

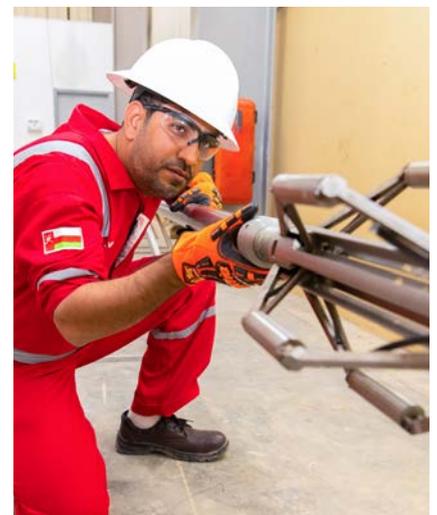


# WELL INTEGRITY DIAGNOSTICS





Vanguard Reservoir Surveillance Services LLC. (VRSS) was established in 2006 in the Sultanate of Oman and is 100% Omani owned company. The company specialises primarily in selected oilfield services related to cased hole logging and gravel pack deliverables. The technologies developed fall under the umbrella of well integrity in this current climate of aging wells; High Temp 600F Production/Injection tools and Surface Steam Quality testing for the purpose of monitoring enhanced oil recovery efficiency. VRSS owns integrated Electric line Logging Units with Crane and Associated 10K Pressure Control Equipment as a standard. Research and development is at the forefront of the company as it develops custom designed logging tools. The main headquarters is in Muscat and operational base in Nimr with a state of the art calibration facility. The company holds a prestigious record by successfully completing 1400+ corrosion logging jobs and other well integrity diagnostics operations in the Middle East region.





## EM scanner

Scanning Electromagnetic Defectoscope  
Multi-string corrosion logging tool

### Description

Industry's rising concerns over the use of Multi-finger caliper and challenges associated with precise allocation of metal elements behind production tubing instigated the development of a tool which combines pulsed electromagnetic defectoscope and electromagnetic imaging tool for detailed allocation of corroded areas in the first pipe. The data capture is achieved via 10 short electromagnetic sondes in two sets of 5 each located in the bottom section of the tool, whereas the upper section represents the conventional pulsed electromagnetic defectoscope for corrosion assessment of the outer barriers. This array of 10 electromagnetic sondes integrated are virtually two scanner sections on collapsible arms. The 5 sondes on each scanner section provides 360 degrees radial coverage of a first measured pipe. This feature allows measurement of pipe defects with better precision and serves as a major enhancement to the conventional pulsed electromagnetic defectoscopy method. Additionally, the electromagnetic scanner includes an accelerometer for determination of tool rotation. The tool is compatible with all logging systems and available in a surface readout mode.



## CPX

Cathodic Protection Examiner  
Downhole cathodic protection evaluation tool

### Description

Cathodic protection examiner (CPX) is designed to evaluate the effectiveness of cathodic protection of the well casings. The tool measures the potential difference between electrodes in contact with a casing. A combination of two electrically activated electrodes, spaced in two independent subs, measure the voltage drop between two contacts. Knowing the potential difference between two electrodes, makes it possible to calculate the current distribution curve, allocate anodic zones and determine the interval of effective cathodic protection.



## EMDS

Electromagnetic Defectoscope  
Multi-string corrosion logging tool

### Description

Pulsed electromagnetic defectoscope is designed to measure the individual wall thickness of concentric pipes in a single run that makes it the most cost-efficient corrosion evaluation tool in the market. The tool provides quantitative wall thickness measurement for up to 4 pipes and makes it possible to conduct thru-tubing corrosion survey in both single and double completions. EMDS consists of two generating (receiving) sondes, transversal sondes for detection of minor radial and axial defects, temperature, pressure, and gamma ray sensors. The pulsed electromagnetic method and unique coil design allow using the same coils in both generating and receiving modes. The tool's high resolution and sensitivity are achieved through a large dataset acquired with 30-40 decay curves. On a basis of a large dataset, the complex calculation algorithm and sophisticated data processing software provide the calculation of individual pipe thickness with a relatively high precision. The tool is compatible with all logging systems and available in a surface readout mode.

