD5325-1 Pull-String Sensor is designed to be mounted at the end of the MRI machine. The mounting bracket may be removed and/or changed to fit various mounting options.

A standard Multimode 62.5/125 duplex fiber optic cable with LC-PC connectors may be connected to the unit. The system can operate over several hundred meters.

A brake prevents the film from inadvertent and uncontrolled retraction that could damage the unit. While the unit is being installed the brake is in the ON position and should the film be released it will slowly and controlled retract without causing damage to the unit.

1.1 Length Measurement

The measurement is accomplished using the Micronor MR338/MR330 absolute position sensor. The sensor resolves to 13950 (14bits) for one full turn. In order to obtain the desired resolution, the formula below is applied:

$$R = \frac{D * PI}{R_e}$$

Where:
R: System resolution
D: Drum diameter
Re: Encoder Resolution -> 13950

The existing system has a measuring wheel diameter of nominal 48.26mm. The thickness of the film must be considered and typically applies as half the thickness (7mils/2 = 3.5mils) with these two dimensions a diameter of 48.5mm is used for the example calculation. The system is calibrated as a unit and slight manufacturing tolerances will be corrected at the time of calibration.

With the drum diameter of 48.5mm the system resolution is:

R = 48.5mm * PI / 13950 = 0.01114mm [11µm].

The film is the next critical element as it must be strong, and uniform so as to effect an accurate repeatable measurement. The film is Kodak ESTAR-based film leader material. It is polyester based and non hygroscopic. Long-term tests at Micronor have revealed that the film has a temperature coefficient of $22*10^{-6}$m/m/° C. This is comparable to materials such as aluminum.

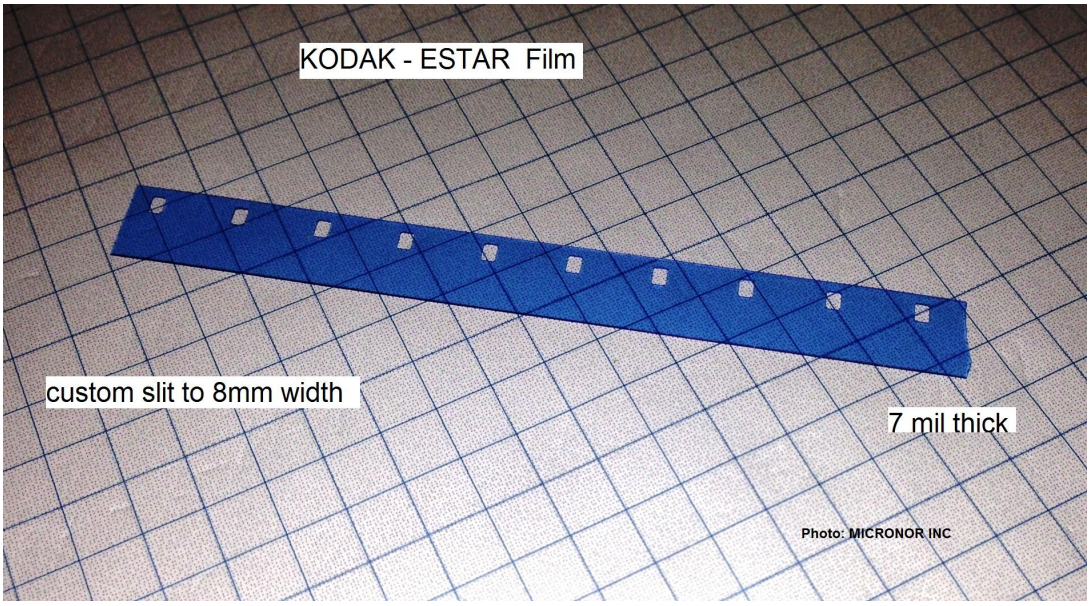

Figure 3. Kodak Film Leader

2. Product Overview

2.1 Position Sensor / Measuring Wheel Mechanism

The EC-TD5325-1 mechanism is designed for accuracy and high resolution. The measuring wheel and the MR338 Fiber Optic Position Sensor are the primary elements affecting accuracy.

