



Measurement of RF Interference from an Orion Gas Invensys Transmitter

For : Badger Meter Inc.
Milwaukee, WI

P.O. No. :

Date Received: May 4, 2006

Dates Tested : May 4 through 17, 2007

Test Personnel: Richard E. King

Specification : FCC "Code of Federal Regulations" Title 47
Part 15, Subpart C, Section 15.249 for Intentional
Radiators Operating Within the 902MHz to 928MHz band

Test Report By : *Richard E. King*
Richard E. King

Witnessed By : John Olsen
Badger Meter Inc.

Approved By : *Raymond J. Klouda*
Raymond J. Klouda
Registered Professional Engineer of
Illinois - 44894



TABLE OF CONTENTS

PARAGRAPH	DESCRIPTION OF CONTENTS	PAGE NO.
1.0 INTRODUCTION		4
1.1 Description of Test Item		4
1.2 Purpose		4
1.3 Deviations, Additions and Exclusions		4
1.4 Applicable Documents		4
1.5 Subcontractor Identification		4
1.6 Laboratory Conditions		4
2.0 TEST ITEM SETUP AND OPERATION		4
2.1 Power Input		5
2.2 Grounding		5
2.3 Peripheral Equipment		5
2.4 Interconnect Cables		5
2.5 Operational Mode		5
2.6 Test Item Modifications		5
3.0 TEST EQUIPMENT		5
3.1 Test Equipment List		5
3.2 Calibration Traceability		5
3.3 Measurement Uncertainty		5
4.0 REQUIREMENTS, PROCEDURES AND RESULTS		5
4.1 Powerline Conducted Emissions		6
4.1.1 Requirements		6
4.2 Duty Cycle Factor Measurements		6
4.2.1 Procedures		6
4.2.2 Results		6
4.3 Radiated Measurements		6
4.3.1 Requirements		6
4.3.2 Procedures		6
4.3.3 Results		7
4.4 Occupied Bandwidth Measurements		8
4.4.1 Requirement		8
4.4.2 Procedures		8
4.3.3 Results		8
5.0 CONCLUSIONS		8
6.0 CERTIFICATION		8
7.0 ENDORSEMENT DISCLAIMER		8
TABLE I - EQUIPMENT LIST		9



REVISION HISTORY

Revision	Date	Description
—	6/1/07	Initial release

Measurement of RF Emissions from an Orion Gas Invensys Transmitter

1.0 INTRODUCTION:

1.1 Description of Test Item - This document represents the results of the series of radio interference measurements performed on an Orion Gas Invensys Transmitter, Serial No. none assigned, (hereinafter referred to as the test item). The test item was designed to transmit at approximately 916.45MHz using an internal antenna. The test item was manufactured and submitted for testing by Badger Meter Inc. located in Milwaukee, WI.

1.2 Purpose - The test series was performed to determine if the test item meets the conducted and radiated RF emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Sections 15.249 for Intentional Radiators. Testing was performed in accordance with ANSI C63.4-2003.

1.3 Deviations, Additions and Exclusions - There were no deviations, additions to, or exclusions from the test specification during this test series.

1.4 Applicable Documents - The following documents of the exact issue designated form part of this document to the extent specified herein:

- Federal Communications Commission "Code of Federal Regulations", Title 47, Part 15, Subpart C, dated 1 October 2006
- ANSI C63.4-2003, "American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz"

1.5 Subcontractor Identification - This series of tests was performed by Elite Electronic Engineering Incorporated of Downers Grove, Illinois. The laboratory is accredited by the National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP). NVLAP Lab Code: 100278-0.

1.6 Laboratory Conditions The temperature at the time of the test was 24.7°C and the relative humidity was 35%.

2.0 TEST ITEM SET-UP AND OPERATION:

The test item is an Orion Gas Invensys Transmitter. A block diagram of the test item set-up is shown as Figure 1. Photographs of the test item are shown as Figure 2.

2.1 Power Input - The test item obtained 3.6VDC from 2 lithium thionylchloride internal batteries.

2.2 Grounding - The test item was ungrounded during the tests.

2.3 Peripheral Equipment - The test item does require peripheral equipment.

2.4 Interconnect Cables - The test item does not require interconnect cables.

2.5 Operational Mode - For all tests the test item was placed on an 80cm high non-conductive stand. The test item was energized. The test item was set to transmit continuously at 916.45MHz.

2.6 Test Item Modifications - No modifications were required for compliance to the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Sections 15.249 requirements.

3.0 TEST EQUIPMENT:

3.1 Test Equipment List - A list of the test equipment used can be found on Table I. All equipment was calibrated per the instruction manuals supplied by the manufacturer.

3.2 Calibration Traceability Test equipment is maintained and calibrated on a regular basis. All calibrations are traceable to the National Institute of Standards and Technology (NIST).

3.3 Measurement Uncertainty - All measurements are an estimate of their true value. The measurement uncertainty characterizes, with a specified confidence level, the spread of values which may be possible for a given measurement system.

The measurement uncertainty budgets were based on guidelines in "ISO Guide to the Expression of Uncertainty in Measurements" and NAMAS NIS81 "The Treatment of Uncertainty in EMC Measurements".

The measurement uncertainty for these tests is presented below:

Conducted Emission Measurements		
Combined Standard Uncertainty	1.07	-1.07
Expanded Uncertainty (95% confidence)	2.1	-2.1

Radiated Emission Measurements		
Combined Standard Uncertainty	2.26	-2.18
Expanded Uncertainty (95% confidence)	4.5	-4.4

4.0 REQUIREMENTS, PROCEDURES AND RESULTS:

4.1 Powerline Conducted Emissions

4.1.1 Requirements – Since the test item was powered by internal batteries, no conducted emissions tests are required.

4.2 Duty Cycle Factor Measurements:

4.2.1 Procedures: The duty cycle factor is used to convert peak detected readings to average readings. This factor is computed from the time domain trace of the pulse modulation signal.

With the transmitter set up to transmit for maximum pulse density, the time domain trace is displayed on the spectrum analyzer. This trace is obtained by tuning center frequency to the transmitter frequency and then setting a zero span width with 2 msec/div. The amplitude settings are adjusted so that the on/off transitions clear the 4th division from the bottom of the display. The markers are set at the beginning and end of a word period. If the word period exceeds 100 msec the word period is set to 100 msec.

4.2.2 Results: The plots of the duty cycle are shown on data pages 13 and 14. The test item transmits a 1.79 msec pulse every 4.12 seconds. Since a word is greater than 100 msec long, the duty cycle factor was computed over a 100 msec interval. The duty cycle correction factor was calculated to be -35.1dB ($-35.1\text{dB} = 20 \cdot \log(1.76\text{msec}/100\text{msec})$).

4.3 Radiated Measurements

4.3.1 Requirements - The test item must comply with the requirements of FCC "Code of Federal Regulations Title 47", Part 15, Subpart C, Section 15.205 et seq.

