Curtis-Straus

# Test Report

| | |
|---|---|
| Report No | EC0959-1 Issue 2 |
| Client | Terabeam Corporation<br>1755 Osgood Street<br>North Andover, MA 01845 |
| Phone<br>Fax | (978)-974-0931<br>(978)-974-0969 |
| FRN | 0007-5882-54 |
| Model | 6451e |
| FCC ID | O2700001-30-30 |
| Equipment Type<br>Equipment Code | DXX<br>Low Power Communication Device Transmitter |
| Results | As detailed within this report |
| Prepared by | Evan Gould – Test Engineer |
| Authorized by | Michael Buchholz – EMC Manager |
| Issue Date | 1/8/03 |
| Conditions of issue | This Test Report is issued subject to the conditions stated in 'terms and conditions' section of this report. |

# Table Of Contents

## *Summary*

This report is an application for Certification of a Transmitter operating pursuant to 47 CFR 15.255 (October 2002). The product covered by this report is the Gigalink - Gigabit Ethernet Radio Tranceiver (Model 6451e). This report is designed to demonstrate the compliance of this device with the requirements outlined in 47 CFR Part 15 using the methods outlined in 47 CFR Part 2 with guidance from FCC's "Millimeter Wave Test Procedures".

Two Gigalink units were tested: S/N: 572 was set to the Low frequency (58.6GHz), and S/N: 573 was set to the High frequency (61.9GHz).

## *Test Methodology*

Radiated emissions testing is performed according to the procedures specified in ANSI C63.4 (2000).

| | | |
|---|---|---|
| Frequency range investigated: | 30MHz – 200GHz | |
| Measurement distance: | 30 - 1000MHz | 3 Meters |
| | 1 - 18GHz | 1 Meter* |
| | 18 - ~60GHz | 0.3 Meters* |
| | ~60GHz (fundamental) | 3 Meters |
| | ~60 – 200GHz | 0.3 Meters* |
| Maximization: | •EUT was rotated around vertical axis.<br>•Receiving antenna height and polarization was varied.<br>•Fundamental emission was maximized by hand. (as per FCC's Millimeter Wave Test Procedure) | |

***Note**: The horn antennas were held close to the EUT in searching for spurious emissions. None were found above 1GHz.

## *Statement of Conformity*

The Terabeam Gigalink has been found to conform with the following parts of the 47 CFR as detailed below:

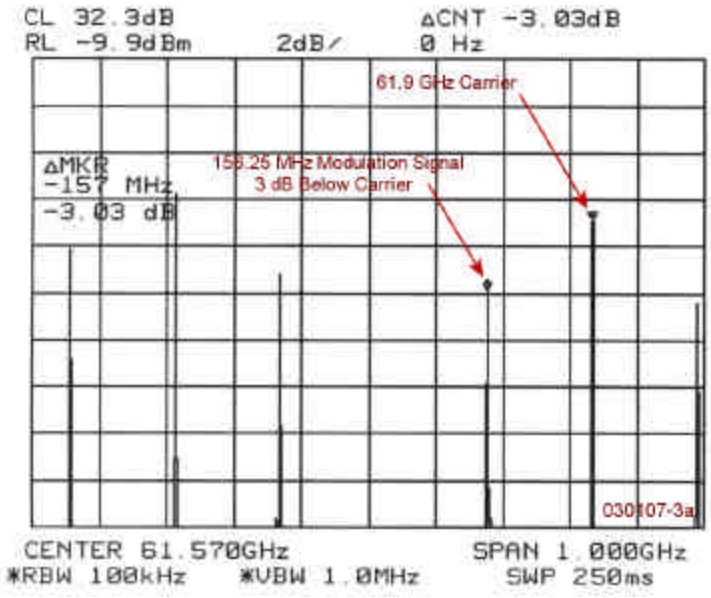
| Part 2 | Part 15 | Comments |
|---|---|---|
| | 15.15(b) | The product contains no user accessible controls that increase transmission power above allowable levels. |
| 2.925 | 15.19 | The label is shown in the label exhibit. |
| | 15.21 | Information to the user is shown in the instruction manual exhibit. |
| | 15.27 | No special accessories are required for compliance. |
| | 15.31(e) | Measurements of the fundamental emissions were taken with the input voltage varied ±15% of the nominal rated supply voltage. |
| | 15.203 | This antenna is not removable. |
| | 15.205<br>15.209<br>15.255(c)(2) | The fundamental is not in a Restricted band and the spurious emissions in the Restricted bands comply with the general emission limits of 15.209. |
| | 15.255(b) | The unit complies with the power density limits of 15.255. |
| | 15.255(c)(3) | No spurious emissions were detected above 40GHz. |
| | 15.255(d) | No emissions appear in the range 57-57.05GHz. |
| | 15.255(f) | The fundamental emission was found to stay within the specified band as temperature was varied from –20° to 50°C, and the supply voltage was varied ±15%. |
| | 15.255(g) | Refer to the attached document “FCC Human Exposure Calculation” |
| | 15.255(h) | The EUT will not be equipped with external phase-locking inputs. |
| | 15.255(i) | EUT is for outdoor use only. |

