

SOLID PETROSERVE LTD.

INTEGRITY SURVEILLANCE SERVICES



Solid Integrity Surveillance Services:

Solid offers specialized equipment and services for reducing risk of incurring lost production and associated environmental damages due to fugitive gas emissions and produced fluid spills. Our Integrity Surveillance systems include equipment and services for both surface and downhole integrity surveillance applications.

Solid/Vanguard Services Partnership:

Solid and Vanguard Reservoir Surveillance Services LLC. jointly offer downhole integrity surveillance services. Vanguard is based in Muskat, Oman, from where it has been performing downhole well integrity surveillance investigations for operators located throughout the Middle East and North Africa regions. Their leading-edge equipment, service capabilities and experience have achieved a highly successful performance track record in completing 4400 well integrity investigations to date.

Vanguard specializes in corrosion logging and quality analysis to safeguard wellbore integrity. Their latest generation of multi-barrier electromagnetic corrosion tools can log up to 4 barriers simultaneously.

Vanguard also offers innovative passive acoustic logging tools that are able to precisely pinpoint the depth of leaks, behind-pipe crossflow and provide accurate formation production/injection profiles.

Together, our Solid/Vanguard team offers oil and gas industry operators with an integrated services approach towards both surface and downhole integrity surveillance, using the latest technology and systems.



Surface Integrity Surveillance Applications

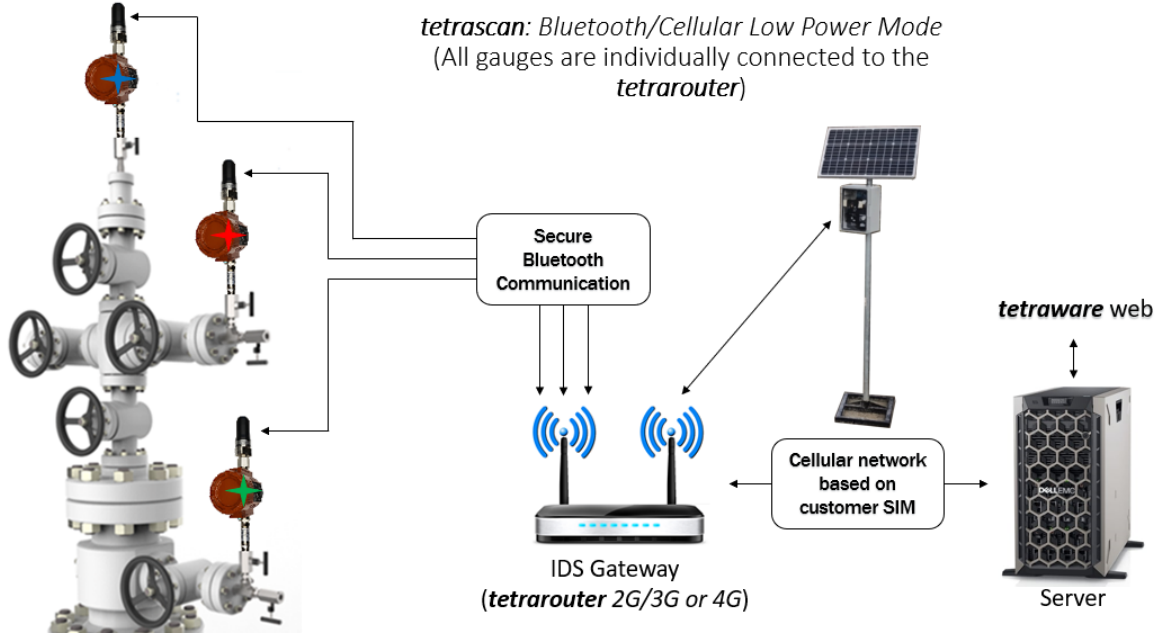
Solid *tetrascan* Wireless Surface Gauge System

Solid's new *tetrascan* PSG system represents the latest evolution in wireless programmable surface gauge technology. *tetrascan's* innovative data acquisition, wireless connectivity, data management, reporting and improved power management features provide an ideal, cost-effective solution for wellhead and surface facility integrity surveillance.