Paragraph 15.249 has the following radiated emission limits:

Fundamental Frequency MHz	Field Intensity uV/m @ 3 meters	Field Strength Harmonics and Spurious @ 3 meters
902 – 928	50,000	500

For radiated emissions below 1GHz, the field strength limits are based on quasi-peak readings. For radiated emissions above 1GHz, the field strength limits are based on average readings. In addition, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20 dB under any condition of modulation.

4.3.2 Procedures - Radiated emissions measurements were performed in a 32ft. x 20ft. x 14ft. high shielded enclosure. The shielded enclosure prevents emissions from other sources, such as radio and TV stations from interfering with the measurements. All powerlines and signal lines entering

the enclosure pass through filters on the enclosure wall. The powerline filters prevent extraneous signals from entering the enclosure on these leads.

A preliminary radiated emissions test was performed to determine the emission characteristics of the test item. For the preliminary test, a broadband measuring antenna was positioned at a 3 meter distance from the test item. The entire frequency range from 30MHz to 10.0GHz was investigated using a peak detector function. The data was then processed by the computer to calculate equivalent field intensity.

The final radiated emission tests were then manually performed over the frequency range of 30MHz to 10.0GHz. A quasi-peak detector was used to measure all radiated emissions between 30MHz and 1000MHz. A tuned dipole antenna was used as the pick-up device for measurements below 1GHz.

A broadband double ridged waveguide antenna was used as the pick-up device for all frequencies above 1GHz. All significant broadband and narrowband signals were measured and recorded. The peak detected levels were converted to average levels using a duty cycle factor which was computed from the pulse train.

To ensure that maximum or worst case, emission levels were measured, the following steps were taken:

- (1) The test item was rotated so that all of its sides were exposed to the receiving antenna.
- (2) Since the measuring antenna is linearly polarized, both horizontal and vertical field components were measured.
- (3) The measuring antenna was raised and lowered from 1 to 4 meters for each antenna polarization to maximize the readings.
- (4) For hand-held or body-worn devices, the test item was rotated through three orthogonal axes to determine which orientation produces the highest emission relative to the limit.

4.3.3 Results - The preliminary plots, with the test item transmitting at 916.45MHz are presented on data pages 15 through 18. The plots are presented for a reference only, and are not used to determine compliance.

The final radiated levels, with the test item transmitting at 916.45MHz are presented on data pages 19 and 20. As can be seen from the data, all emissions measured from the test item were within the specification limits. The emissions level closest to the limit (worst case) occurred at 916.45MHz. The emissions level at this frequency was 1.4dB within the limit. See data pages 19 and 20 for details. Photographs of the test configuration which yielded the highest, or worst case, radiated emission levels

are shown on Figure 3.

4.4 Occupied Bandwidth Measurements

4.4.1 Requirement - In accordance with paragraph 15.249(d), all emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuate by at least 50dB below the level of the fundamental or to the general radiated emissions limits in 15.209, which ever is the lesser attenuation.

4.4.2 Procedures - The test item was placed on an 80cm high non-conductive stand. The unit was set to transmit continuously. With an antenna positioned nearby, occupied bandwidth emissions were displayed on the spectrum analyzer. The resolution bandwidth was set to 100 kHz and span was set to 30 MHz. The frequency spectrum near the fundamental was plotted.

4.3.3 Results - The plot of the emissions near the fundamental frequency, with the test item transmitting at 916.45MHz is presented on data page 21. As can be seen from this data page, the transmitter met the occupied bandwidth requirements.

The 99% bandwidth was measured to be 360 kHz.

5.0 CONCLUSIONS:

It was determined that the Badger Meter, Inc. Orion Gas American Transmitter, Serial No. None Assigned, did fully meet the conducted and radiated emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Sections 15.207 and 15.249 for Intentional Radiators Operating within the 902MHz -928MHz band, when tested per ANSI C63.4-2003.

6.0 CERTIFICATION:

Elite Electronic Engineering Incorporated certifies that the information contained in this report was obtained under conditions which meet or exceed those specified in the test specifications.

The data presented in this test report pertains to the test item at the test date as operated by Badger Meter, Inc. personnel. Any electrical or mechanical modification made to the test item subsequent to the specified test date will serve to invalidate the data and void this certification.

7.0 ENDORSEMENT DISCLAIMER:

This report must not be used to claim product endorsement by NVLAP or any agency of the US Government.



TABLE I: TEST EQUIPMENT LIST

ELITE ELECTRONIC ENG. INC.

Page: 1

Eq ID	Equipment Description	Manufacturer	Model No.	Serial No.	Frequency Range	Cal Date	Cal Inv	Due Date
Equipment Type: ACCESSORIES, MISCELLANEOUS								
XPQ3	HIGH PASS FILTER	K&L MICROWAVE	4IH30-1804/T	4	1.8GHZ-10GHZ		12	
XZG0	ATTENUATOR/SWITCH DRIVER	HEWLETT PACKARD	11713A	3439A02724	---		N/A	
Equipment Type: AMPLIFIERS								
APK0	PRE-AMPLIFIER	HEWLETT PACKARD	8449B	3008A00662	1-26.5GHZ	03/16/07	12	03/16/08
Equipment Type: ANTENNAS								
NDQ0	TUNED DIPOLE ANTENNA	EMCO	3121C-DB4	311	400-1000MHZ	03/06/07	12	03/06/08
NDQ1	TUNED DIPOLE ANTENNA	EMCO	3121C-DB4	313	400-1000MHZ	03/28/07	12	03/28/08
NTA0	BILOG ANTENNA	CHASE EMC LTD.	BILOG CBL611	2057	0.03-2GHZ	08/21/06	12	08/21/07
NWF0	RIDGED WAVE GUIDE	EMCO	3105	2035	1-12.4GHZ	10/09/06	12	10/09/07
Equipment Type: CONTROLLERS								
CDS2	COMPUTER	GATEWAY	MFATXPNT NMZ	0028483108	1.8GHZ		N/A	
CMA0	MULTI-DEVICE CONTROLLER	EMCO	2090	9701-1213	---		N/A	
Equipment Type: PRINTERS AND PLOTTERS								
HRE1	LASER JET 5P	HEWLETT PACKARD	C3150A	USHB061052	---		N/A	
Equipment Type: RECEIVERS								
RAC1	SPECTRUM ANALYZER	HEWLETT PACKARD	85660B	3407A08369	100HZ-22GHZ	02/21/07	12	02/21/08
RACB	RF PRESELECTOR	HEWLETT PACKARD	85685A	3506A01491	20HZ-2GHZ	02/21/07	12	02/21/08
RAF3	QUASISPEAK ADAPTER	HEWLETT PACKARD	85650A	3303A01775	0.01-1000MHZ	02/21/07	12	02/21/08
RBB0	EMI TEST RECEIVER 20HZ TO	ROHDE & SCHWARZ	ESIB40	100250	20 HZ TO 40GHZ	09/29/06	12	09/29/07
Equipment Type: SIGNAL GENERATORS								
GBR6	SIGNAL GENERATOR	HEWLETT PACKARD	8648C	3642U02047	9KHZ-3000MHZ	02/20/07	12	02/20/08

Cal. Interval: Listed in Months I/O: Initial Only N/A: Not Applicable
 Note 1: For the purpose of this test, the equipment was calibrated over the specified frequency range, pulse rate, or modulation prior to the test or monitored by a calibrated instrument.

