Project Number 00474-10

Prepared for:

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July 2002

FCC Application for Certification of an Intentional Radiator

Sercel, Inc.
17200 Park Row
Houston, Texas 77084

Opseis Remote Eagle Module (REM) for Radio Telemetry Model 903 (Transmitter Portion)

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Certificate Of Compliance

Applicant:	Sercel, Inc.
Applicant's Address:	17200 Park Row Houston TX 77084
Model:	Opseis Remote Eagle Module (REM) for radio telemetry Model 903
Serial Number:	0125
Project Number:	00474-10
Test Dates:	20 March 2001 through 23 March 2001

I, Jeffrey A. Lenk, for Professional Testing (EMI), Inc., being familiar with the FCC rules and test procedures have reviewed the test setup, measurement data, and this report. I believe them to be true and accurate. The Sercel, Inc. Opseis Remote Eagle Module for radio telemetry (REM) Model 903 was found to be in compliance with FCC Part 90 for Intentional Radiators.

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Jeffrey A. Lenk
President

1.0 Equipment Under Test (EUT) Description

The Sercel Opseis Remote Eagle Module (REM) for radio telemetry Model 903 transceiver is a component in a seismic data-gathering system used in oil and natural gas exploration. In the field, such a system would include a portable seismic array of up to 1000 seismic sensors connected to 260 seismic acquisition remote units. The REM Model 903 receives data from other devices in the system and transmits this data in real-time or non-real-time to a Central Recording Station.

The REM transmitter operates in the 216 to 220 MHz band, which is allocated for telemetering data. The operating frequency is determined by a synthesizer that references a temperature-compensated, 12.80 MHz crystal oscillator. The synthesizer operates under software control and is capable of changing the transmit frequency in 50 kHz steps.

The system defaults to the factory pre-set 217.500 MHz on power-up. The user may select other operating frequencies using a local computer port. Operating frequencies may be set at intervals of 50 kHz in the range, 216.050 to 219.950 MHz.

The REM transmitter generates single-level FSK output using either Manchester or non-return-to-zero (NRZ) encoded FM. The data rate is 400 kilobits per second, resulting in a bit-rate frequency of 400 kHz. Transitions occur at least once per bit period. Peak deviation is 200 kHz, and the maximum output power is 13 Watts.

To achieve bit error rates of 10^{-6} or better, the following antennas are available to installers of the system:

Communication Distance	Mast Height	Antenna Type
100 m to 16 km	8m	Yagi
100 m to 24 km	18 m	Yagi
100 m to 5 km	8 m	Omnidirectional
100 m to 10 km	18 m	Omnidirectional

Transmissions are in the 216 to 220 MHz band is permitted under FCC Parts 90.238 and 90.259 (Telemetry Operations). Part 90.259 requires that information about characteristics of the telemetry transmitter be disclosed in this application. Specifically, the disclosure must include the following:

1. Emission Characteristics. The REM transmitter generates single-level FSK output using non-return-to-zero encoded FM at an operating frequency of 217.6 MHz. The data rate is 400 kilobits per second, resulting in a bit-rate frequency of 400 kHz. Transitions occur at least once per bit period.

2. Transmitter Frequency Deviation. Peak deviation is 7.0 kHz, ±2 kHz.

3. Output Power. The maximum output power is 13 Watts. (Typical power output at 25° C is 12 Watts.)

4. Antenna Type and Directional Characteristics. To achieve bit error rates of 10^{-6} or better, one of the following antenna configurations will be selected:

Communication Distance	Mast Height	Antenna Type
100 m to 16 km	8m	Yagi
100 m to 24 km	18 m	Yagi
100 m to 5 km	8 m	Omnidirectional
100 m to 10 km	18 m	Omnidirectional

5. Minimum Necessary Hours of Operation. The transmitter is operated for periods of less than 10 seconds when remote data acquisition is required. The period between transmissions varies and depends upon the nature of the seismic stimulus. In a specific event, 128 samples of data can be transmitted in 4 ms.

The REM Model 903 transceiver contains a receiver and a transmitter with a rated power output of up to 13 Watts. Receiver compliance was verified under Sections 15.19, 15.21, and 15.105 of the FCC rules. The transmitter is intended for use by trained operators and is not available for retail sale to consumers. This device meets the requirements of Part 90.238(d). Specific test requirements include the following:

47 CFR 90.207	Types of Emissions
47 CFR 90.209	Bandwidth Limitations
47 CFR 90.210	Emission Masks
47 CFR 90.211	Modulation Requirements
47 CFR 90.213	Frequency Stability
47 CFR 90.214	Transient Frequency Behavior
47 CFR 2.1046	RF Power Output
47 CFR 2.1047	Modulation Characteristics
47 CFR 2.1049	Occupied Bandwidth
47 CFR 2.1051	Spurious Emissions at Antenna Terminals
47 CFR 2.1053	Field Strength of Spurious Radiation
47 CFR 2.1055	Frequency Stability
47 CFR 1.1310	Radio Frequency Radiation Exposure Limits

The Sercel Opseis Remote Eagle Module (REM) for radio telemetry Model 903 was tested in transmit mode of operation over the range of battery voltages from 11 VDC through 14.5 VDC and from –30° C to +50° C with no out-of-specification conditions noted.