### Key features

- Quantitative 3-4 pipes corrosion evaluation
- Allocation of holes, cracks and parted casings
- Applicable for single and dual completions
- Time-lapsed corrosion monitoring
- Allocation of completion elements and perforations

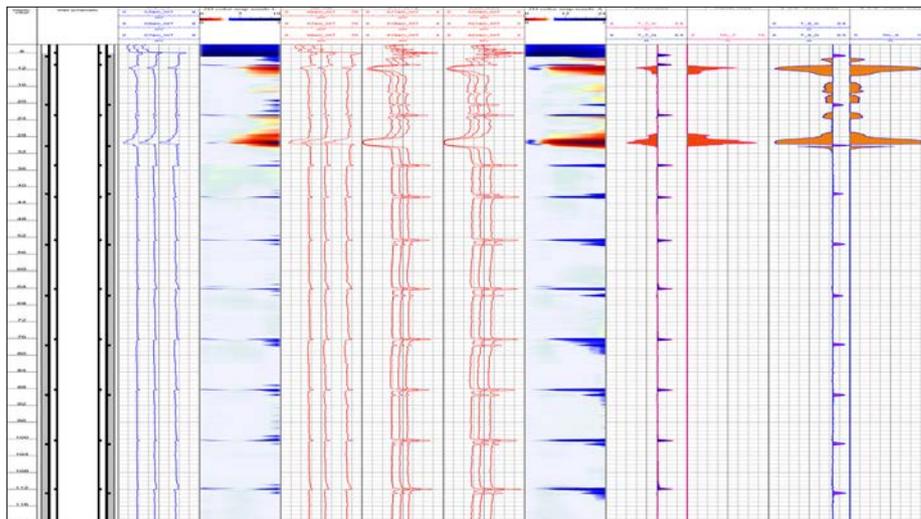
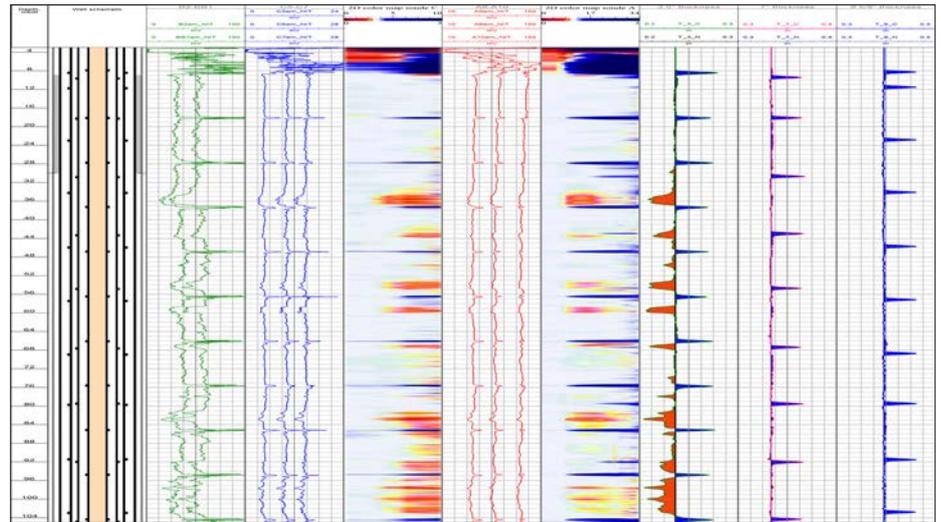
### General specifications