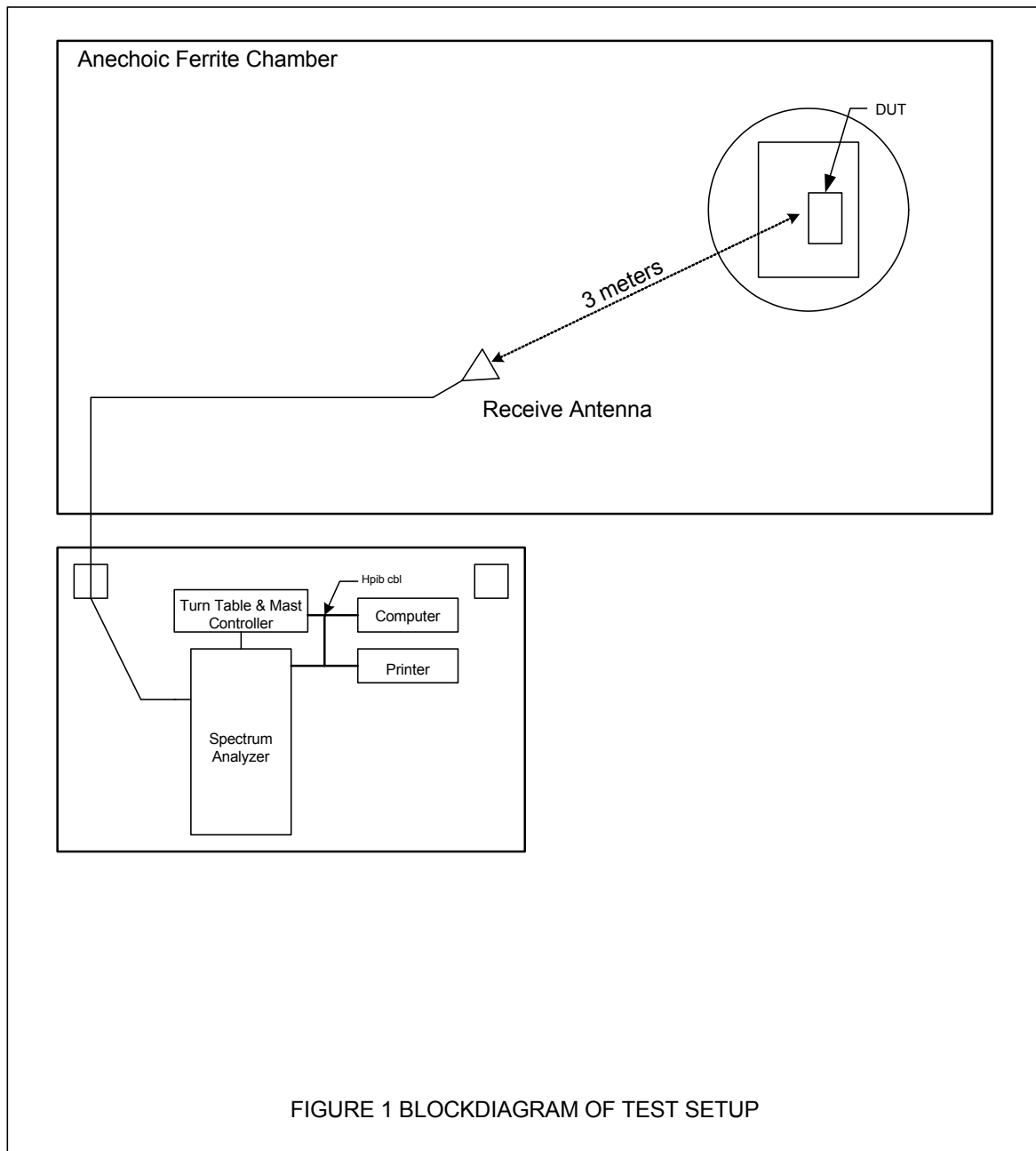
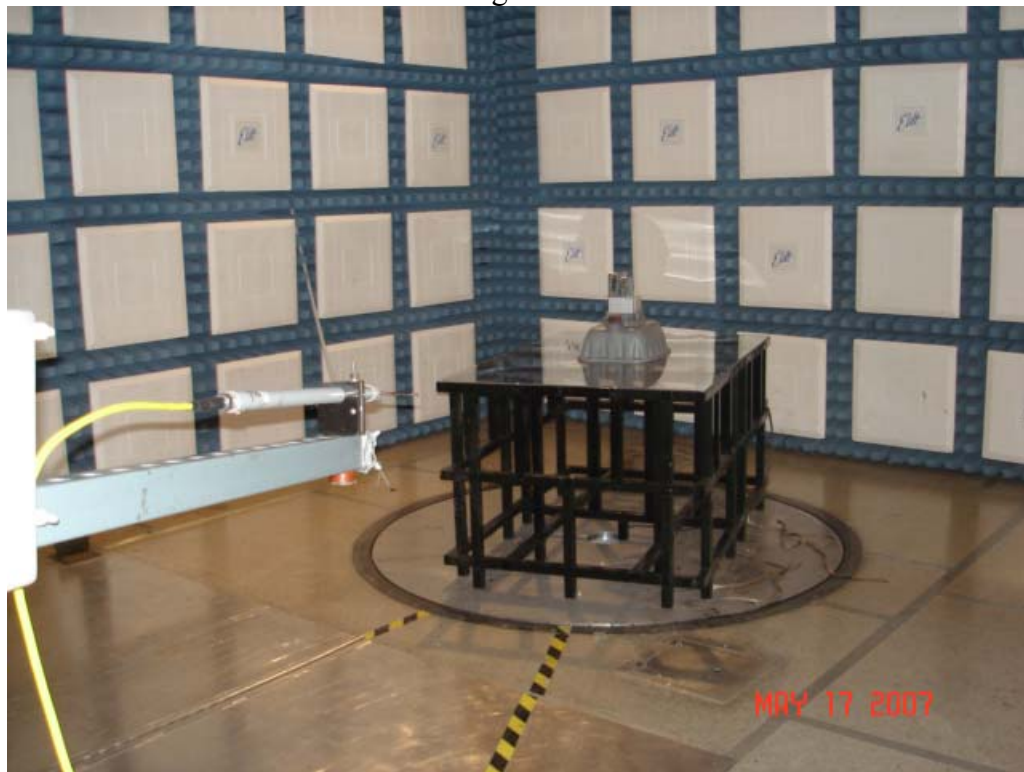


Figure 2



Test Item Set-up.