Key operating features of the *tetrascan* wireless PSG system include:



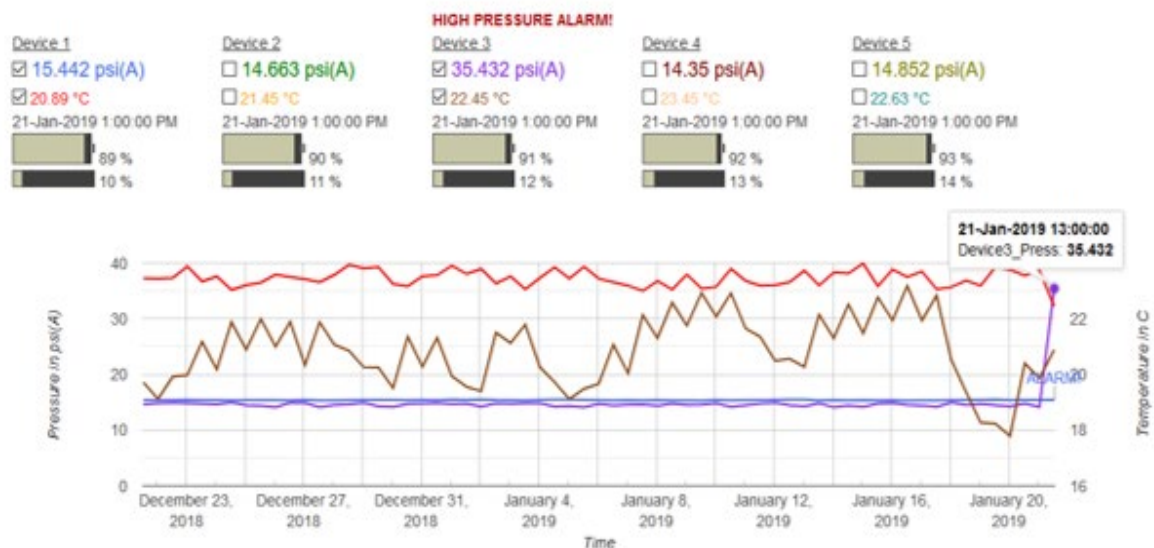
- Lower capital cost compared to conventional surface data acquisition and transmission systems.
- Gauges that can be installed and monitoring process data acquisition, transfer, and over/under alarm surveillance within minutes.
- No data acquisition system removal and reinstallation costs. Tetrascan gauges are designed for portability; removal from service and subsequent re-installation at a new site location is fast and easy to accomplish.
- A 16 million data set backup memory capacity which is by far the largest available on the market.
- The only wireless programmable surface gauge offering 3 modes of wireless connectivity; providing both real-time data acquisition and upper/lower alarm notification.
- User-friendly software that provides real-time operating data, alarm notification, worldwide cellular/WiFi communications including bi-directional remote access for gauge programming purposes at no extra cost
- Advanced energy management system that maximizes battery life. Lithium D-cell batteries typically last 2+ years under normal operating conditions.
- Ideal real-time integrity surveillance solution for early detection of produced gas leaks to minimize greenhouse gas emissions, and well environmental damage/property loss resulting from produced fluid spills.



tetraware web real-time online display indicating a high-pressure alarm condition:

- The display shown below is for a multi-gauge installation including 5 tetrascan PSG's with alarm condition alert occurring on one of the gauges (Device 3).
- Individual PSG identification labels can be set by user.
- Real-time online display also shows current pressure at each gauge location; as well as remaining battery power level and device memory consumed.

Cellular Mode



Downhole Integrity Surveillance Applications

Vanguard Reservoir Surveillance Services LLC



EMDsX⁴

General information

Pulsed electromagnetic tool is a non-destructive corrosion logging tool which was designed to measure the individual wall thickness of concentric pipes in a single run. The latest generation of this tool provides quantitative wall thickness measurement for up to 4 barriers.