|   | EMDS-3-1.65"          | EMDS-3-1.9"           | EMDS-4-2.3"           |
|---|-----------------------|-----------------------|-----------------------|
| Number of measureble pipes              | 3                     | 3                     | 4                     |
| Depth of investigation, pipe OD         | 2 7/8-13 3/8"         | 2 7/8-20"             | 3 1/2-20"             |
| OD, inch                                | 1.65"                 | 1.9"                  | 2.3"                  |
| Max. temperature                        | 150 C (302 F)         | 150 C (302 F)         | 150 C (302 F)         |
| Max. pressure                           | 8700 psi (60 MPa)     | 8700 psi (60 MPa)     | 8700 psi (60 MPa)     |
| Length with centralizers                | 12' (3.67 m)          | 12' (3.67 m)          | 12' (3.67 m)          |
| Weight                                  | 58 lbs ( 26 kg)       | 65 lbs (29 kg)        | 78 lbs (35 kg)        |
| Max. cumulative pipe thickness          | 1.25" (32 mm)         | 1.7" (43 mm)          | 1.9" (48 mm)          |
| Min. detectable hole size (1st pipe)    | 0.6" (20 mm)          | 0.6" (20 mm)          | 0.6" (20 mm)          |
| Min. detectable hole size (outer pipes) | 1/6 of a pipe circum. | 1/6 of a pipe circum. | 1/6 of a pipe circum. |
| Single pipe measurement accuracy        | 0.013"                | 0.013"                | 0.013"                |
| Multi-pipe measurement accuracy         | 0.050"                | 0.050"                | 0.050"                |
| Max. logging speed                      | 4 m/min               | 3 m/min               | 2.5 m/min             |
| Max. cable length                       | 23000' (7000 m)       | 23000' (7000 m)       | 23000' (7000 m)       |
| Cable type                              | mono-conductor        | mono-conductor        | mono-conductor        |
| Body material                           | titanium              | titanium              | titanium              |

## EMDS CASE STUDIES

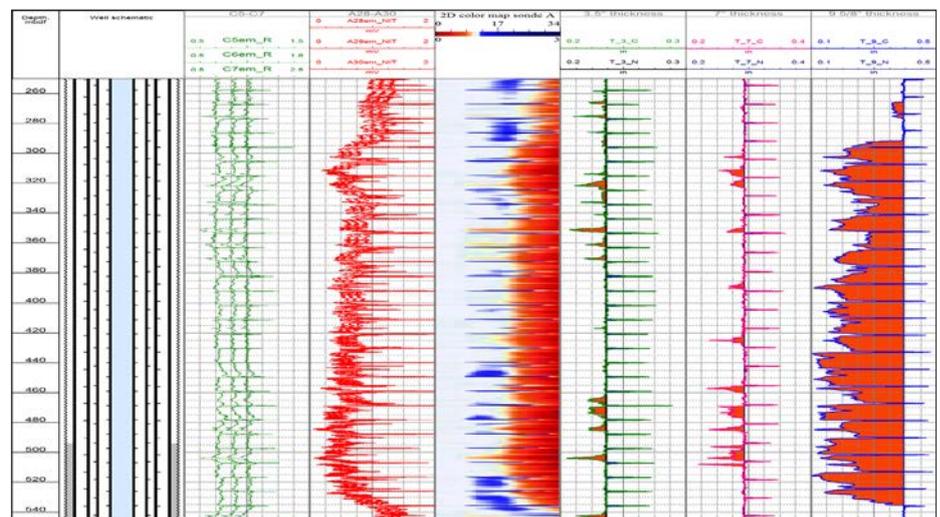


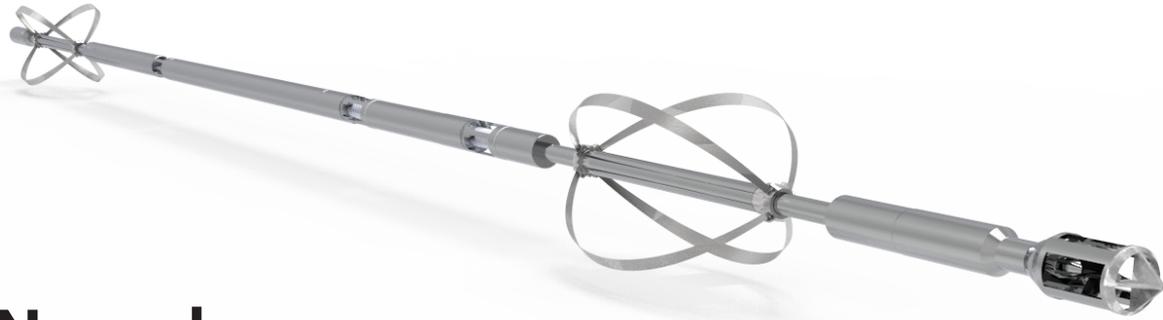
The main objective of the log was to identify condition of tubing/casing. Log shows multiple zones of corrosion of the tubing which confirmed by all sondes: C and B (which cover first pipe only) and long sonde A which can cover up to 4 pipes.



