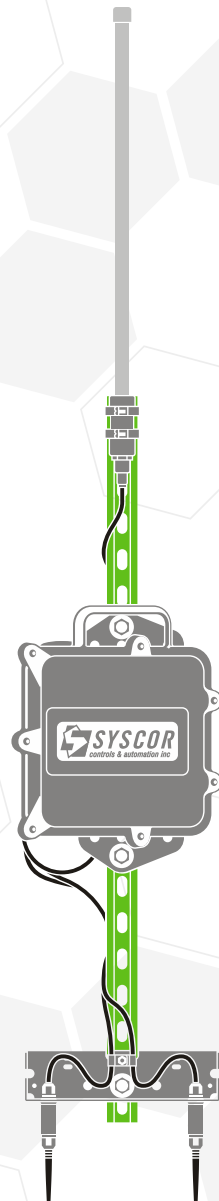# FR-Tracker™

Safety System for Monitoring Floating Roof ASTs

SYSCOR
controls & automation inc
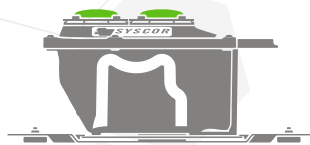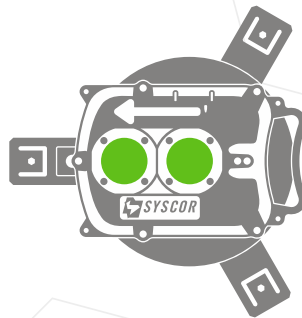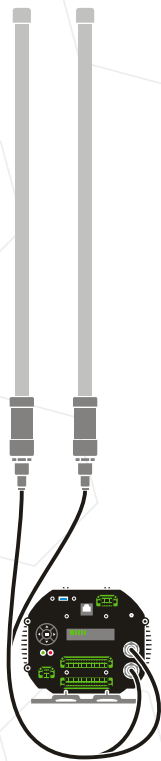
Introduction

For over ninety years, the floating roof has maintained its status as the preferred method for controlling product evaporation from ASTs. Unfortunately, despite this technology's remarkable track record, the risk of floating roof failures is steadily increasing as the population of tanks throughout the world ages. Experience, however, shows that regardless of the root cause of an accident, floating roofs exhibit specific behavior patterns prior to failure. API research and many accident investigations have concluded that, through early recognition of such patterns, the majority of floating roof accidents are preventable. As such, AST owners have been seeking sensor solutions that can detect signs of impending failure within sufficient time to prevent incidents. To fill the existing void, the FR-Tracker™ monitoring solution was developed in close cooperation with the petroleum industry as an effective and economical tool for accident prevention through continuous monitoring of key AST parameters.
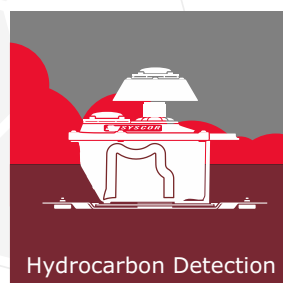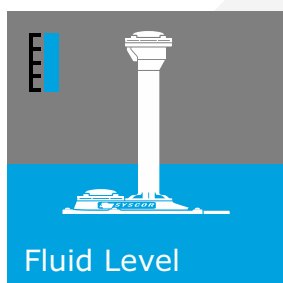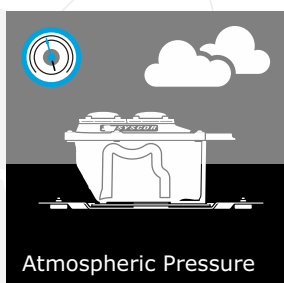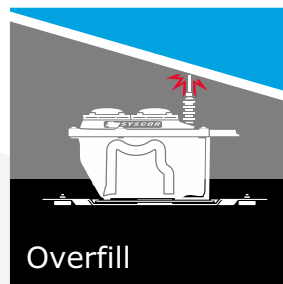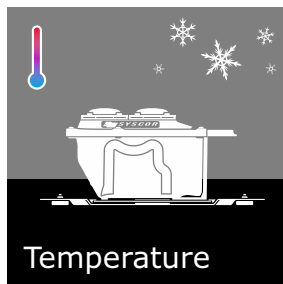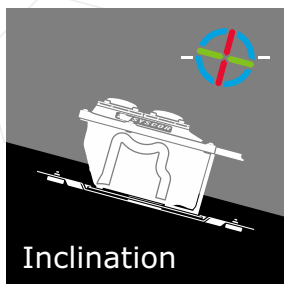
The FR-Tracker™ sensor system evaluates the state of the floating roof to determine whether it is operating safely. Wireless sensors are permanently installed on the deck and constantly monitor a variety of parameters. The sensor information is relayed wirelessly to an intelligent controller for analysis and long-term recording of data. Alarms are generated and relayed to the plant's DCS when abnormal conditions are detected that may be caused by:

The system simultaneously interprets data from multiple sensors across the floating roof to ensure reliability, detection accuracy, and immunity to false alarms.

Principle of Operation

- Dangerous rain water accumulation
- Excessive snow load
- Loss of buoyancy due to leaky pontoon or punctured deck
- Delayed roof collapse as a result of seismic events
- Overfilling

- Roof misalignment
- Abnormal rotation of the FR
- Large gas bubbles in liquid product
- Sticking seals
- Sticking ladders
- Dangerous accumulation of hydrocarbons on the FR deck

| Inclination | Temperature | Overfill | Vibration |

| Atmospheric Pressure | Fluid Level | Hydrocarbon Detection | GPS |

Base Station
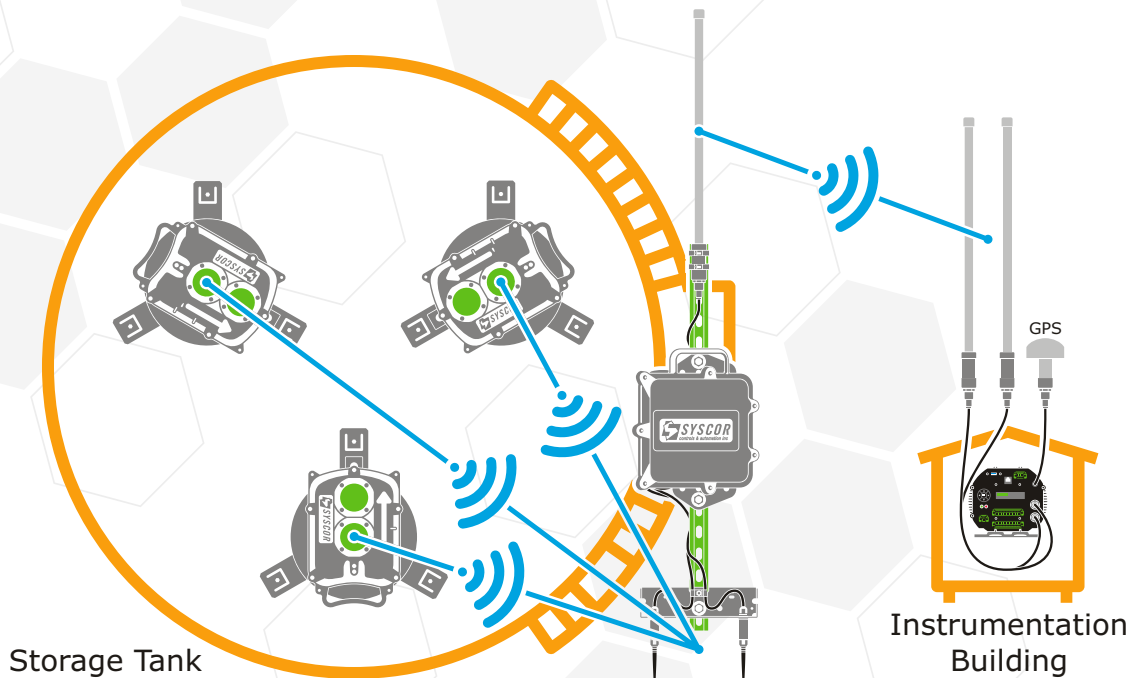

Repeater

System Components

The FR-Tracker™ monitoring system consists of Multi-Sensors, Repeaters, and a Base Station. To minimize installation and maintenance costs, the Multi-Sensors and Repeaters are battery-operated wireless devices with battery life expectancy exceeding 10 years.