## *Total Output Power*

### LIMIT

Peak: 500mW [15.255(e)]

The peak output power limit is 500mW for devices which have a 6dB power spectral density bandwidth of 100MHz or more. As is indicated in the plot below, and detailed in the attachment "Theory of Operation", the 6dB bandwidth for typical data rates is in excess of 100MHz.




In the above plot, the lower sideband is shown 3dB down from the carrier and 156.25MHz away.

### MEASUREMENTS

**Peak Output Power** *Curtis-Straus LLC*

| | | | | | |
|---|---|---|---|---|---|
| **Date:** 18-Dec-02 | | **Engineer:** Evan Gould | | **Work Order:** C0959 | |
| **Company:** Terabeam | | **EUT:** Gigalink | | **Fundamental Frequency:** 58/62GHz | |
| **Test Site:** "T" | | **Sensor Adaptor:** MA4002B | | **TC Mount:** MP716A | |
| **Antenna:** V-band 25dB Std Gain | | **Filter/Attenuator:** N/A | | **Meter:** ML4803A | |
| **Measurement Distance:** 3m | | | | | |
| **Notes:** Operating CW; Unmodulated<br>This product supports operation on only two channels: Low and High | | | | | |

| Transmit Band (low/high) | Transmit Frequency (MHz) | Power Reading (dBm) | Voltage (dBµV) | Antenna Factor (dB/m) | Field Strength (dBµV/m) | Peak Power (W) | Peak Power Limit (W) | Result (Pass/Fail) |
|---|---|---|---|---|---|---|---|---|
| Low | 58618 | -14.7 | 92.3 | 40.6 | 132.9 | 0.0582 | 0.5 | Pass |
| High | 61894 | -15 | 92 | 41.1 | 133.1 | 0.061 | 0.5 | Pass |

# *Power Density*

## LIMITS

Average: 9µW/cm$^2$ @ 3m [15.255(b)(1)]
Peak: 18µW/cm$^2$ @ 3m [15.255(b)(1)]
**Note:** If Peak measurements meet Average limits, then calculated Average values are not required.

## MEASUREMENTS

### Power Density Measurements — Curtis-Straus LLC

**Date:** 18-Dec-02 **Engineer:** Evan Gould **Work Order:** C0959
**Company:** Terabeam **EUT:** Gigalink **Fundamental Frequency:** 58/62GHz
**Test Site:** "T" **Sensor Adaptor:** MA4002B **TC Mount:** MP716A
**Antenna:** V-band 25dB Std Gain **Filter/Attenuator:** N/A **Meter:** ML4803A
**Measurement Distance:** 3m
**Notes:** Operating CW; Unmodulated
This product supports operation on only two channels: Low and High

| Transmit Band (low/high) | Transmit Frequency (MHz) | Power Reading (dBm) | Voltage (dBµV) | Antenna Factor (dB/m) | Field Strength (dBµV/m) | Peak EIRP (W) | Peak Pd (uW/cm^2) | Ave Pd Limit (uW/cm^2) | Peak Pd Limit (uW/cm^2) | Result (Pass/Fail) |
|---|---|---|---|---|---|---|---|---|---|---|
| Low | 58618 | -14.7 | 92.3 | 40.6 | 132.9 | 5.82 | 5.15 | 9 | 18 | Pass |
| High | 61894 | -15 | 92 | 41.1 | 133.1 | 6.1 | 5.36 | 9 | 18 | Pass |