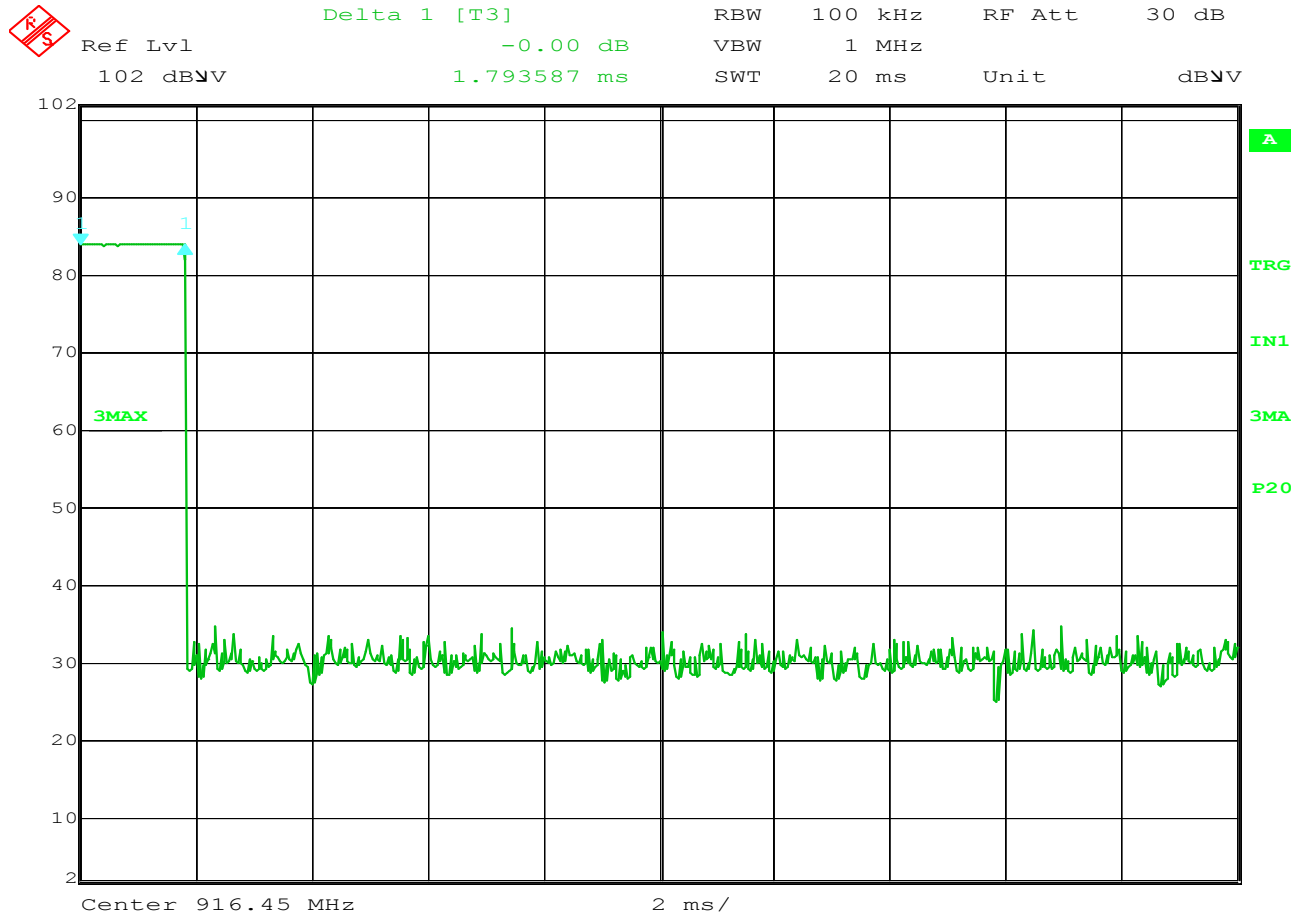
Figure 3



Test Set-up for Radiated Emissions, 916.45MHz Horizontal Polarization



Test Set-up for Radiated Emissions, 916.45MHz Vertical Polarization



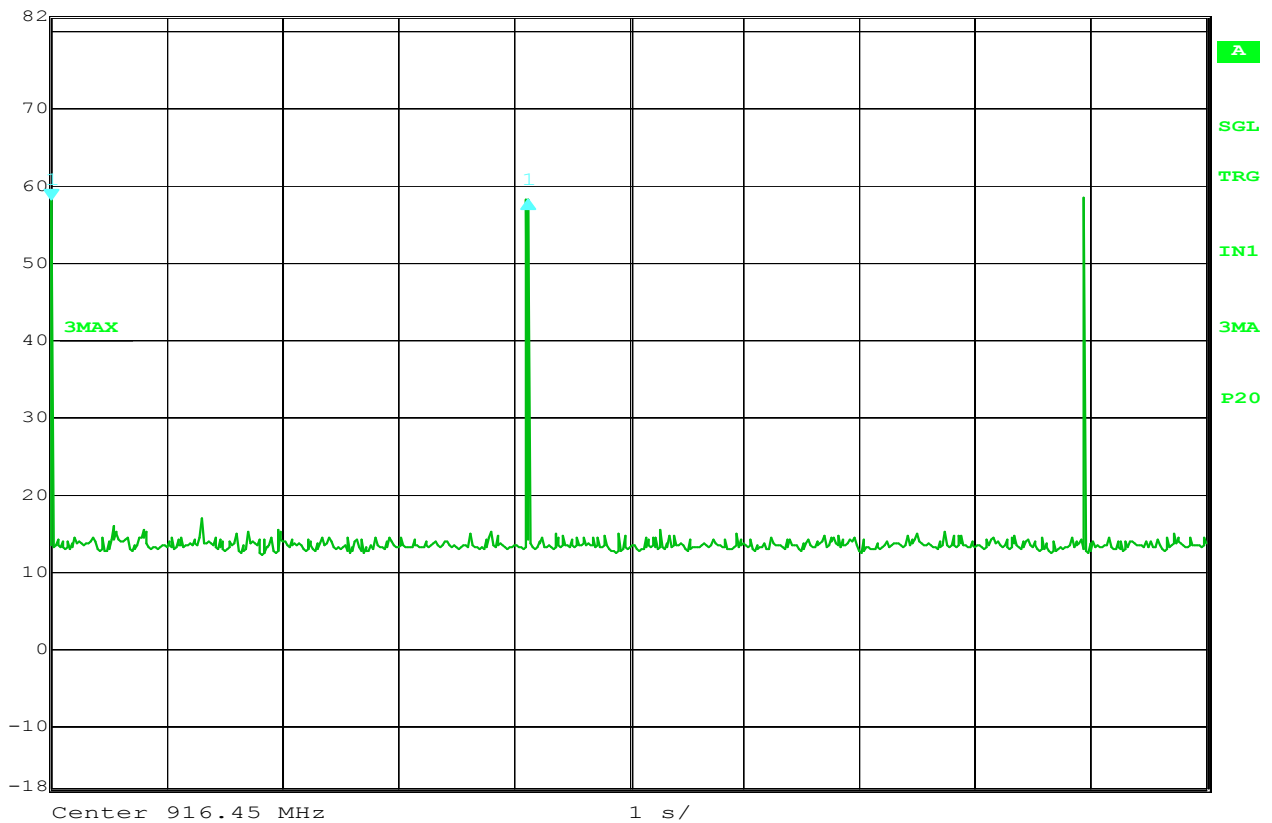
Date: 10.MAY.2007 20:15:09

FCC 15.249 Duty Cycle