The log was conducted during hoist intervention when tubing was pulled and casing has PT failure. EMDS processed data indicates extensive corrosion on both casings at the upper section of the well.

The main objective of the log was to monitor condition of 7" scab liner which was run in hole due to intermediate casing failure. Interpretation shows that there are multiple zones of corrosion on tubing, few zones of corrosion on 7" scab liner and extended interval of extensive corrosion on both intermediate and surface casings.





## EDSN combo

Electromagnetic Defectoscope & Spectral noise logging tool

### Description

EDSN combo represents the complete well integrity toolbox which enables operators investigate and locate integrity failures before they escalate. Designed to deal with the complex well integrity issues, EDSN combo comprises electromagnetic defectoscope, two hydrophones for spectral noise logging, flowmeter and other conventional sensors necessary to conduct a well integrity survey. Superior to memory tools, the surface readout technology provides full control and allows saving operational time. In a single run, the tool provides corrosion evaluation of three concentric pipes and allows to detect and confirm the well integrity failures in a real-time. The combo tool is compatible with all logging systems and can be run on a mono-conductor cable.

### Key features

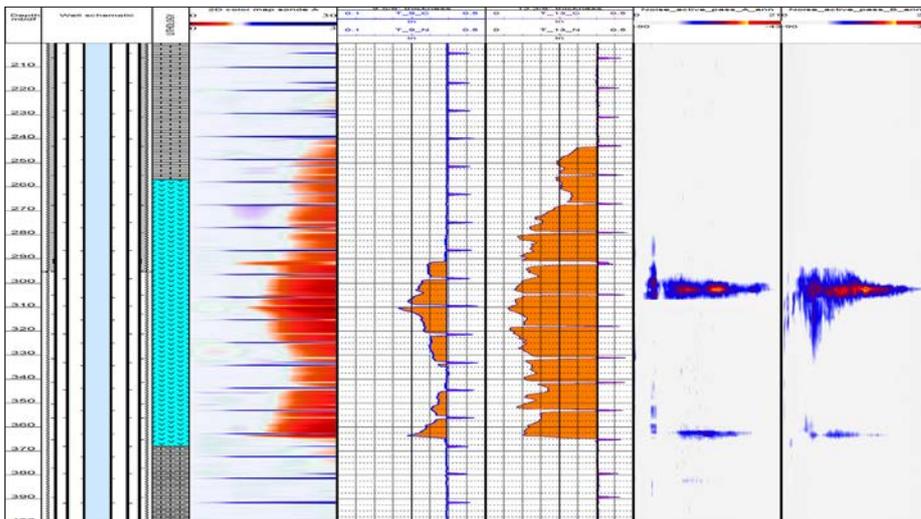
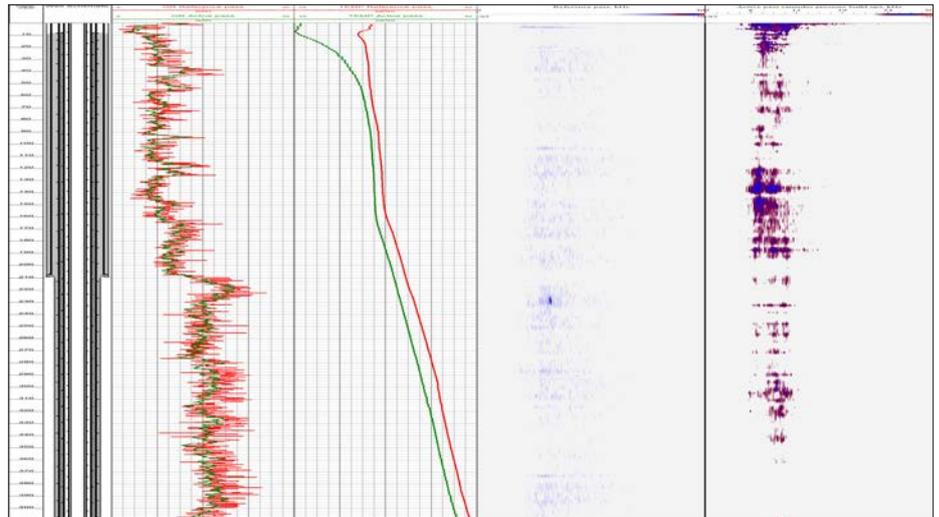
- EMDS, SNL, PLT modules can be run in combination as well as independently
- Quantitative 3 pipes corrosion evaluation
- Leak detection
- Annular crossflow detection
- Cement channeling
- Allocation of completion elements and perforations
- Allocation of cracks, holes and parted casings