### Band Edges — Curtis-Straus LLC

**Date:** 17-Dec-02 **Engineer:** Evan Gould **Work Order:** C0959
**Company:** Terabeam **EUT:** Gigalink **Fundamental Frequency:** 58/62GHz
**Test Site:** "T" **Cable:** RG142LL **Pre-amp:** Black
**Antenna:** V-band 25dB Std Gain **Mixer:** 11970V **Analyzer:** Orange
**Measurement Distance:** 3m
**Notes:** Operating CW; Unmodulated
This product supports operation on only two channels: Low and High

| Band | Frequency (GHz) | Reading | Voltage (dBµV) | Antenna Factor (dB/m) | Field Strength (dBµV/m) | Peak EIRP (W) | Peak Pd (uW/cm^2) | Ave Pd Limit (uW/cm^2) | Limit (pW/cm^2) | Result (Pass/Fail) |
|---|---|---|---|---|---|---|---|---|---|---|
| Low Band Edge | 57 | no emissions detected at 1cm from EUT | | | | | | | 90 | Pass |
| Coordination Band | 57-57.05 | no emissions detected at 1cm from EUT | | | | | | | 90 | Pass |
| High Band Edge | 64 | no emissions detected at 1cm from EUT | | | | | | | 90 | Pass |



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# *Sample Power Calculations*

Sample Calculations (as per FCC millimeter wave test procedure)

***Peak Power Output of EUT***

**$P = (E * d)^2 / 30G$**

Power Measured at 3m = -15dBm

For 50 Ohm system, dBm => dBuV = +107dB

V [dBuV] = -15dBm + 107dB = 92dBuV

E [V/m] = 92dBuV + 41.1dB/m (ant fact) = 133.1 dBuV/m = 4.5V/m

$P = (4.5V/m * 3\ m)^2 / (30 * 100$ (numeric gain of EUT ant) )
P = 0.061W = **61mW**

For EIRP G = 1

Therefore,

$P_{EIRP} = 6.1\ W = P_t$

***Peak Power Density***

**$P_d = P_t / (4* Pi * d^2) = E^2 / 377$**

$P_d = 6.1\ W / (4 * Pi * 3\ m^2) = 0.054\ W/m^2$ = **5.4 uW/cm$^2$**



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# *Spurious Emissions*

## REQUIREMENTS

*"Radiated emissions below 40 GHz shall not exceed the general limits in Sec. 15.209."* [15.255(c)(2)]
*"Between 40 GHz and 200 GHz, the level of these emissions shall not exceed 90pW/cm$^2$ at a distance of 3 meters."* [15.255(c)(3)]

## LIMITS

| Frequency (MHz) | Limit (µV/m) | Measurement Distance (meters) |
|---|---|---|
| 0.009-0.49 | 2400/F(kHz) | 300 |
| 0.49-1.705 | 24000/F(kHz) | 30 |
| 1.705-30 | 30 | 30 |
| 30-88 | 100 | 3 |
| 88-216 | 150 | 3 |
| 216-960 | 200 | 3 |
| Above 960 | 500 | 3 |

[47 CFR 15.209]

## MEASUREMENTS

**Spurious Emissions Table** — *Curtis-Straus LLC*

**Date:** 16-Dec-02 **Company:** Terabeam **Table:** 3
**Engineer:** Evan Gould **EUT Desc:** Gigalink Model 6451e (high) **Work Order:** C0959

**Frequency Range:** 30-1000MHz **Measurement Distance:** 3 m

**Notes:** **EUT Max Freq:** 60GHz

| Antenna Polarization (H / V) | Frequency (MHz) | Reading (dBµV) | Preamp Factor (dB) | Antenna Factor (dB/m) | Cable Factor (dB) | Adjusted Reading (dBµV/m) | 47 CFR 15.209 Limit (dBµV/m) | Margin (dB) | Result (Pass/Fail) |
|---|---|---|---|---|---|---|---|---|---|
| H | 180.0 | 44.9 | 21.7 | 9.8 | 1.4 | 34.4 | 43.5 | -9.1 | Pass |
| H | 200.0 | 42.7 | 21.6 | 10.5 | 1.5 | 33.1 | 43.5 | -10.4 | Pass |
| H | 220.0 | 51.4 | 21.6 | 11.6 | 1.6 | 43.0 | 46.0 | -3.0 | Pass |
| H | 240.0 | 45.4 | 21.7 | 12.6 | 1.7 | 38.0 | 46.0 | -8.0 | Pass |
| H | 260.0 | 40.4 | 21.7 | 13.3 | 1.8 | 33.8 | 46.0 | -12.2 | Pass |
| H | 300.0 | 45.8 | 21.8 | 14.0 | 2.0 | 40.0 | 46.0 | -6.0 | Pass |
| H | 400.0 | 35.3 | 21.8 | 16.6 | 2.4 | 32.5 | 46.0 | -13.5 | Pass |