Main Advantages:

- Measures individual wall thickness of concentric pipes in a single run.
- No to special well preparation requirement prior to logging (scraper etc.).
- Survey can be conducted in the presence of any type of fluid (oil, water, gas).
- Presence or absence of cement behind pipes will not affect data quality.
- Unique design of sondes that allow each coil to function as generating and receiving modes. This helps minimizing tool length thus facilitating ease of operation in the field.
- The tool incorporates Gamma ray, Temperature and Pressure sensors, thus capturing additional information in a single run.
- The sondes, both axial and transversal, clearly allows to identify type of defect especially in the case of the first barrier.

Taking into consideration all advantages mentioned above makes this tool the most cost-effective corrosion evaluation tool in the market.

The tool's high resolution and sensitivity are achieved through a large dataset acquired with 34 decay curves from long axial sonde.

The tool is available in both memory and surface readout mode. EMDs can be run in combination with MFC.

■ **Application**

- Quantitative 4 pipes corrosion evaluation
- Allocation of holes, cracks, "worn-out" areas, parted casing
- Allocation of casing/ tubing completion accessories, perforated intervals
- Applicable for single and dual completion design
- Time-lapse corrosion monitoring, forecast of metal loss trend

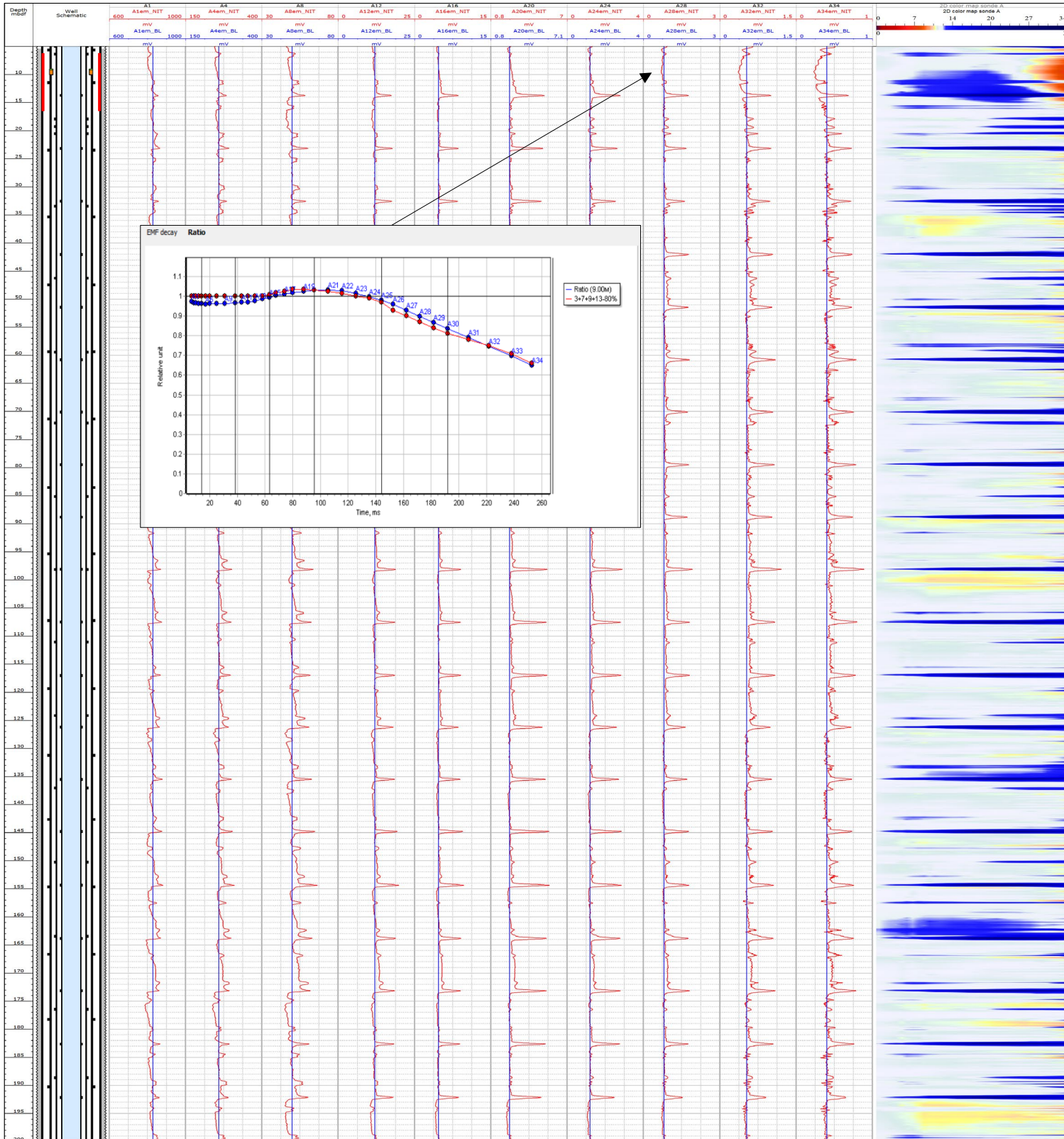
■ **General specification**

Max. temperature	302 F (150C)
Max. pressure	11600 psi (80 MPa)
Length with centralizers	12' (3.67 m)
OD	1.9" (48 mm)
Minimum detectable hole size (first barrier)	0.6" (20 mm)
Minimum detectable hole size (outer barriers)	1/6 of a pipe circumference
Weight	65 lbs (29 kg)
Recommended logging speed	8-12 ft/min (2.5-3.8 m/min)
Measurement range, OD	2 7/8" - 20"
Max. cumulative pipe thickness	1.7" (43 mm)
Single pipe measurement accuracy	0.013"
Multi-string measurement accuracy	0.050"
Number of measurable pipes	up to 4 pipes
Cable type	monocable
Max. cable length	23000' (7000 m)
Temperature accuracy	0.1 C
Temperature resolution	0.01 C
Temperature sensor type	Platinum
Pressure sensor type	Quartzdyne
Pressure accuracy	0.025% FS
H2S	25%
Body material	titanium