A system block diagram is presented in Appendix A. Appendix B contains a photograph of the equipment label. Photographs of the exterior of the REM and printed wiring assemblies are found in Appendix C. Appendix D contains excerpts from the Installation Manual. In addition to discussions of how the equipment is installed, the manual contains photographs of the REM transmitter modules. Radiated spurious emissions test plots are presented in Appendix E. Appendix F contains portions of the transmitter alignment procedure that pertain to deviation adjustment.

The system tested consisted of the following:

Manufacturer & Model	**Serial #**	**FCC ID #**
Sercel, Inc. REM Model 903 216-220 MHz Transceiver	0125	KQ9903

Cables and Cords:

None required.

Support Equipment:

No options or sub-models are available for this product. The measurements reported herein are representative of testing at worst-case conditions to verify compliance of the transmitter section of the transceiver with FCC Rules Parts 2 and 90 for intentional radiators. A separate verification report pursuant to Part 15, Subpart B has been submitted for the Sercel, Inc. REM Model 903 as a Digital Device and as a Receiver.

2.0 RF Output Power, Part 2.1046

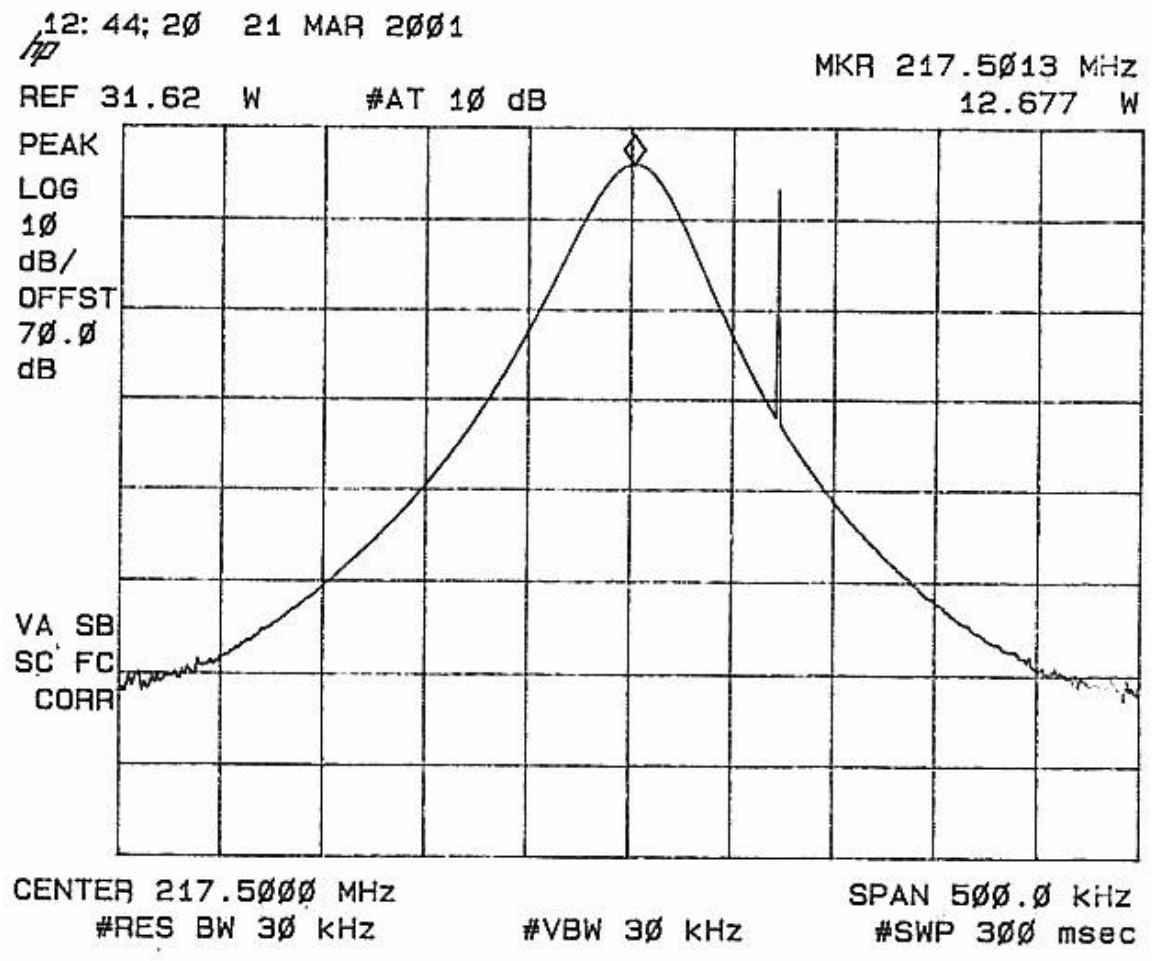
The manufacturer's maximum rated power output for the Sercel, Inc. REM Model 903 is 13 Watts. Typical power output for a REM operated at 25°C is 12 Watts. This level is required in order to achieve bit error rates of 10^{-6} or better with the Yagi or omnidirectional antennas that are sold with the system. Measurements were performed to confirm that the REM complies with this rating.