***Table Result:*** Pass by -3.0 dB ***Worst Freq:*** 220.0 MHz

**Test Site:** "T" **Pre-Amp:** Black **Cable:** 65 ft RG8A/U **Analyzer:** Blue **Antenna:** Grn-Wht

**Note:** No spurious emissions were detected above 1GHz.

## *Frequency Vs. Temperature/Voltage Variations*

### REQUIREMENT

*"Fundamental emissions must be contained within the frequency bands specified in this section...over the temperature range –20 to +50 degrees celsius with an input voltage variation of 85% to 115% of rated input voltage..."* [15.255(f)]

### MEASUREMENTS

**Frequency Stability**

| | | | |
|---|---|---|---|
| **Date:** | 12/19/02 | **Company:** | Terabeam |
| **Engineer:** | Evan Gould | **EUT:** | Model 6451e |
| **Test Site:** | Environmental Chamber | | |
| **Analyzer:** | Orange | **RBW:** | 10kHz |
| **Antenna:** | 50-75GHz horn | **VBW:** | 10kHz |

**Nominal (25°C @ 48V):** 61894.26MHz

| Temperature (°C) | Center Frequency (MHz) | Drift (kHz) | Pass/Fail |
|---|---|---|---|
| 50 | 61894.99 | +730 | Pass |
| 40 | 61895.18 | +920 | Pass |
| 30 | 61894.89 | +630 | Pass |
| 25 (55.2V) | 61894.27 | +10 | Pass |
| 25 (41.8V) | 61894.28 | +20 | Pass |
| 20 | 61894.56 | +300 | Pass |
| 10 | 61894.58 | +320 | Pass |
| 0 | 61894.52 | +260 | Pass |
| -10 | 61894.39 | +130 | Pass |
| -20 | 61894.25 | -10 | Pass |

The frequency was allowed to stabilize at each temperature and voltage.

### RESULTS

The frequency stability of the EUT is within ±1MHz over the entire temperature and voltage range. This ensures that the fundamental emission will stay within the specified frequency band.

## *Amplitude Vs. Voltage Variation*

### REQUIREMENT

*"For intentional radiators, measurements of the variation of the...radiated signal level of the fundamental frequency component of the emission...shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage."* [15.31(e)]

### MEASUREMENTS

**Voltage Variation**

**Date:** 18-Dec-02 **Work Order:** C0959
**Company:** Terabeam **Engineer:** Evan Gould
**EUT:** Gigalink Model 6451e
**Antenna:** 50-75GHz horn
**Analyzer:** Orange

| Supply Voltage | Frequency (GHz) | Reading (dBµV) |
|---|---|---|
| (85%) 41.8V | 61.89 | 59.1 |
| (nominal) 48V | 61.89 | 59.9 |
| (115%) 55.2V | 61.89 | 59.7 |

# *Test Equipment Used*

REV. 12/13/02

| ***SPECTRUM ANALYZERS*** | RANGE | MN | MFR | SN | ASSET | CALIBRATION DUE |
|---|---|---|---|---|---|---|
| BLUE | 9kHz-1.8GHz | 8591E | HP | 3223A00227 | 00070 | 04-SEP-2003 |
| ORANGE | 9kHz-26.5GHz | E4407B | HP | US39440975 | 00394 | 07-JUN-2003 |

| ***OPEN AREA TEST SITE (OATS)*** | FCC CODE | IC CODE | VCCI CODE | CALIBRATION DUE |
|---|---|---|---|---|
| SITE T | 93448 | IC 2762-T | R-905 | 04-FEB-2004 |

| ***ANTENNAS*** | RANGE | MN | MFR | SN | ASSET | CALIBRATION DUE |
|---|---|---|---|---|---|---|
| GREEN-WHITE BILOG | 30MHz-2GHz | CBL6112B | CHASE | 2574 | 00319 | 11-JUL-2004 |
| ORANGE HORN | 1-18GHz | 3115 | EMCO | 0004-6123 | 00390 | 27-MAY-2003 |
| WHITE HORN | 18-26.5GHz | 3160-09 | EMCO | 9610-1068 | 00758 | 26-JUN-2003 |