MANUFACTURER : Badger Meter
TEST ITEM : Gas Meter
MODEL NUMBER : Orion Gas Invensys
TEST MODE : Tx @ 916.45 MHz
NOTES : 1.79 mS pulse width



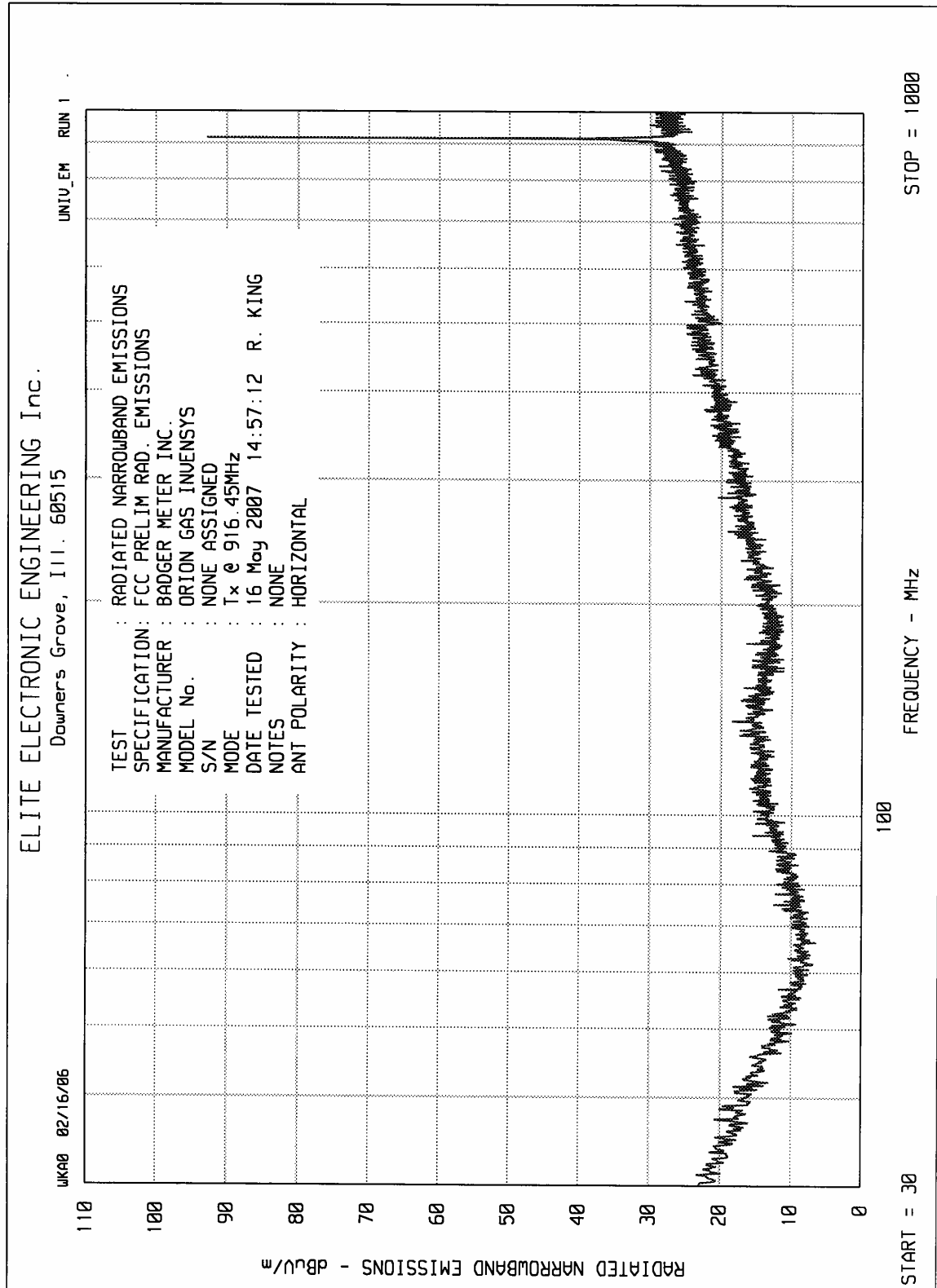
Delta 1 [T3] RBW 100 kHz RF Att 10 dB
Ref Lvl 0.02 dB VBW 1 MHz
82 dB μ V 4.122725 s SWT 10 s Unit dB μ V