2.1 Test Procedure

The antenna port of the EUT was terminated with a 70 dB attenuator connected to the 50 Ohm input of a spectrum analyzer. The EUT was powered an internal battery, which was fully charged prior to the test. Special control software was used on a laptop computer to command modulated transmissions typical of those generated when the EUT is in normal operation. The Spectrum Analyzer was adjusted for peak detection, and a 30 kHz bandwidth was selected to measure the maximum RF output power. The spectrum analyzer calibration was verified against a reference HP 436A power meter to provide a 95% confidence U_c of 0.1 dB, 44 mW.

2.2 Test Results and Conclusion

The maximum RF output power obtainable was 12.677 Watts. Plot 1 shows the spectrum analyzer display obtained in this measurement. The power output is within the limits given in Part 2.1046.



Plot 1. Peak output power measured while the Opseis Remote Eagle Module (REM) was transmitting representative data .

3.0 Modulation Characteristics, Part 90.210(b)

Because of the complexity and periodic nature of the data transmitted on the Sercel Opseis Remote Eagle Module (REM) for radio telemetry, the modulation characteristics of the device were determined using the 99% Occupied Bandwidth option described in Part 2.1049(h), in lieu of calculating the Necessary Bandwidth.

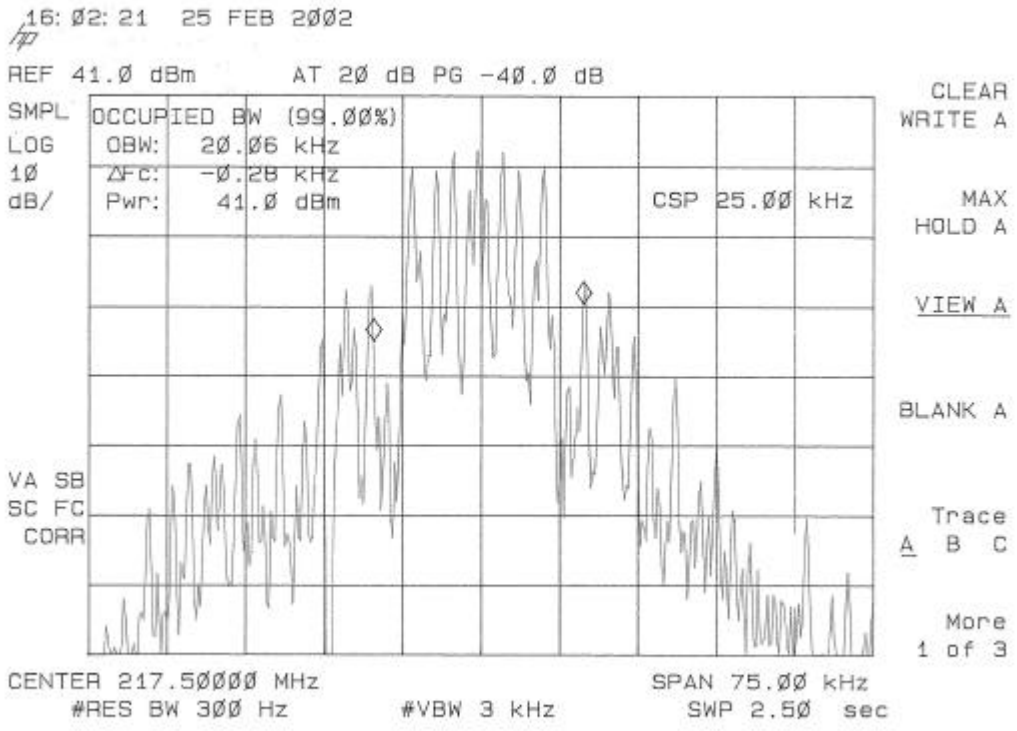
3.1 Test Procedure

The measurement was made using the 99% Occupied Bandwidth function in an HP 8591E Spectrum Analyzer. The EUT antenna port was terminated with a 40 dB attenuator and the spectrum analyzer. The transmitter was sending data typical of that which would be broadcast in normal operation.

This measurement determines the frequencies at which 0.5% of the total mean power lies above and 0.5% of lies below the test frequency. Thus, 99% of the mean transmitted power lies between these frequencies, and the difference between them is the 99% occupied bandwidth.

3.3 Test Results and Conclusion

The spectrum analyzer display for this measurement is found in Plot 2. The Occupied Bandwidth measured for the Sercel Opseis Remote Eagle Module for radio telemetry (REM) is nominally 20.06 kHz. The 0.5% mean power points are both 20 dB below the 41.0 dBm carrier level.



Plot 2. 99% occupied bandwidth of signal transmitted by REM is 20.06 kHz. The power output measured in this test is +41.0 dBm.