| ***MIXERS/DIPLEXERS*** | RANGE | MN | MFR | SN | ASSET | CALIBRATION DUE |
|---|---|---|---|---|---|---|
| MIXER / HORN | 26.5-40 GHz | 11970A/28-442-6 | HP/ATM | 2332A00900/A046903-01 | 00369 | EACH USE |
| MIXER / HORN | 90-140 GHz | MO8HW/A | OML | F21206-1 | 00811 | EACH USE |
| MIXER / HORN | 140-220 GHz | MO5HW/A | OML | G21206-1 | 00812 | EACH USE |
| MIXER / HORN | 40-60GHz | 1197OU/0689A | HP/MICOLAB FXR | 3003AD1397/BLANK | | EACH USE |
| MIXER / HORN | 50-75GHz | 11970V/15-7025 | HP/AEROWAVE | | | EACH USE |
| MIXER / HORN | 75-90GHz | 11970W/861W/387 | HP/AI MMW DIV | 2521A00483/327 | | EACH USE |
| DIPLEXER | | DPL.26 | OML | N/A | 00813 | EACH USE |

| ***PREAMPS*** | RANGE | MN | MFR | SN | ASSET | CALIBRATION DUE |
|---|---|---|---|---|---|---|
| BLACK | 0.01-2000MHz | ZFL-1000-LN | C-S | N/A | 00799 | 22-MAR-2003 |
| ORANGE-BLACK | 1-20GHz | SMC-12A | C-S | 690639 | 00761 | 27-AUG-2003 |
| YELLOW | 18-26.5GHz | AFS4-18002650-60-8P-4 | C-S | 467559 | 00758 | 27-AUG-2003 |

| ***CHAMBERS AND STRIPLINE*** | MN | MFR | SN | ASSET | CALIBRATION DUE |
|---|---|---|---|---|---|
| ENVIRONMENTAL (SAFETY) | SGTH-31S | B-M-A INC. | 2245 | 00321 | 07-JUN-2003 |

| ***POWER METERS*** | MN | MFR | SN | CALIBRATION DUE |
|---|---|---|---|---|
| POWER METER | ML4803A | ANRITSU | 6100011821 | JUNE-2003 |
| TC MOUNT | MP716A | ANRITSU | 6100032396 | JUNE-2003 |
| SENSOR ADAPTER | MA4002B | ANRITSU | 6100032347 | |

Unless otherwise noted the calibration interval is one year. All equipment is calibrated using standards traceable to NIST or other nationally recognized calibration standard.

# *Terms And Conditions*

**Paragraph 1.** SERVICES. LABORATORY will:

1.1 Use the degree of care and skill ordinarily exercised by and consistent with the standards of the profession.
1.2 Perform all technical services in substantial accordance with the generally accepted laboratory principles and practices.
1.3 Retain all pertinent records relating to the services performed for a period of three (3) years following submission of the report describing such services, during which period the records will be made available to CLIENT upon reasonable request.

**Paragraph 2**. CLIENT'S RESPONSIBILITIES. CLIENT or his authorized representative will:

2.1 Provide LABORATORY with all plans, schematics, specifications, addenda, change orders, drawings and other information for the proper performance of technical services.
2.2 Designate a person to act as CLIENT's representative with respect to LABORATORY's services to be performed on behalf of the CLIENT; such person or firm to have complete authority to transmit instructions, receive information and data, interpret and define CLIENT's policies and decisions with respect to the LABORATORY's work on behalf of the CLIENT and to order, at CLIENT's expense, such technical services as may be required.
2.3 Designate a person who is authorized to receive copies of LABORATORY's reports.
2.4 Undertake the following:
(a) Secure and deliver to LABORATORY, without cost to LABORATORY, preliminary representative samples of the equipment proposed to require technical services, together with any relevant data.
(b) Furnish such labor and equipment needed by LABORATORY to handle samples at the LABORATORY and to facilitate the specified technical services.