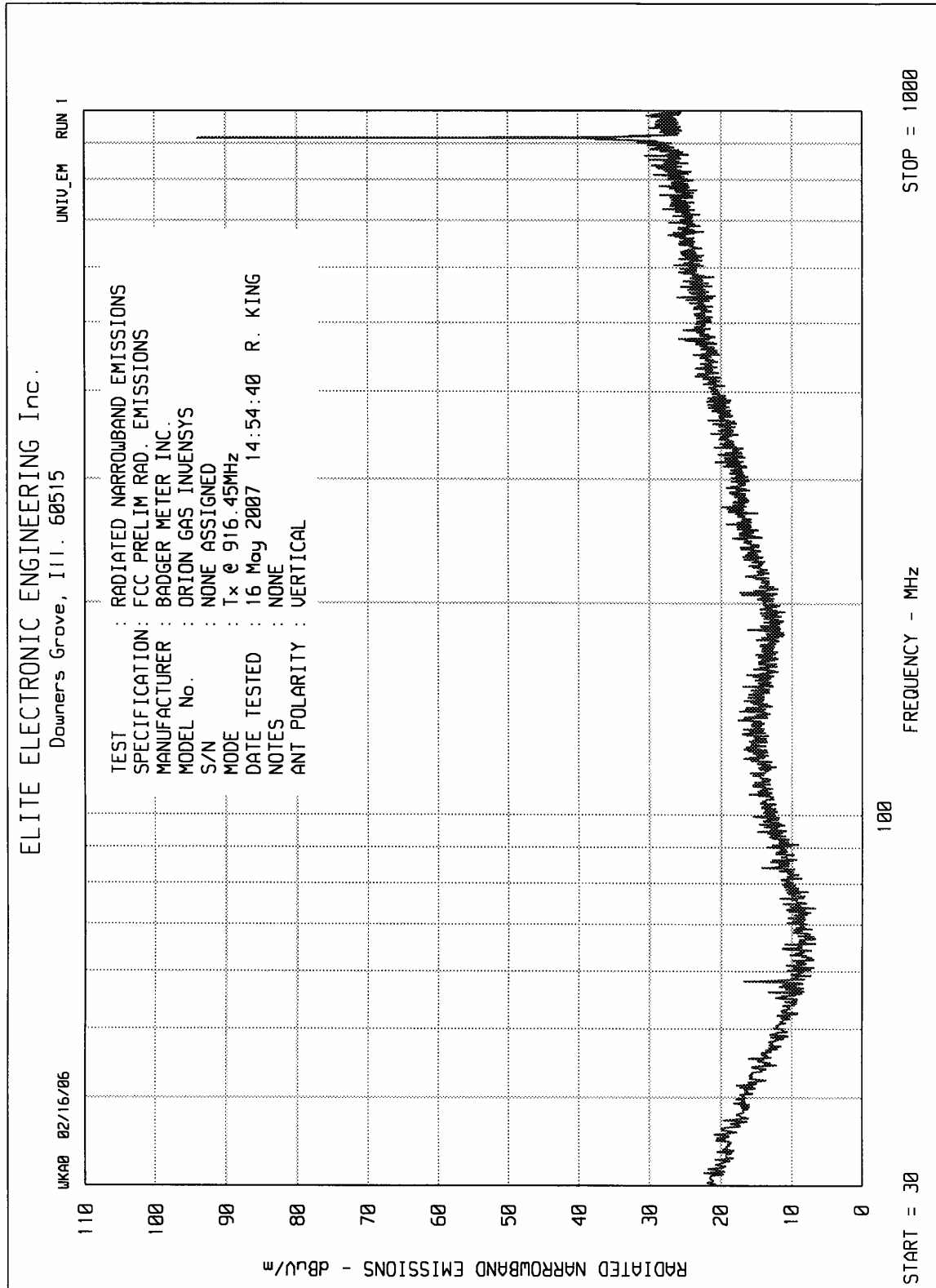


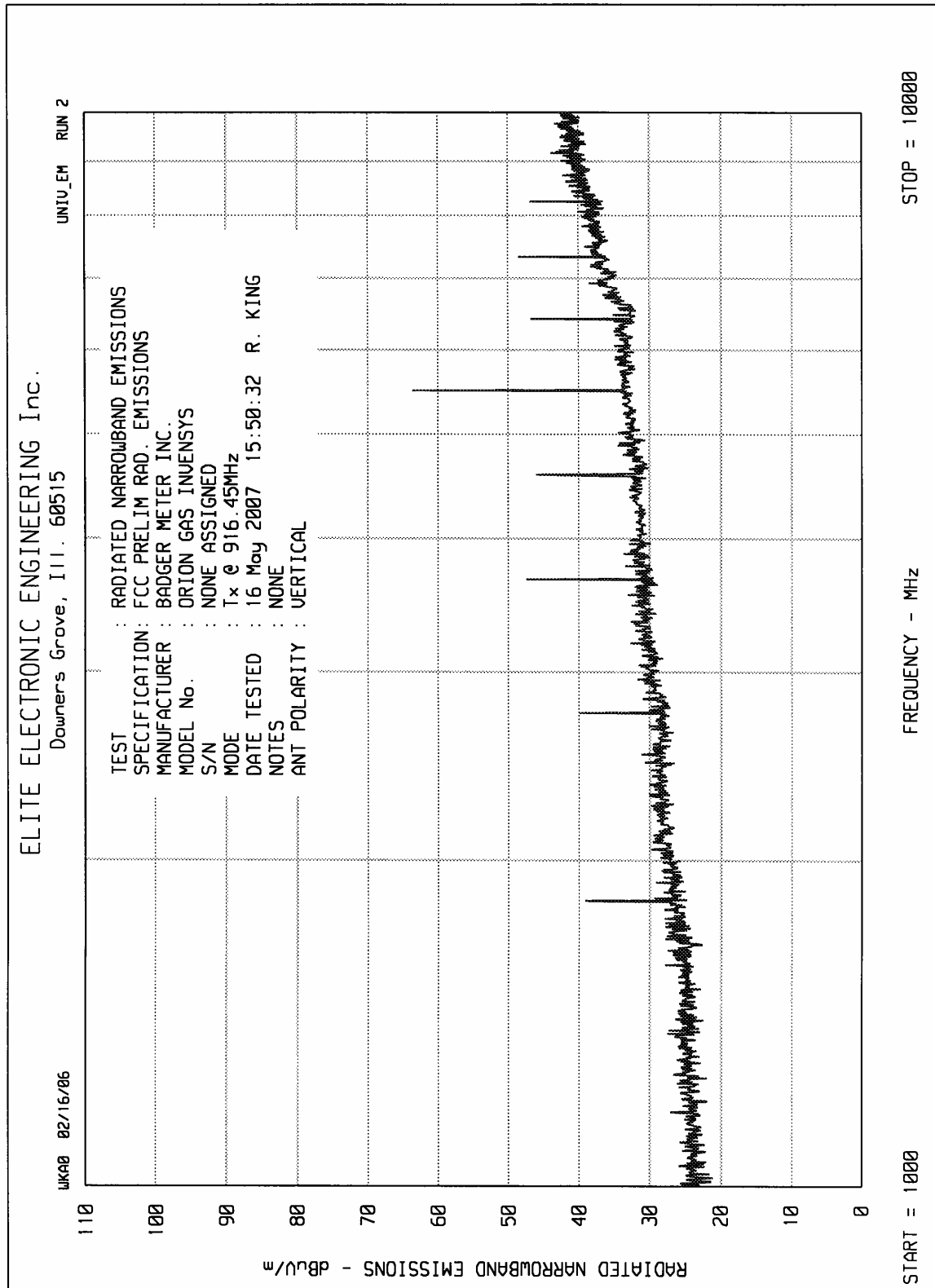
Date: 16.MAY.2007 17:55:04

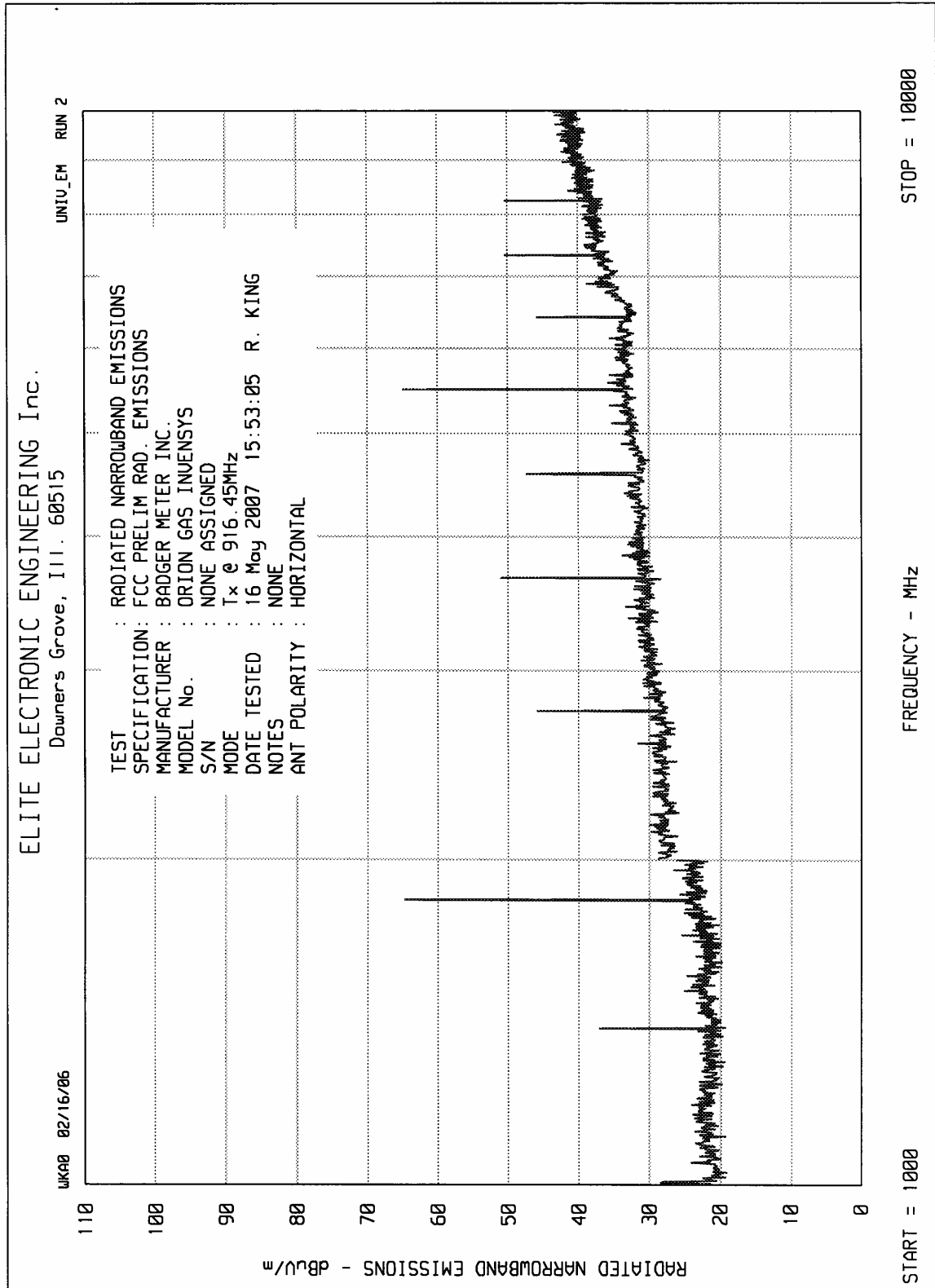
FCC 15.249 Duty Cycle

MANUFACTURER : Badger Meter
TEST ITEM : Gas Meter
MODEL NUMBER : Orion Gas American
TEST MODE : Tx @ 916.45 MHz
NOTES : 4.12 Seconds between pulses











Manufacturer : Badger Meter Inc.
Model No. : Orion Gas American Transmitter
Serial No. : none assigned
Test Specification : FCC Part 15, Subpart C, Section 15.249, Radiated Emissions
Date : May 16, 2007
Mode : Transmit @ 916.45MHz
Test Distance : 3 meters
Notes : Quasi-Peak Detector Used Below 1GHz, Peak Detector Used Above 1GHz.
Peak limit (limit + 20dB) is de facto since duty cycle correction factor is greater than 20 dB.

Frequency MHz	Antenna Polarity	Meter Reading dBuV	Ambient	Cable Loss dB	Antenna Factor dB	Pre Amp Gain dB	Total dBuV/m	Total uV/m	Limit uV/m