### General specifications

|  | EDSN combo             |
|--|------------------------|
| Number of measureble pipes               | 3                      |
| Depth of investigation, pipe OD          | 2 7/8 -13 3/8"         |
| OD, inch                                 | 1.65" (42 mm)          |
| Max. cumulative pipe thickness           | 1.25" (32 mm)          |
| Max. temperature                         | 150 C (302 F)          |
| Max. pressure                            | 8700 psi (60 MPa)      |
| Length with centralizers (full assembly) | 18' (5.5 m)            |
| Weight                                   | 72 lbs (32 kg)         |
| Cable type                               | monoconductor          |
| Max. cable length                        | 23000' (7000m)         |
| <b>Spectral noise general specs</b>      |                        |
| Sensor type                              | 2 x hydrophones        |
| Frequency range                          | 0.1-60 kHz             |
| Dynamic range                            | 90 dB                  |
| Sampling frequency                       | 16, 24, 38, 96, 102 Hz |
| Measurement                              | stationary             |

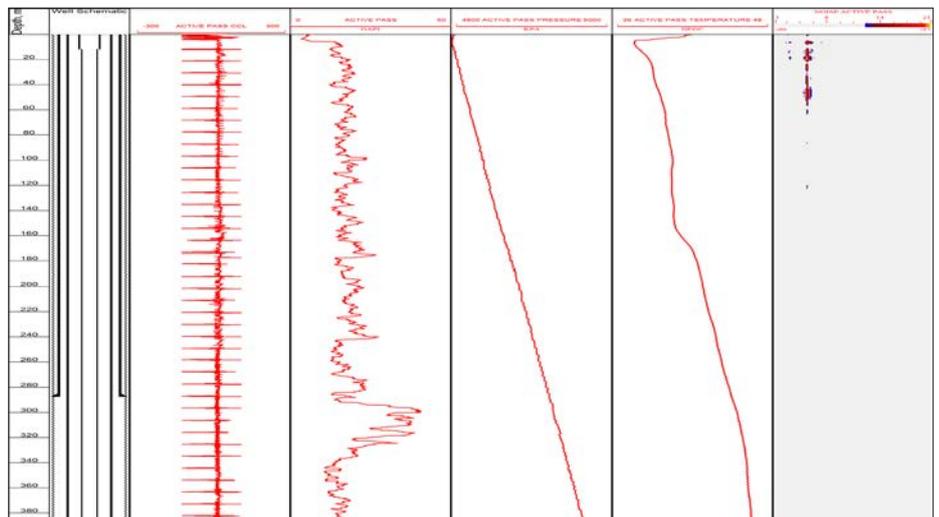


The well suffers from B annulus pressure and the main objective of the Noise log was to identify source of gas which causes pressure build up in B annulus. Two Noise passes were conducted: reference pass and Active pass (during pressure bleed off). The conclusion is that gas moves from formation upwards through channels in cement.



SIT was conducted in this well. A and B annulus failed leak-off test. In order to identify leak point, 2 active Noise passes were conducted. First, active, when water was pumped into A annulus shows that production casing has integrity issue at depth XXX, second, active pass when water pumped in B annulus show that surface casing has integrity issue at depth XXX. Corrosion log confirms Noise data.

The well has LOT failure of B annulus. In order to identify leak point, Noise log under pumping was conducted. Result that leak point locates at the upper section of the well at depth of XXX m.





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