To achieve this occupied bandwidth, the transmitter deviation is adjusted to 7 kHz. The manufacturing procedure used at Sercel is presented in Appendix F.

4.0 Spurious Emissions at Antenna Terminals, Part 2.1051

Spurious emissions of the Sercel Opseis Remote Eagle Module (REM) for radio telemetry were measured in the laboratory using the method found in Part 2.1053. Measurements were taken under the conditions specified in Part 2.1049(i).

4.1 Test Procedure

Spurious emissions from the Opseis Remote Eagle Module (REM) transmitter were measured from 30 MHz to 2.5 GHz using a 70 dB attenuator and an Advantest R3265 spectrum analyzer. Peak-hold mode was used to capture the harmonic behavior because of the periodic nature of these signals. The REM was configured to transmit typical data during the test. Photo 1 shows the test equipment setup.

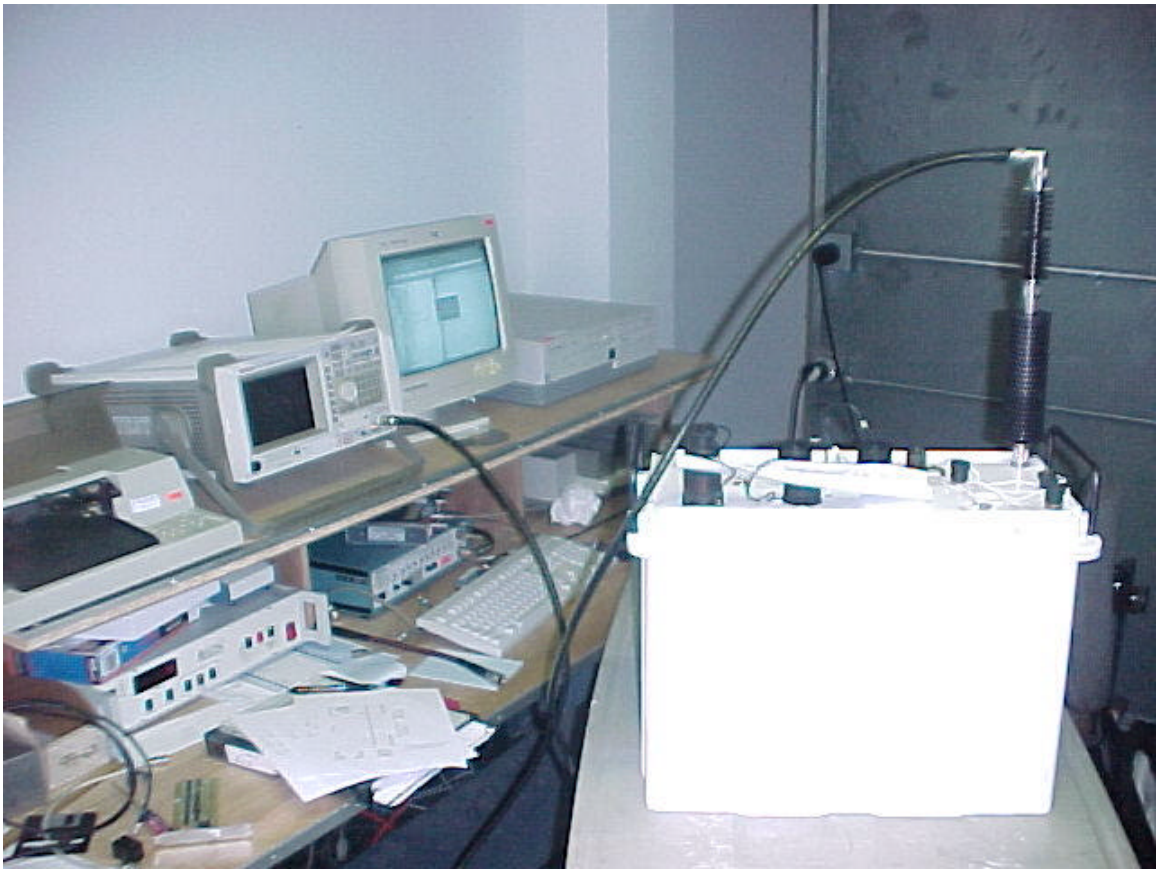


Photo 1. spurious emissions measurement. Attenuators totaling 70 dB reduce output power to a level appropriate for spectrum analyzer measurement without front-end compression.

4.2 Test Results and Conclusion

No emissions were observed below the carrier frequency. Worst-case measurements at up to –65.4 dBc are reported in Table 1 below. The limit for emissions spaced more than 250% of the Occupied Bandwidth from the carrier frequency was calculated using the expression, 43+10 log P where P=12.677 Watts. The limit was found to be -54.03 dBm.

Unwanted Emission Frequency (MHz)	Recorded Level (dBm)	Limit (dBm)	Margin (dB)
446.1	-65.4	-54.03	-11.37

Table 3. Unwanted emission frequencies and amplitudes.