Multi-Sensor

GPS

Storage Tank

Instrumentation Building

FR-Tracker™ Multi-Sensors are attached magnetically on steel FRs. Installation is quick and there are no requirements for cold or hot metal work. For aluminum FRs, 3M VHB adhesive tape is used.

The Repeaters are fastened with a standard strut channel mounting system on any suitable structure close to the rim of the tank.

The Base Station is installed in the instrumentation building and connected to the host DCS or alarm system. Each FR-Tracker™ device has an on-board GPS sensor that provides geolocation of equipment and alarms. Wireless network reliability is assured by using both antenna diversity and a mesh topology where information passes through the system via redundant network paths. A high level of security is guaranteed through the use of industry standard encryption algorithms.

3M VHB Adhesive Tape
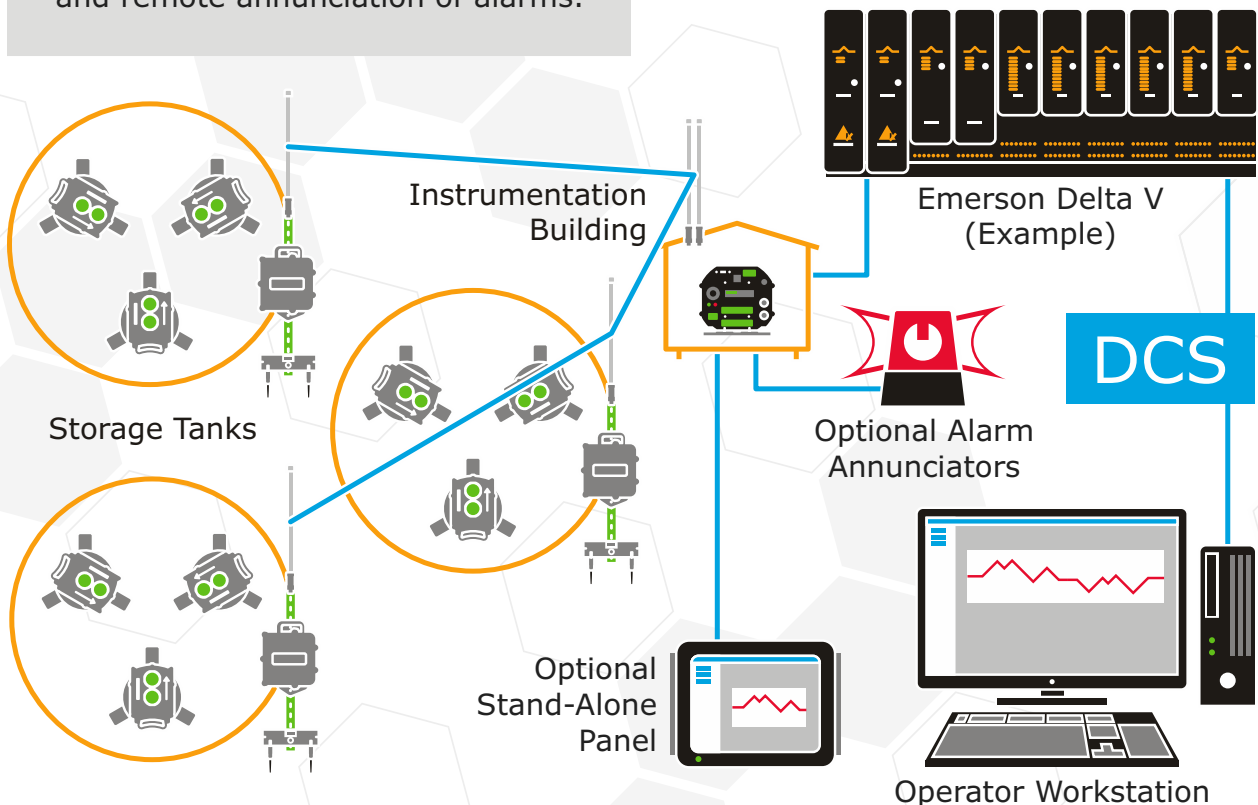(aluminum FR)