916.45	H	57.2		2.0	27.8	0.0	86.9	22179.5	50000
916.45	V	62.9		2.0	27.8	0.0	92.6	42800.8	50000
1832.90	H	54.2		2.9	28.1	-36.3	48.9	279.4	5000
1832.90	V	59.1		2.9	28.1	-36.3	53.8	491.1	5000
2749.35	H	44.2		3.8	31.5	-35.9	43.6	151.0	5000
2749.35	V	41.1	*	3.8	31.5	-35.9	40.5	105.7	5000
3665.80	H	53.4		4.4	32.6	-35.5	54.8	551.7	5000
3665.80	V	51.7		4.4	32.6	-35.5	53.1	453.6	5000
4582.25	H	42.0	*	4.8	33.0	-35.3	44.6	169.5	5000
4582.25	V	42.7	*	4.8	33.0	-35.3	45.3	183.8	5000
5498.70	H	56.0		5.3	35.5	-35.2	61.5	1190.1	5000
5498.70	V	53.9		5.3	35.5	-35.2	59.4	934.5	5000
6415.15	H	40.6	*	5.9	36.2	-35.3	47.4	234.5	5000
6415.15	V	40.5	*	5.9	36.2	-35.3	47.3	231.9	5000
7331.60	H	48.8		6.7	37.8	-35.6	57.7	767.7	5000
7331.60	V	48.8		6.7	37.8	-35.6	57.7	767.7	5000
8248.05	H	43.7	*	7.1	37.7	-35.8	52.7	433.4	5000
8248.05	V	43.8	*	7.1	37.7	-35.8	52.8	438.4	5000
9164.50	H	46.1		7.5	38.1	-36.3	55.4	588.6	5000
9164.50	V	45.1		7.5	38.1	-36.3	54.4	524.6	5000