Table 3 shows that an unwanted emission was found at the second harmonic of the operating frequency. The emission was at –65.4 dBm, which is 11.37 dB below the limit. Emissions were observed at higher frequencies, but all were more than 20 dB below the calculated limit.

5.0 Field Strength of Spurious Emissions Part 2.1049 and 2.1053

Radiated spurious emissions of the Sercel Opseis Remote Eagle Module (REM) for radio telemetry were measured on an open-air test site. The conditions under which the measurement was made are defined in Part 2.1049(h). The method of measurement is specified in Part 2.1053.

5.1 Test Procedure

The EUT was placed on the 80 cm table on a turntable at the open-air test site. The amplitudes of emissions in the 30 MHz to 2.5 GHz portion of the spectrum were maximized by rotating the turntable through 360 degrees in azimuth and changing the antenna elevation from 1 through 4 meters. Photo 2 shows the REM in position on the turntable at the OATS.

Measurements were taken at 3 m with the transmitter terminated in a 50-Ohm dummy load while producing test software-generated modulation and output power. A broadband preamplifier and spectrum analyzer were used to measure signals produced by the EUT.

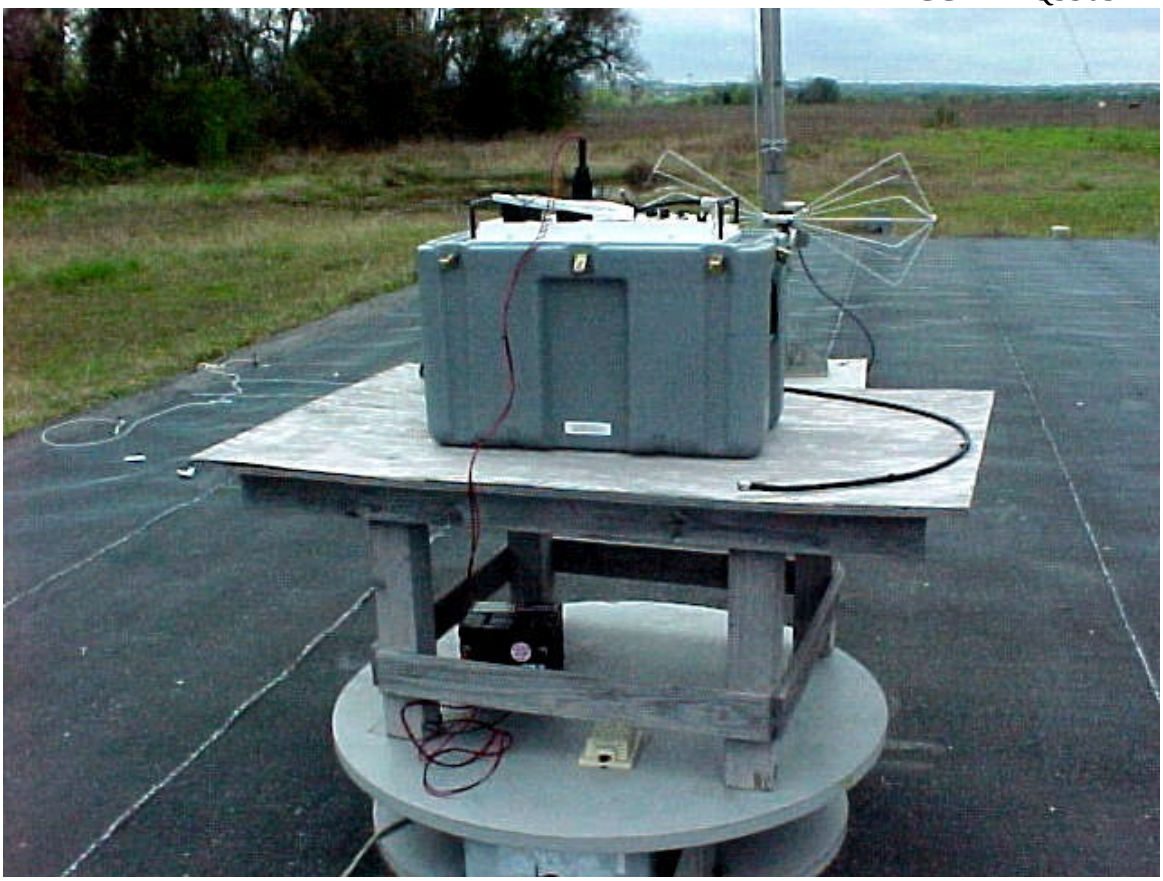


Photo 2. The REM on turntable at OATS.

5.2 Test Results and Conclusion

Spectrum analyzer plots of the emissions are found in Plots 1, 2, and 3 in Appendix E. The data are summarized in Table 4 below.

Emission Frequency	Emission Amplitude (dBc)
435.0	-47.8 dBc

Table 4. Spurious emissions measured on OATS.

The strongest spurious emission was found at the second harmonic of the fundamental frequency. It was more than 40 dB below carrier level. Other emissions, which are not shown here, were more than 60 dB below carrier level.