Magnetic Feet
(steel FR)
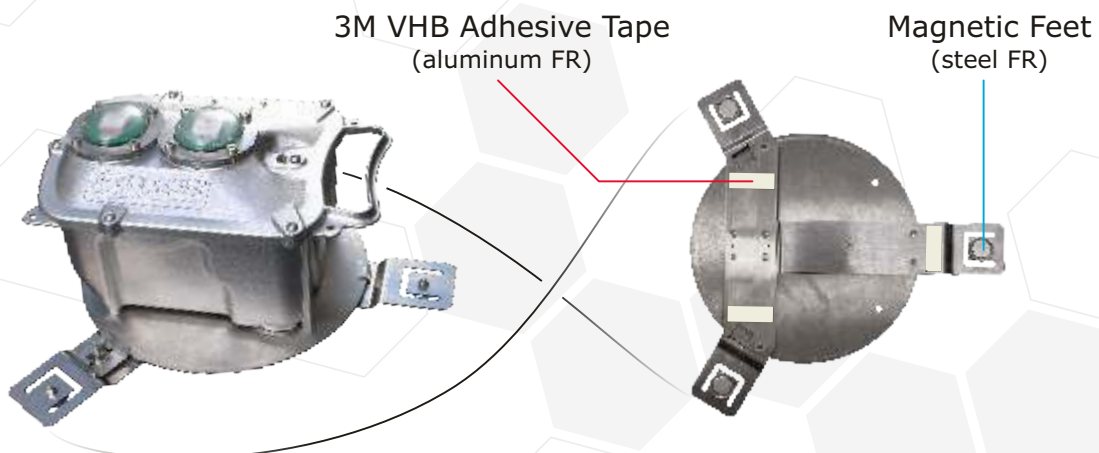
The FR-Tracker™ system is an integration of proven sensor technologies that do not require maintenance or re-calibration. In addition, a powerful intrinsically safe lithium battery pack provides power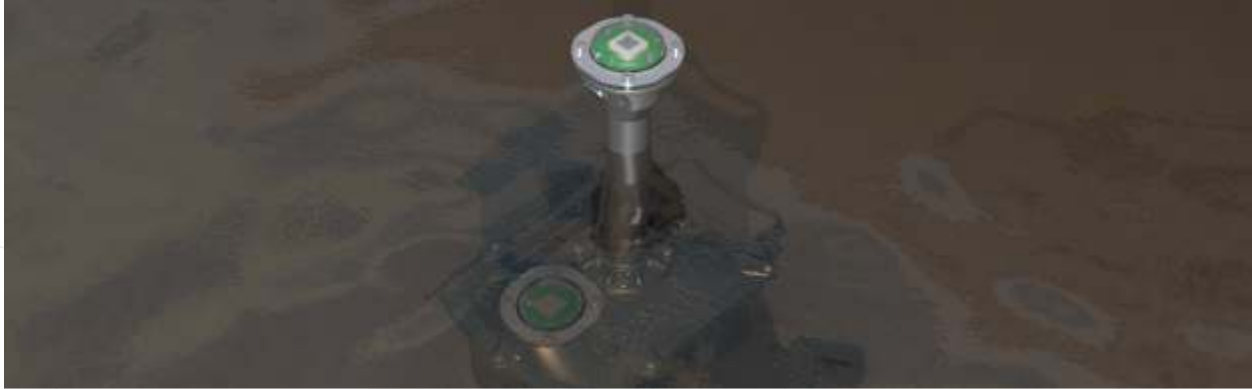 to the system for over 10 years without the need for battery changes. Finally, if a Multi-Sensor unit is damaged, the system will automatically compensate for the fault to ensure uninterrupted FR protection through redundancy provided by neighboring nodes.

Flexible, Future-Proof

The FR-Tracker™ can be integrated into the plant's DCS through industry standard protocols or digital I/O. Alternatively, the FR-Tracker™ can be connected directly to an alarm control panel for local and remote annunciation of alarms.

The FR-Tracker™ devices form a standards-based wireless cloud that allows over-the-air software updates and the addition of other wireless equipment within the same network. The facility owner will not be left behind as technology evolves and new sensor types become available.

Instrumentation Building

Emerson Delta V (Example)

DCS

Storage Tanks

Optional Alarm Annunciators

Optional Stand-Alone Panel

Operator Workstation

The FR-Tracker™ generates alarms when it observes abnormal conditions on the FR:

- **Liquid Flooding Detected:** If a wireless module's liquid level sensor detects a liquid level greater than its level setpoint for longer than a predetermined time interval, then the wireless module will annunciate the alarm condition to the Base Station. If the Base Station receives similar alarms from other nodes, then it will conclude that the floating roof is being flooded.