Total = Meter Reading + Cable Loss + Antenna Factor + Preamp Gain

Checked By: *RICHARD E. KING*

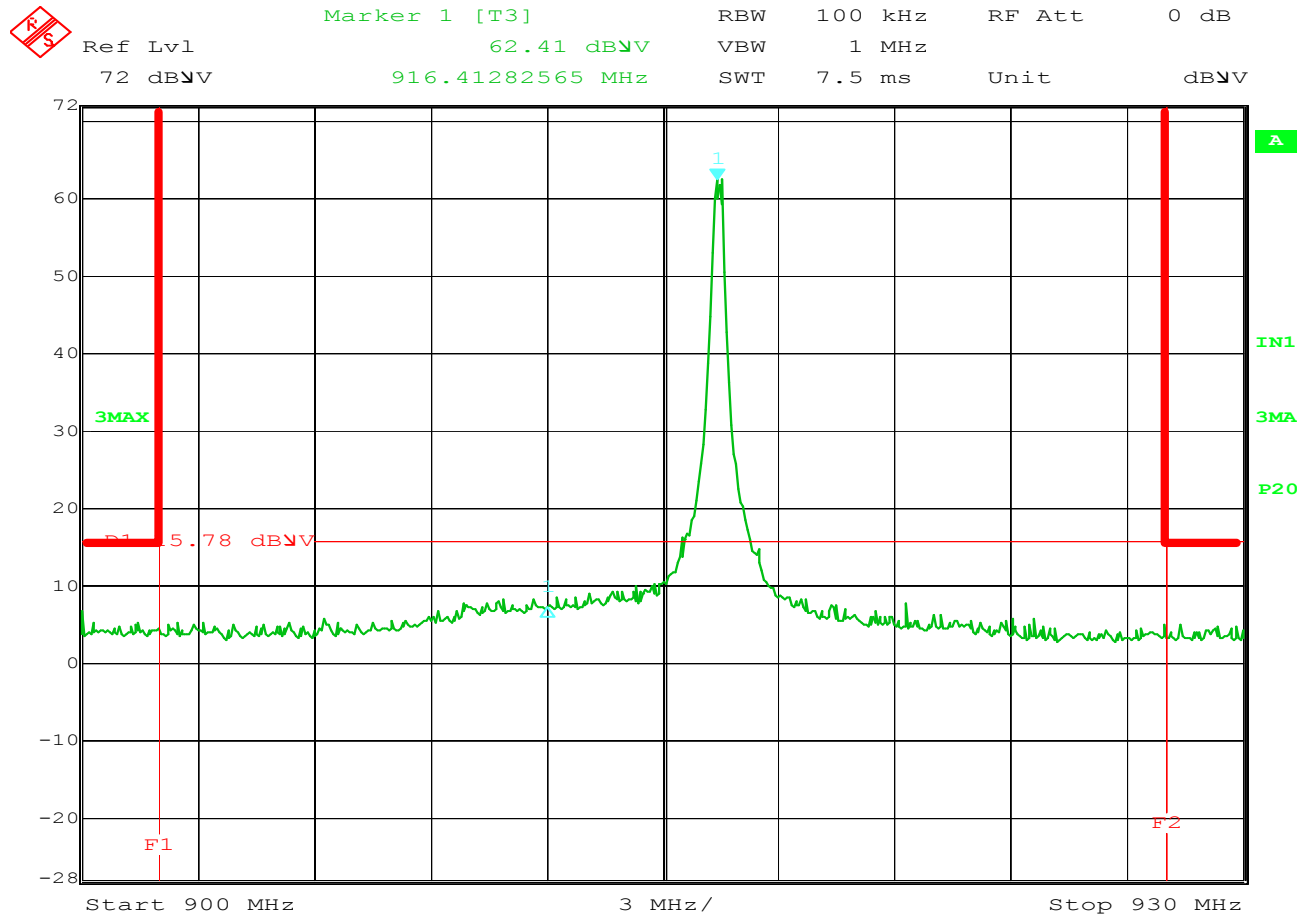


Manufacturer : Badger Meter Inc.
Model No. : Orion Gas American Transmitter
Serial No. : none assigned
Test Specification : FCC Part 15, Subpart C, Section 15.249, Radiated Emissions
Date : May 16, 2007
Mode : Transmit @ 916.45MHz
Test Distance : 3 meters
Notes : Quasi-Peak Detector Used Below 1GHz, Peak Detector Used Above 1GHz
: Peak readings converted to average readings using the duty cycle correction
: factor

Frequency MHz	Antenna Polarity	Meter Reading dBuV	Ambient	Cable Loss dB	Antenna Factor dB	Pre Amp Gain dB	Duty Cycle Factor dB	Total dBuV/m	Total uV/m	Limit uV/m
916.5	H	57.2		2.0	27.8	0.0	0.0	86.9	22179.5	50000
916.5	V	62.9		2.0	27.8	0.0	0.0	92.6	42800.8	50000
1832.9	H	54.2		2.9	28.1	-36.3	-35.1	13.8	4.9	500
1832.9	V	59.1		2.9	28.1	-36.3	-35.1	18.7	8.6	500
2749.4	H	44.2		3.8	31.5	-35.9	-35.1	8.5	2.7	500
2749.4	V	41.1	*	3.8	31.5	-35.9	-35.1	5.4	1.9	500
3665.8	H	53.4		4.4	32.6	-35.5	-35.1	19.7	9.7	500
3665.8	V	51.7		4.4	32.6	-35.5	-35.1	18.0	8.0	500
4582.3	H	42.0	*	4.8	33.0	-35.3	-35.1	9.5	3.0	500
4582.3	V	42.7	*	4.8	33.0	-35.3	-35.1	10.2	3.2	500
5498.7	H	56.0		5.3	35.5	-35.2	-35.1	26.4	20.9	500
5498.7	V	53.9		5.3	35.5	-35.2	-35.1	24.3	16.4	500
6415.2	H	40.6	*	5.9	36.2	-35.3	-35.1	12.3	4.1	500
6415.2	V	40.5	*	5.9	36.2	-35.3	-35.1	12.2	4.1	500
7331.6	H	48.8		6.7	37.8	-35.6	-35.1	22.6	13.5	500
7331.6	V	48.8		6.7	37.8	-35.6	-35.1	22.6	13.5	500
8248.1	H	43.7	*	7.1	37.7	-35.8	-35.1	17.6	7.6	500
8248.1	V	43.8	*	7.1	37.7	-35.8	-35.1	17.7	7.7	500
9164.5	H	46.1		7.5	38.1	-36.3	-35.1	20.3	10.3	500
9164.5	V	45.1		7.5	38.1	-36.3	-35.1	19.3	9.2	500

Total = Meter Reading + Cable Loss + Antenna Factor + Preamp Gain + Duty Cycle Factor

Checked By: *RICHARD E. KING*



Date: 16.MAY.2007 20:56:10

FCC 15.249 Occupied Bandwidth Measurement

MANUFACTURER : Badger Meter
 TEST ITEM : Gas Meter
 MODEL NUMBER : Orion Gas Invensys
 TEST MODE : Tx @ 916.45MHz
 NOTES : 92.6 dBuV/m – 46 dBuV = 46.6 dBc
 62.41 dBuV – 46.6 dBc = 15.81 dBuV General Limit