**Paragraph 3.** GENERAL CONDITIONS:

3.1 LABORATORY, by the performance of services covered hereunder, does not in any way assume any of those duties or responsibilities customarily vested in the CLIENT, its employees, or any other party, agency or authority.
3.2 LABORATORY shall not be responsible for acts of omissions of any other party or parties involved in the design, manufacture or maintenance of the equipment or the failure of any employee, contractor or subcontractor to undertake any aspect of equipment's design, manufacture or maintenance.
3.3 LABORATORY is not authorized to revoke, alter, release, enlarge or release any requirement of the equipment's design, manufacture or maintenance unless specifically authorized by CLIENT or his authorized representative.
3.4 THE ONLY WARRANTY MADE BY LABORATORY IN CONNECTION WITH ITS SERVICE PERFORMED HEREUNDER IS THAT IT WILL USE THAT DEGREE OF CARE AND SKILL AS SET FORTH IN PARAGRAPH 1 ABOVE. NO OTHER WARRANTY, EXPRESS OR IMPLIED, IS MADE OR INTENDED FOR SERVICES PROVIDED HEREUNDER.
3.5 Where the LABORATORY indicates that additional testing is advisable to obtain more valid or useful data, and where such testing has not been authorized, CLIENT agrees to view such test reports as inconclusive and preliminary.
3.6 The LABORATORY will supply technical service and prepare a report based solely on the sample submitted to the LABORATORY by the CLIENT. The CLIENT understands that application of the data to other devices is highly speculative and should be applied with extreme caution.
3.7 The LABORATORY agrees to exercise ordinary care in receiving, preserving and shipping (F.O.B. Littleton, MA) any sample to be tested, but assumes no responsibility for damages, either direct or consequential, which arise from loss, damage or destruction of the samples due to the act of examination, modification or testing, or technical services or circumstances beyond LABORATORY's control.
3.8 The LABORATORY will hold samples for thirty (30) days after tests are completed, or until the CLIENT's outstanding debts to the LABORATORY are satisfied, whichever is later.
3.9 The CLIENT recognizes that generally accepted error variances apply and agrees to consider such error variances in its use of test data.
3.10 It is agreed between LABORATORY and CLIENT that no distribution of any tests, reports or analysis other than that described below shall be made to any third party without the prior written consent of both parties unless such distribution is mandated by operation of law. It is agreed that tests, reports, or analysis results may be disclosed to third party auditors of the laboratory at the laboratory facility in the course of accreditation maintenance audits. No reference to reports or technical services of the LABORATORY shall be made in any advertising or promotional literature without the express written permission of the LABORATORY.
3.11 The CLIENT acknowledges that all employees of LABORATORY operate under employment contracts with the LABORATORY and CLIENT agrees not to solicit employment of such employees or to solicit information related to other clients from said employees.
3.12 In recognition of the relative risks and benefits of the project to both CLIENT and LABORATORY, the risks have been allocated such that the CLIENT agrees, to the fullest extent permitted by law, to limit the liability of the LABORATORY to the CLIENT for any and all claims, losses, costs, damages of any nature whatsoever or claims expenses from any cause or causes, including attorneys' fees and costs and expert witness fees and costs, so that the total aggregate liability of the LABORATORY to the CLIENT shall not exceed $100,000, or the LABORATORY'S total fee for services rendered on this project, whichever is greater. It is intended that this limitation apply to any and all liability or cause of action however alleged or arising, unless otherwise prohibited by law.

**Paragraph 4.** INSURANCE:

4.1 LABORATORY shall secure and maintain throughout the full period of the services provided to the CLIENT adequate insurance to protect it from claims under applicable Workmen's Compensation Acts and also shall maintain one million dollars of general liability coverage to cover claims for bodily injury, death or property damage as may arise from the performance of its services.
4.2 The CLIENT hereby warrants that it has sufficient insurance to protect its employees adequately under applicable Workmen's Compensation Acts and for bodily injury, death, or property damage.
4.3 No insurance of whatever kind or type, which may be carried by either party is to be considered as in any way limiting any other party's responsibility for damages resulting from their operations or for furnishing work and materials.

**Paragraph 5.** PAYMENT:

5.1 CLIENT shall pay to LABORATORY such fees for services as previously agreed, orally or in writing, within 30 days of presentment of a bill for such services performed. In the event CLIENT ordered, orally or in writing, services but such services were not assigned a rate for billing, such services shall be billed at the LABORATORY's reasonable and customary rate.
5.2 CLIENT shall be responsible for all shipping, customs and other expenses related to services provided by LABORATORY to the CLIENT, and shall fully insure any test sample or other equipment provided to LABORATORY by the CLIENT.
5.3 Amounts overdue from CLIENT to LABORATORY shall be charged interest at a rate of 1½% per month.

**Paragraph 6.** ISO/IEC GUIDE 17025 ADDITIONS:

6.1 CLIENT agrees that this test report will not be reproduced except in full, without written approval from the LABORATORY.
6.2 CLIENT agrees that this test report shall not be used to claim product endorsement by A2LA or ANSI or any agency of the U.S. Government.
6.3 CLIENT agrees that test results presented herein relate only to the sample tested by the LABORATORY.