- **Misalignment/Inclination Alarm:** If the Base Station's software detects inclination sensor readings that are abnormal across the tank, it will conclude that the roof is stuck, misaligned, or moving inappropriately.

- **Vibration Alarm:** The vibration transducer is set to detect abnormal vibrations exceeding an adjustable threshold. The sensor unit will record and analyze these vibrations in real time and annunciate an alarm under certain conditions associated with seismic activity, gas bubbles hitting the floating roof, and roof or ladder binding.

- **Overfill Alarm:** Elevation transducer activation across the floating roof is an unmistakable sign of an overfill event.

In addition, the system will generate maintenance warnings such as low battery, loss of communication, or transducer fault.
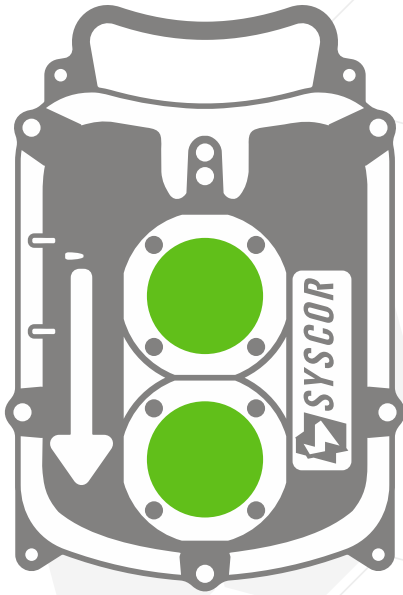
Inclination
- Micro-Electro-Mechanical System (MEMS) Technology
- Accuracy: 0.1°
- Resolution: 0.025°
- Dual–axis, inclinometer range: ±30°

Liquid Level Detector
- Capacitive Ceramic Technology
- Liquid depth Full Scale Output (FSO): 0"-39" (0-1000mm)
- Accuracy: 3/32" (2.5mm)
- Long term stability < ± 0.1 % FSO / year

Elevation Alarm
- Magnetically activated internal Reed Switches
- 2-trigger positions; 0.5" (13mm) apart
- Accuracy: 1/4" (6mm)

Vibration/Acceleration
- Micro-Electro-Mechanical System (MEMS) Technology
- Dynamically selectable range ±2g/±4g/±8g/±16g
- 1 Hz to 5 kHz sampling frequency
- Motion detection
- Embedded self-test

Temperature Sensor
- ± 1.8°F (1.0°C)

Altimeter/Atmospheric Pressure
- Micro-Electro-Mechanical System (MEMS) Technology
- Altimeter Measurement Mode (AMM) resolution: 12" (300 mm)
- Barometric Measurement Mode (BMM) resolution: 4.4×10^{-4}inHg (1.5Pa)

GPS
- SiRF Star IV high-sensitivity technology
- Precise Point Positioning (PPP)
- Precision timing based on GPS synchronization: 1μs
- Optimized for performance in urban canyon and dense foliage environments

Operating Temperature Range
- -40°F to 140°F (-40°C to 60°C)

Materials
- SS316 stainless steel body and mounting bracket, Sabic XYLEX X7519HP antenna ports, carbon fiber elevation whisker with Sabic VALOX V3900WX holder

Environmental Protection
- IP 68 (EN 60529)

Power Supply
- Integrated Lithium Thionyl Chloride (Li-SOCl2) battery pack. -67°F to 185°F (-55°C to 85°C), estimated life span >10 years

Electrical Interfaces
- None

**Wireless Communication**
- License-free 2.4 GHz IEEE 802.15.4 radios
- Modulation: Direct Sequence Spread Spectrum (DSSS)
- Security: AES-128 Data Encryption