Worst-case emissions from the Sercel Opseis Remote Eagle Module (REM) for radio telemetry were more than 20 dB below carrier level.

6.0 Frequency Stability with Temperature and Voltage Parts 90.213

The EUT must be compliant with the frequency stability requirements of Part 90.213, using the methods described in Part 2.1055, Paragraph a1. Transmitters operating in this frequency range with over 2 Watts output power must be stable within 50 parts per million (PPM) when the ambient temperature is varied, in increments of less than 10° C, from –30° to +50° C.

The Sercel Opseis Remote Eagle Module (REM) for radio telemetry was tested for compliance with the Part 90.213 using the methods described in Part 2.1055. Part 90.259 requires that the application include precise information concerning the performance of the transmitter. Data taken in this test describe how the transmitter frequency changed as ambient temperature was varied.

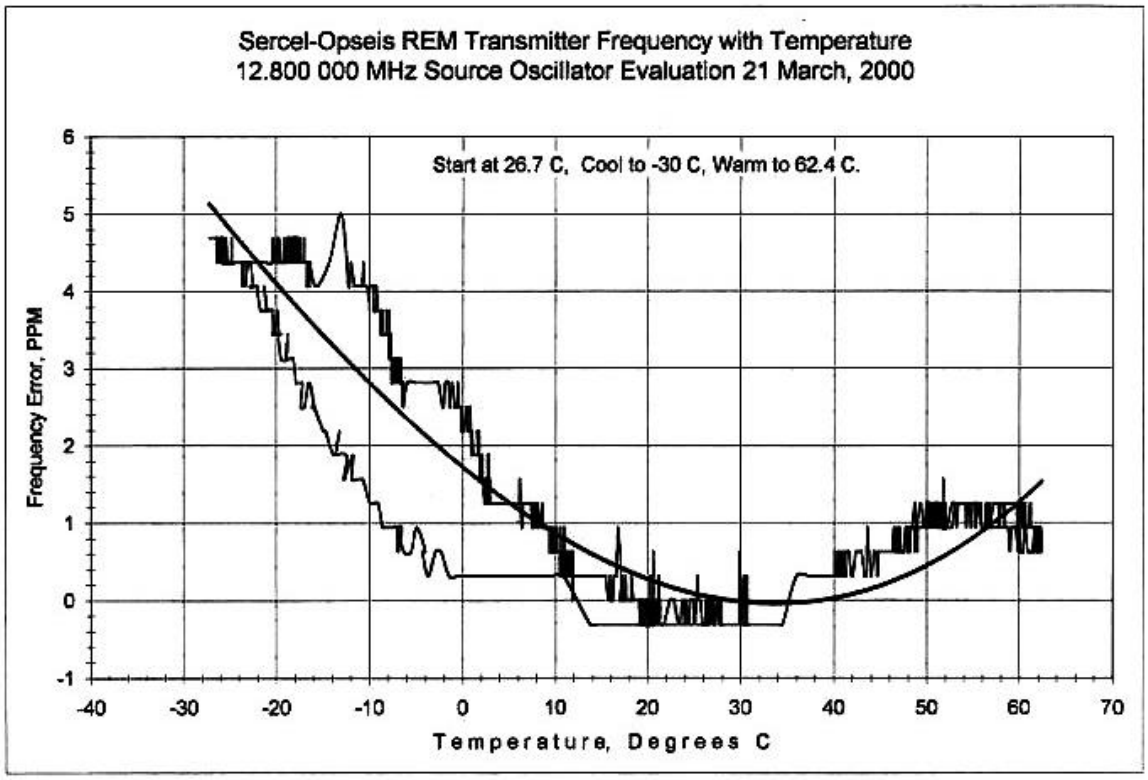
6.1 Frequency Stability with Temperature Test Procedure

In this test, the REM was placed in an environmental chamber. Power and communication were routed to the device through a port in the side of the chamber. DC power was provided at 12.0 Volts and a probe was inserted in the REM to monitor the 12.80 MHz reference oscillator. A frequency counter and directional coupler were used to measure the carrier frequency of the Opseis Remote Eagle Module (REM) transmitter.

The frequency counter was adjusted to sample the transmitter frequency at 10-second intervals. The temperature was initially allowed to stabilize at 26.7°C, and ten measurements were taken. Then, it was lowered to –30° C, and the REM was allowed 60 minutes to stabilize. Measurements were recorded as the temperature was raised, over a period of two hours, to +62.4° C.

6.2 Test Results

The EUT maintained its operating frequency within ± 5 ppm over the temperature range of –26.7° to +62.4° C. The frequency at 26.7° C is taken as the reference temperature. The maximum frequency error was 5 PPM, which was recorded at –13°C. This is within the 50 ppm limit given in Part 90.213. The results are presented in Plot 4.



Plot 4. Transmit frequency in PPM as ambient temperature was changed from 26.7° C to –30°C and then to 62.4°C.