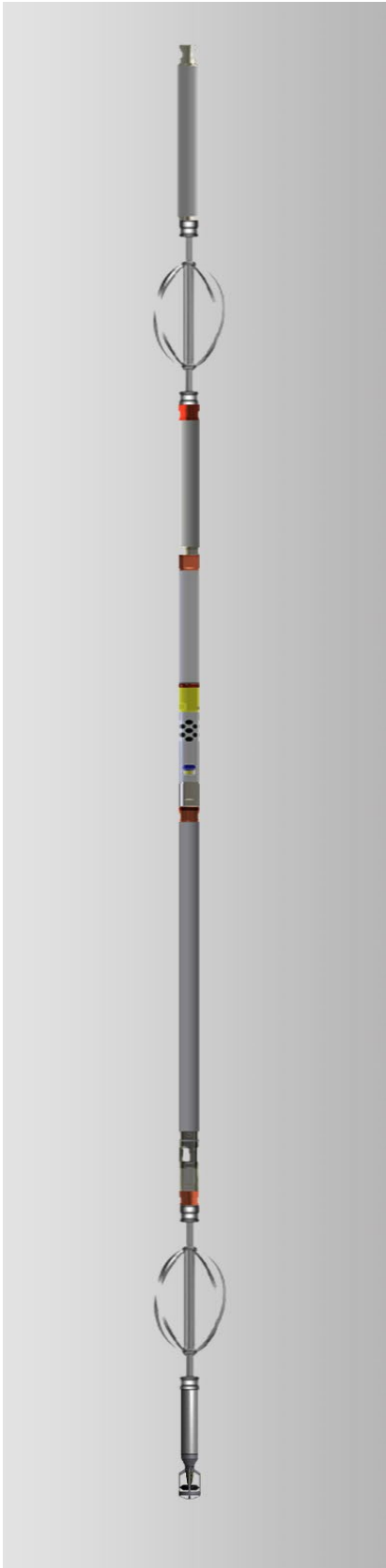


EMDsX4 data 2021

EMDsX4 data of 2021 confirms the presence of severe corrosion on the 13-3/8" casing (4th pipe). Comparison of calibrated and real ratio decay shows that maximum metal loss increased when compared with year 2015 standing at 90%. Additionally, corrosion migrated from surface casing to the 9-5/8" casing at 9.0-10.2 mbdf.



EPST



Application:

- RFA
- Wellbore inflow/injecting profile
 - Formation active intervals
 - Crossflow between active formation intervals.
 - Qualitative analysis of formation saturation across non-perforated intervals.
 - Upwards and downwards crossflow.

Leak detection

- Intervals of crossflow behind tubing/casing and the nature of crossflow
- Leak point on the casing
- Integrity status of wellbore accessories.

General Specification:

Parameter	Unit	Value
General parameters:	Deg C	150
Tool OD	in	1.65
Tool length without centralizers	m	3.8
Tool type		Memory
Battery type		Lithium
Operating voltage	V	18
Max operating temperature	Deg C	150
Max operating pressure	MPa	80
Base module (BM):		
Length	m	1.248
Type of temperature sensor		RTD
Temperature sensor accuracy	Deg C	0.5
Temperature sensor resolution	Deg C	0.003
Type of pressure sensor		Quartz
Pressure sensor accuracy	% of full scale	0.02
Pressure sensor resolution	% of full scale	0.0005
Pressure drift from zero	% of full scale	0.02
CCL ratio of collar to pipe body in 7"		1:5
Gamma Ray crystal type		NaI
Operating hours with max temperature	Hour	800
Current consumption	mA	68
SNL module:		
Length	m	0.831
Frequency range	kHz	0.1-62.5
Dynamic range	dB	115
Current consumption	mA	34
VVL module:		
Length	m	0.482
Frequency range	kHz	0.01-5.2
Dynamic range	dB	110
Current consumption	mA	27
Flowmeter:		
Length	m	0.554
Flowmeter type		conventional
Spinner type		turbine
Max rotation	Rpm	6000
Current consumption	mA	10
BAT module:		
Length	m	0.587

Case study 2. B annulus leak detection.

The well is S-shape Gas Lift oil producer drilled in 1992. The was completed with 13 3/8" surface casing, the 9 5/8" intermediate casing, the 7" production liner and 3.5" GL completion string.

In 2021 corrosion logging was performed, indicating metal loss on the 13 3/8" casing at shallower section of the well. Additionally, corrosion migrated to the 9 5/8" casing across the same interval.

In 2022 SIT was conducted resulting B annulus LOT failure (annulus was accepting water with no pressure build-up). A annulus BUT failed also.

EPST survey was conducted under Hoist intervention when GL completion string was pulled out of hole and tool was run through the 9 5/8" casing. Since well has static losses, the 9 5/8" casing was continuously filled with water (in average 8 m3/d). So, first pass was conducted under 9 5/8" casing fill-up condition.

Second pass was performed when water was supplied in B annulus and the 9 5/8" casing was filled with water. Both passes indicates that water which was used to fill the 9 5/8" casing, enter B annulus through defect on the casing, then enter the 13 3/8" casing across zone of severe metal loss. Further, water travels downward to depth 220 mbdf behind 13 3/8" casing. Formation accepts injected water with different intensity across an interval 86-200 mbdf.

Second pass confirms finding of the first pass. Since volume of water is doubled (additional injection in B annulus), flow movement became more pronounced, intake zone can be identified very clear.

Comparison of EPST passes