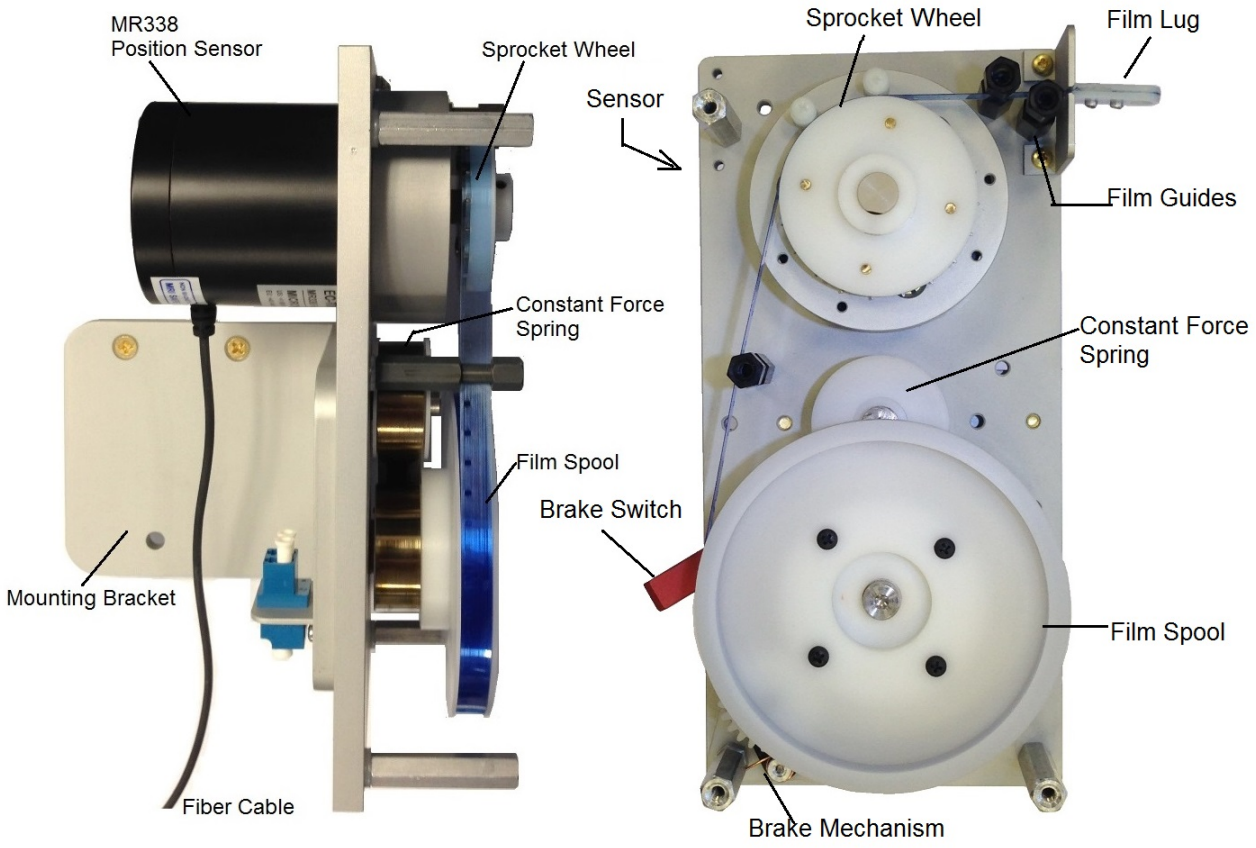

Figure 4. Inside View of the EC-TD5325-1 Positioning Sensor

Material Usage:
The entire design is based on MRI compatibility. All materials are Aluminum, Stainless Steel or non-metallic. The constant force spring is made of Stainless Steel 318. This spring material is slightly magnetic. Tests inside the MRI environment have shown no negative effect on measurement precision. The MR338 Position Sensor is made entirely of non-metallic materials.

2.2 Film Brake

Figure 5. Film Brake

The film brake will protect the unit from damage during handling and installation. When installing, the brake switch must be ON. With the brake ON, the film can be pulled out with very little additional resistance but will retract slowly and controlled when the film is released. Typically the film lug is moved to the measurement point where the film is attached using a shoulder screw. When pulling the film out, there is an extra length of film which is gently taken out by the slow controlled retraction of the film. Once the film is tensioned, the brake can be safely moved to the OFF position where it should remain during measurement. After the measurements have been completed and before removal of the sensor unit, the brake must be put in the ON position.

NOTE to USER

Engage Break when Parking

2.3 Installation

Before measurements on the patient cradle can be performed, set up the system as shown below:

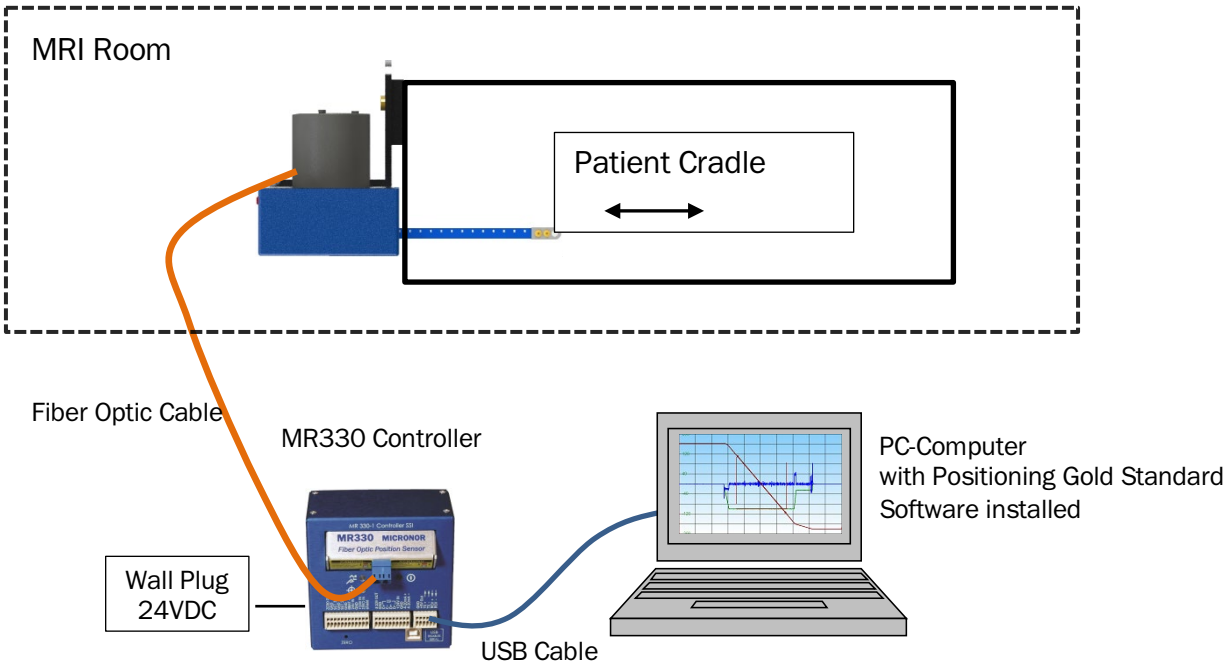

Figure 6. System Setup

- Install the Sensor Unit to the MRI machine.
- Make sure the Brake is in the ON (down) position. While the Brake is ON and the tape is pulled out, a ratcheting sound confirms that the brake is operational.
- Pull out the film lug and affix with shoulder screw to the Patient Cradle Table.
- Connect the Fiber Optic Cable and route outside the MRI room to the MR330 controller module.
- Use the supplied Universal AC Wall Plug to power the MR330 controller. When everything is connected properly the MR330 PWR LED should be ON.
- Connect the PC computer with the supplied USB cable.
- Run the Test per Engineering Instructions.

When installing the position sensor unit, it is important that the unit is solidly mounted so as to provide a rigid position reference.

Install the unit so that the film will run perfectly parallel both horizontal and vertical to the moveable attachment point.

2.4 Specifications

Performance Specifications		
Max. Length	4000mm	Do not exceed this length. Practicable useable length should be limited to 3700mm.
Max Speed	500mm/s	For maintaining mechanical integrity do not exceed 1000mm/sec
Accuracy	0.15mm (StdDev)	Calibrated to NIST traceable standard
Repeatability	0.075mm (StdDev)	
Resolution	11µm	
Hysteresis	< 0.25mm	Similar to a gear backlash when direction of movement is reversed.
Dead Point Movement	< 0.05mm/m	Due to the catenary effect with long payout lengths a minimal change in movement may not be registered when film is moved.
Linear Thermal Coefficient	+20µm/m/° C	This is the film thermal coefficient of expansion
Fiber Type:	62.5/125µm GI MMF 0.275 NA	Type OM1 c
Fiber Link Loss	d6 dB	
Optical Loss for Sensor	4.5dB typical 5.5dB max	
Sensor loss variation over full temperature range	< 3.0dB	

Environmental Specifications		
Operating Temperature	15° C to +30° C	Laboratory Environment
Humidity	35% to 55% RH	

Mechanical Specifications	
Sensor Unit Dimensions Weight	 105mm wide x 1502mm depth x 200mm height 1.2kg (2lbs 10oz) including mounting bracket
Controller Dimensions Weight	 102mm wide x 102mm depth x 68mm height 600g (22oz)
System Complete Dimensions Shipping Weight	 420mm wide x 180mm depth x 345 height 5kg (11lbs)

2.5 Controller / Fiber Connection

The EC-TD5325-2 Controller is a standard MR330-1 controller module which is paired to the EC-TD5325-1 Sensor Unit. Otherwise operation is identical to the standard MR330-1 Controller.