6.3 Frequency Stability with Input Voltage Change Procedure

The EUT must be compliant with the frequency stability requirements of Part 90.213, using the method described in Part 2.1055, Paragraph d1. Transmitters operating in this frequency range with over 2 Watts output power must be stable within 50 parts per million (PPM) when the supply voltage is varied from 85 to 115 percent of the nominal value.

In this test, the REM was operated at 26° C, and the DC supply voltage was set at 11.0, 12.5, and 14.5 VDC. Voltage measurements were made with a Tektronix DMM 870 digital voltmeter. Power was provided by an external variable power supply and voltages were within the end-points specified by the manufacturer. The REM was placed in Test mode so that it would produce a steady carrier. The frequency was measured using an HP 8566B spectrum analyzer, for which the span was narrowed to 2 kHz so that 1 Hz resolution would be available. The REM was allowed to become temperature-stable before the test was begun.

6.4 Test Results

The frequency errors with changes in supply voltage are given in column 3. The maximum error was +3 Hz, which represents a change of less than 1 PPM. This is within the 50 ppm limit given in Part 90.213. No adjustments were made to the

frequency-determining circuit element before or during these tests. The findings are presented in Table 2.

EUT Serial #0125	Opseis Remote Eagle Module (REM)	Test Date: 3/22/2001
DC Power (Volts)	**Measured Transmit Frequency**	**Frequency Change (Hz)**
11.0	219.500054	+3 Hz
12.5	219.500051	0
14.5	219.500051	0

Table 2. Changes in transmit frequency as DC supply voltage was Set at 11.0, 12.5, and 14.5 VDC.

7.0 Radio Frequency Radiation Exposure Evaluation Part 1.1310

The Sercel Opseis Remote Eagle Module (REM) for radio telemetry was evaluated according to the Radio frequency Radiation Exposure requirements of Part 1.1310. The REM operates in the 30 to 300 MHz range, so the Maximum Permissible Exposure (MPE) is 61.4 V/m.

7.1 Evaluation Procedure

The primary method of controlling radio frequency radiation exposure from the Sercel Opseis Remote Eagle Module (REM) for radio telemetry is the correct installation of the equipment. The installer is responsible for locating the antenna such that human exposure is minimized. The device is intended for use in seismic oil exploration and normally enters transmit mode while seismic events are under way and human observers are removed from the active area. If personnel were present while the REM transmitter is in operation, the following procedures would apply.

We may calculate the levels of the exposure a person would encounter if they were near the antenna when the transmitter is operating. Assuming a transmitter power output of 15 Watts and negligible feedline loss, calculations can be done for three cases—that of the omnidirectional antenna, the yagi antenna, and the 4-bay, stacked yagi array. The installation instructions given in the Sercel ***408UL Installation Manual*** (Chapter 8, "Description of the radio telemetry equipment") indicates that all of the antennas are intended to be mast-mounted. We may assume this would place them at least 2 metres from personnel on the ground while the system is in operation.

Worst-case exposures created by the Opseis Remote Eagle Module (REM) transmitter and associated antenna can be calculated using information taken from the ***408UL Installation Manual*** and from measurements performed in preparing this report.

The field strength in Volts/metre can be calculated using the expression: $E = \frac{(30P_t g)}{d}$

where P_t =Transmit power, g = antenna gain over an isotropic source, and d=the distance from the antenna at which a measurement would be made. If P_t =15 Watts and the omnidirectional antenna gain is 3 dBi, then the maximum field strength developed at 1 metre from the antenna will be 18.37 V/m. The same calculation for the 2-element Yagi antenna, for which we assume a typical gain of 6.7 dBi, yields 27.45 V/m.

Four-antenna arrays of 7-element yagis are also shown in the ***408UL Installation Manual.*** The Installation Manual gives the gain of the array as 16.0 dBd. This figure must be increased 2.2 dB to derive gain over an isotropic source. The array gain is thus 18.2 dBi. The field strength 1 meter in front of such an array would be 90.5 V/m. At a separation of 1.5 metres would reduce the field strength to 60.33 V/m.

Because of its size the 12.5-foot tall array would likely be elevated above ground and removed from human observers by considerably more than 1 metre. This would justify the assumption of a slightly greater separation between observers and the antenna array. The narrower horizontal and vertical beam-widths of the array would further reduce stray energy in the vicinity of the antenna.

7.2 Evaluation Results

These calculations indicate that exposures to electric fields generated by the low-gain vertical antennas and higher-gain Yagi antennas are within the limits prescribed in Part 1.1310. The findings are summarized in Table 5.

Antenna Type	Antenna Gain	Transmit Power (Watts)	Operator Separation From Ant.	E-Field Limit (V/m)	E-Field (V/m)
Omni vertical	3 dBi	15	1 m	61.4	18.37
2-element Yagi	6.7 dBi	15	1 m	61.4	27.45
4-bay, 7-element Yagi Array	18.2 dBi	15	1.5 m	61.4	60.33

Table 5. Human Exposure Levels for Remote Eagle Module (REM)

The Sercel Opseis Remote Eagle Module (REM) for radio telemetry complies with radiation exposure limits given in Part 1.1310. The calculated E-fields for both of the antennas used with the REM are less than the allowed 61.4 V/m.

