



Verification Statement



RemScan VerifiGlobal Registration Number: V-2017-09-01 Date of Issue: 2017-09-15 (amended: 2018-07-18)

Technology type	RemScan™ is a handheld infrared device for the rapid infield measurement of petroleum hydrocarbon contaminants in soil.
Application	RemScan™ has been verified as a viable technology that can be used to measure total petroleum hydrocarbons (TPH) in soils with upper range TPH concentrations of at least 50,000 mg/kg.
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Verified Performance Claim

RemScan™ is a viable technology that can be used to measure total petroleum hydrocarbons (TPH) in soils with upper range TPH (C_{10} to $C_{36/40}$) concentrations of at least 50,000 mg/kg.

The performance claims of accuracy, repeatability and detection limit of the RemScan™ technology were independently verified in accordance with the ISO 14034 ETV standard and the VerifiGlobal Performance Verification Protocol. The accuracy of the RemScan™ was verified at a relative standard deviation (RSD) of <9.4% for site soils and <11% for a soil reference standard. The repeatability was verified at <3.3% for site soils and <1.5% for the soil reference standard. The detection limit of the RemScan™ technology was <66 mg/kg TPH (C_{10} to $C_{36/40}$) at 1 standard deviation.

Technology Application

RemScan™ is a handheld infrared device for the rapid infield measurement of petroleum hydrocarbon contaminants in soil. RemScan™ can be used to measure TPH concentration infield in soil in less than (20 seconds, with similar performance to laboratory assays. The infrared device uses diffuse reflectance technology, where a mid-infrared beam hits the soil surface and reflects back to a detector, generating an onscreen measurement of TPH. No solvent extraction or hazardous chemicals are required – it is a direct measurement.



Technology Description

The RemScan™ is a portable hand-held instrument used to perform rapid field measurements of total petroleum hydrocarbons (TPH) in soil. It is a rugged, weatherproof and portable instrument capable of measuring TPH concentrations in less than 20 seconds in any location where a soil sample can be accessed. The RemScan™ is equipped with two batteries, each of which allows continuous use for 4 hours (i.e. a total of 8 hours of continuous use). The charge cycle takes less than 4 hours. The unit also is equipped with a power cord, which can be used when local power is available and continuous extended use of the unit is expected. The unit is equipped with a personal data assistant (PDA), providing a user-friendly interface for entering sample information such as identification names and dates, performing calibration checks, and allowing data access and export. The PDA battery provides at least 8 hours of continuous use.

The RemScan™ technology is based on a diffuse reflectance infrared Fourier transform (DRIFT). It shoots a mid-infrared beam at the soil and the reflected light is captured in a detector. The instrument software then converts the unique reflected signal into an accurate TPH (C_{10} to C_{36}) readout in milligrams (mg) of TPH per kilogram (kg) of soil. Soil samples are analyzed by first air-drying the surface of the sample so that it contains less than 5% free moisture content. The sample is then gently tamped to form a flat surface. The nosecone of the RemScan™ is placed against the soil in a perpendicular position and the trigger is pressed once and released. After 20 seconds, the sample measurement is complete. A result is then displayed for TPH (C_{10} to C_{36}) in mg/kg and the data is automatically saved to a standard secure digital (SD) card. Data can be downloaded from the SD card to a computer as a .csv file which can be opened in Microsoft Excel®.

The high throughput and low incremental cost per sample means that RemScan™ can take many times more soil measurements at a site than is feasible using conventional laboratory analysis. This leads to a high degree of confidence in crucial decision-making processes on site.

The RemScan™ technology was commercialized by Ziltek, an Australian-based company that develops and markets innovative environmental technologies. Ziltek is a licensed distributor of the RemScan™ technology with global, exclusive rights for 20 years. The technology owner is the Commonwealth Scientific and Industrial Research Organization (CSIRO), the Australian Government's leading national research body.

Performance Testing Description

The Technology Assessment Report (Battelle, 2014) was the main performance testing document that provided data for this verification. Two additional data reports prepared by Ziltek Pty. were also reviewed by the verifier. For each site, a site-specific calibration model was developed using a minimum of 60 site samples to calibrate the RemScan™ unit. To evaluate accuracy at least 40 samples from each site were denoted as blind validation samples, analyzed by the RemScan™ and the results were compared to laboratory values. Each sample was scanned five times and the samples were thoroughly mixed between scans. To evaluate repeatability, at least three select samples from each site were analyzed a minimum of 10 times with the RemScan™ unit, without moving the unit between scans. To verify the detection limit, at least 77 samples from each site below the vendor specified detection limit were analyzed with the RemScan™ Unit.

As a separate exercise, the ability of the RemScan™ to accurately measure a commercially available soil reference sample (ERM CC0172) was also tested, and the values were compared to laboratory values. Accuracy and repeatability measurements for this reference sample were made as described above.

There were no deviations to the verification plan.

Verification Results

The RemScan™ verification was conducted by Battelle Memorial Institute (505 King Avenue, Columbus, OH 43201 USA) in accordance with the International Organization for Standardization (ISO) standard for environmental technology verification (ETV), ISO 14034:2016, and the VerifiGlobal Performance Verification Protocol. The performance claim verification is based on data and information provided by Ziltek Pty. Ltd. regarding the efficacy of the RemScan™ technology.