The controller unit is powered by 24V using less than 70mA current. A wall plug 24V DC power supply is included with the entire system. All measurement are conducted through the Positioning Gold Standrad Software provided with the system.

The sensor is connected using communications grade duplex multimode fiber (62.5/125µm).
The interconnects are standard readily available Duplex LC connectors.

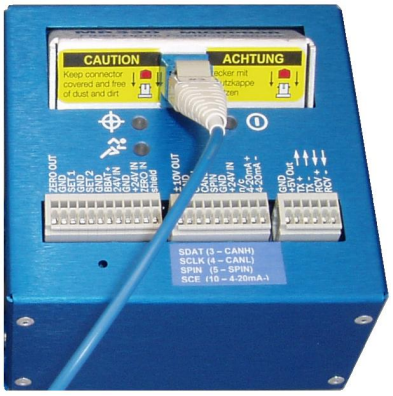

Figure 7. EC-TD5325-2 Controller Module

Figure 8. LC Duplex Connector

When 24VDC voltage is applied the controller PWR LED will light up. A steady light indicates proper operation and the sensor is installed correctly. (Blinking of this LED indicates an error condition. See table below)

The ZERO indicator LED will be On when the position sensor is at 0 position.

The RUN indicator LED will be ON whenever the sensor is in motion.

Status information is provided by a blinking PWR LED.

Blinks	Code Description
Steady ON	System is ok. Shaft position within measuring range
1	Outside Range for Turn-Restore
2	Bad position signal. -> Sensor may need to be “paired” to the controller box
3	No optical signal, i.e. Fiber disconnected
4	System Problem

For further information, please consult the MR330 Instruction Manual.

3. Contents of System Kit

A complete system is delivered in a sturdy Pelican case and consists of:

- EC-TD5325-1 Pull-String Sensor
- EC-TD5325-2 Controller
- AC Wall Adapter Universal Voltage
- Various global power adaptors
- USB Cable
- EC-TD5325-3 Cradle Monitor Software (a copy is supplied with an EC-TD5325 system order)
- Carrying Case
- MR320-D06CXX Fiber Optic Cable Assembly where XX=Length in meters (or equivalent)

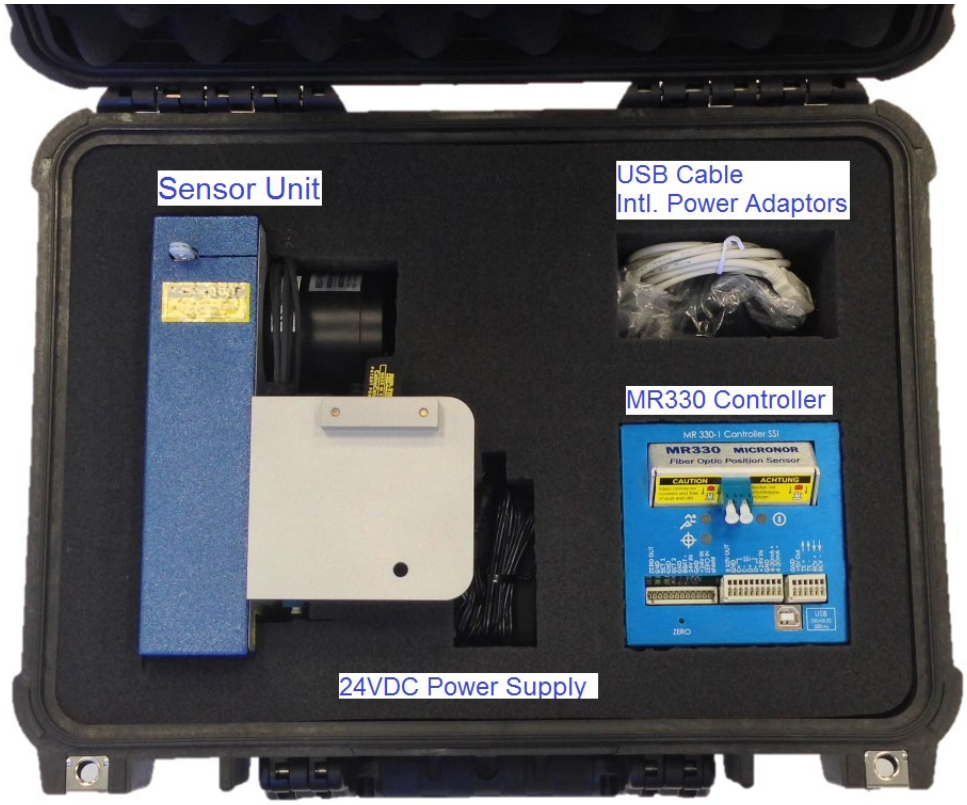

Figure 9. Shipping Case and Contents