Certifications
- Environmental: NEMA 4X enclosure
- Safety:
  - Intrinsically safe (Exia)
  - Class I, Division 1, Groups A, B, C & D
  - Ambient temperature -40°C to 60°C Temperature code T5
  - CSA Standard CAN/CSA-C22.2 No. 157-92 (R2006)
  - UL Standard No. 913, 7th Edition
- Telecommunications Compliance:
  - FCC Part 15B
  - FCC Part 15.247
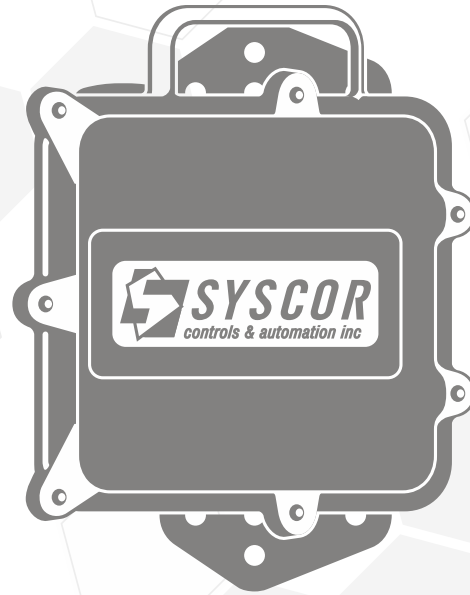
Repeater Specifications

Temperature Sensor
• Accuracy Options: ± 0.9°F (0.5°C), ± 1.8°F (1.0°C), ± 4.5°F (2.5°C)

Altimeter/Atmospheric Pressure
• Micro-Electro-Mechanical System (MEMS) Technology
• Altimeter Measurement Mode (AMM) resolution: 12" (300 mm)
• Barometric Measurement Mode (BMM) resolution: 4.4x10-4inHg (1.5Pa)

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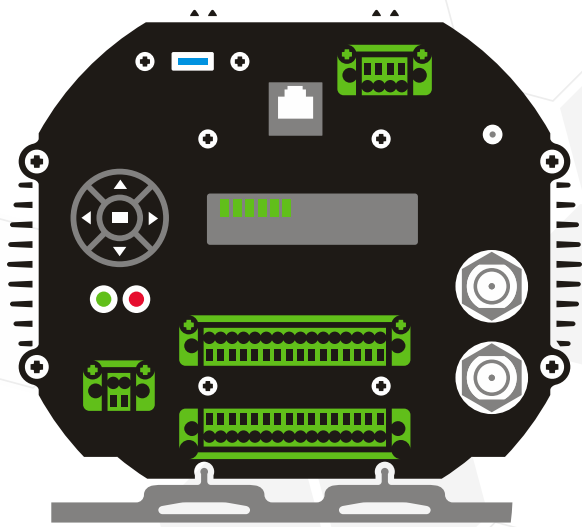
Electrical Interfaces
• None

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• Telecommunications Compliance:
  - FCC Part 15B
  - FCC Part 15.247

Summary
- Standard PC/104 aluminum enclosure with support for 4 PC/104 modules:
  - CPU module
  - Wireless module
  - I/O module (many I/O configurations available)
  - Optional communications module (GSM, Satellite)

CPU Module
- PC/104 standard compliant x86 compatible module
- Fanless

Storage
- Industrial grade SSD (solid state disk)

Wireless Module
- License-free 2.4 GHz IEEE 802.15.4 radios
- Modulation: Direct Sequence Spread Spectrum (DSSS)
- Security: AES-128 Data Encryption

GPS (located on Wireless Module)
- SiRF Star IV high-sensitivity technology
- Precise Point Positioning (PPP)
- Precision timing based on GPS synchronization: 1μs
- Optimized for performance in urban canyon and dense foliage environments

Operating Temperature Range
- -40°F to 140°F (-40°C to 60°C)

Operating Humidity Range
- 10-90% non-condensing relative humidity

Materials
- Standard PC/104 aluminum enclosure.

Environmental Protection
- IP 40 (EN 60529)

Power Supply
- External power 4.5 Vdc to 33 Vdc
- UPS capability

Electrical Interfaces
- 1 x 10baseT/100base-TX Ethernet communication port (RJ 45 connector)
- 1 x Type A USB port
- 2 x Isolated RS-485 ports (screw terminal block)
- 16 x SPDT Relays

Interface Protocols
- Supports Modbus TCP/IP
- Supports Modbus RS485

Certifications
- Telecommunications Compliance:
  - FCC Part 15B
  - FCC Part 15.247

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