To ensure that personnel are not exposed to radiated energy in excess of the MPE, the following text has been added to the ***408UL Installation Manual***:

"Warning: Maximum Permissible Exposure to RF energy may be exceeded if the transmitter is activated while personnel are within two (2) meters of the antenna. Do not operate the transmitter while personnel are within two (2) meters of the antenna."

8.0 Form 731 Information

The following information is provided for inclusion in the FCC Form 731 for the Sercel Opseis Remote Eagle Module (REM) for radio telemetry**.**

8.1 Emission Designator

20K0F1D

8.2 Output Power

In the conducted power tests, the highest power attained was 41.1 dBm (12.7 watts). The manufacturer specifies a maximum power output of 13 Watts for this product.

Maximum Rated Output Power: 13.0 Watts

8.3 Frequency Band of Operation

The Sercel Opseis Remote Eagle Module (REM) for radio telemetry operates in the frequency range, 216.0 to 220.0 MHz.

Operating Frequency Range: 216.0-220.0 MHz

8.4 Grant Notes

No exceptions or notes are listed for this device.

9.0 Modifications

No modifications were made to the Sercel Opseis Remote Eagle Module (REM) for radio telemetry to enable it to meet current FCC requirements.

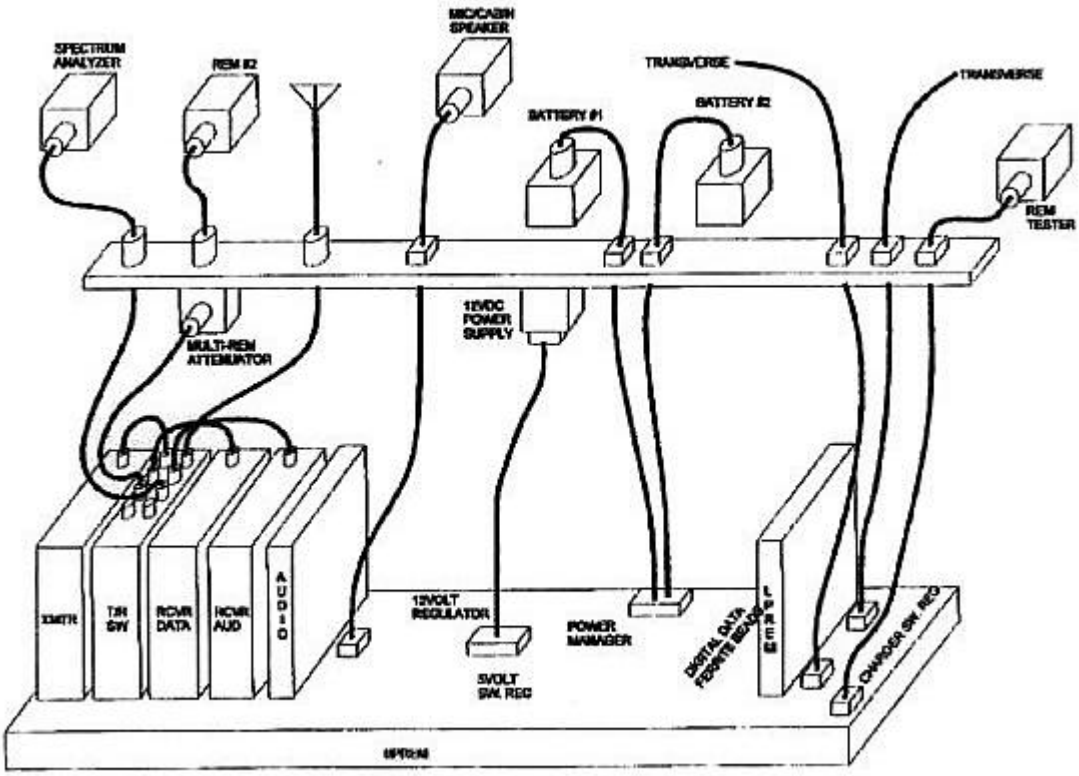
10.0 List of Test Equipment

A list of the test equipment utilized to perform the conducted and radiated emission measurements is given below. The date of calibration is given for each.

Device	Description	Calibration Due
Thermotron SM-3	Environmental. Test Chamber	Not Required
TEK DMM 870	Digital Voltmeter	January 2002
40 dB, 70 dB	Attenuators	At Use
OMEGA HH506R	Temperature Probe	March 2002
EMCO 3108	Biconical Antenna	November 2002
EMCO 3146	Log Periodic Antenna	November 2002
Werlatone C1460	Directional Coupler	June 2002
Advantest R3265	Spectrum Analyzer	February 2002
HP 8591E	Spectrum Analyzer	April 2002
HP 8566B	Spectrum Analyzer	January 2003
HP 8447D	Preamplifier	November 2002
Miteq ZKL	Preamplifier	January 2002

Appendix A System Diagram

Opseis Remote Eagle Module (REM) Block Diagram



REM
ELECTRICAL BLOCK DIAGRAM