The claims stated in Table 1 below were verified using statistical methods such as relative standard deviation (RSD), percent error and coefficient of determination (R^2 values). The result of these statistical analyses is presented in Table 2 below. Confirmation that the performance is verified and confirmed as originally stated is presented in Table 3. Overall the performance claims that were verified were met.

Table 1. Accuracy and Repeatability Claims

Soil Samples	Accuracy (RSD)	Repeatability (RSD)
Selected site sample with 5,000 mg/kg to 10,000 mg/kg TPH C ₁₀ to C ₃₆	<12%	<7%
Soil reference standard ERM CC0172 (6,600 mg/kg TPH C ₁₀ to C _{36/C40})	<30%	<10%

Table 2. Statistical Evaluation of Performance Claims

Performance Claim	Predicted/required	Actual	Comments
Cross validation ¹	N/A	R ² of 0.96 to 0.97	
Accuracy of site samples	RSD of < 12%	RSD of 9.4%, 13%, 18%	Higher RSDs result from readings taken several months apart on samples that were stored. The higher RSDs are therefore a result of volatilization of TPH, riffling and soil heterogeneity
Repeatability of site samples	RSD of < 7%	RSD of 3%	
Accuracy of soil reference standard	RSD of < 30%	RSD of <11%	
Repeatability of soil reference standard	RSD of < 10%	RSD of <3%	
Detection Limit	250 mg/kg TPH	< 66 mg/kg TPH at one standard deviation	User can be 95% confident that a sample with a predicted TPH concentration of less than 870 mg/kg has an actual TPH concentration of less than 1,000 mg/kg. This is critical since regulatory values for TPH in soil tend to be around 1000 mg/kg.

¹Comparison of “predicted vs observed” TPH readings. The closer the R² value is to 1, the closer the RemScan predicted values for TPH correlate to laboratory assay values for TPH

Table 3. Verification of Performance Claims

Performance Specifications	Twenty-Nine Palms Site	North Island Site	Vendor Claims Met
Accuracy	RSD of 9.40%	insufficient data ¹	✓
Repeatability	RSD of 1.80%	RSD of 3.30%	✓
Detection limit	66 mg/kg	64 mg/kg	✓
False positives/negatives (1,000 mg/kg)	Nil	Nil	N/A
Battery life	Full day of continuous use with one battery swap		
Throughput rate	10 to 20 samples per hour		
Operational cost	No incremental cost		
Formal training required	Two hours		
Infield calibration time	Three minutes every hour		

¹The North Island Site had only one blind validation sample and one calibration sample in the 5,000 to 10,000 mg/kg range so a statistically significant RSD could not be calculated.



The verifier also confirmed the following technology operational claims:

- RemScan™ is a hand-held portable instrument that can be operated standalone without the need for electricity or computer equipment.
- RemScan™ is suitable for a full 8-hour day of infield use with only one battery swap.
- RemScan™ is easy to use and can be operated by relatively unskilled personnel in the field (i.e. <2 hours of training). No extra certification is required.
- It takes less than 30 seconds to collect a measurement from an air-dried sample with RemScan™. For air-dried soil samples (<5% free moisture content by weight), the total sample measurement time, including preparation of a flat surface, is less than 2 minutes. Under this scenario, the instrument can collect more than 30 TPH measurements per hour.
- Operation of RemScan™ does not require any consumables or hazardous chemicals.
- Calibrating the instrument takes less than 3 minutes after every hour of continuous use.
- Data is downloaded easily from the RemScan™ SD card as a .csv file which can be viewed in Microsoft Excel®.
- The RemScan™ method is non-destructive in the sense that the measured soil can be left in, or returned to, its original location without significantly altering its physical and chemical properties.

In conclusion:

RemScan™ is a viable technology that can be used to measure total petroleum hydrocarbons (TPH) in soils with upper range TPH (C_{10} to $C_{36/40}$) concentrations of at least 50,000 mg/kg. The performance claims of accuracy, repeatability and detection limit of the RemScan™ technology were verified. The accuracy of the RemScan™ was verified at an RSD of <9.4% for site soils and <11% for the soil reference standard. The repeatability was verified at <3.3% for site soils and <1.5% for the soil reference standard. The detection limit of the RemScan™ technology was <66 mg/kg. The high throughput and low incremental cost per sample means that RemScan™ can take many times more soil measurements at a site than is feasible using conventional laboratory analysis. This leads to a high degree of confidence in crucial decision-making processes on site.

ISO 14034

The purpose of environmental technology verification is to provide a credible and impartial account of the performance of environmental technologies. Environmental technology verification is based on principles to ensure that verifications are performed and reported accurately, clearly, unambiguously and objectively. The International Organization for Standardization (ISO) standard for environmental technology verification (ETV), ISO 14034, was published in November 2016.

Benefits of ETV

ETV contributes to protection and conservation of the environment by promoting and facilitating market uptake of innovative environmental technologies, especially those that perform better than relevant alternatives. ETV is particularly applicable to those environmental technologies whose innovative features or performance cannot be fully assessed using existing standards. Through the provision of objective evidence, ETV provides an independent and impartial confirmation of the performance of an environmental technology based on reliable test data. ETV aims to strengthen the credibility of new, innovative technologies by supporting informed decision-making among interested parties.

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