Appendix A- Sensus FlexNet 510M and 520M technical data

FlexNet™
SmartPoint™ M2

Description

Model 510M – Non Pit Set

The FlexNet SmartPoint M2 is a radio transceiver that provides water utilities inbound and outbound access to water measurement and ancillary device diagnostics via radio signal. The SmartPoint 510M is designed for non-submersible/non-pit installations. With its migratable, two-way communication ability, the M-Series SmartPoint functions as a walk-by/drive-by endpoint, fixed base endpoint, or combination of the two. This flexibility increases utility data collection capabilities and streamlines operations.

Features

TOUCHCOUPLER DESIGN

The SmartPoint M2 utilizes TouchCoupler, the patented Sensus inductive coupling communication platform, to interface with the encoded meter. With TouchCoupler, the SmartPoint M2 can connect to the meter using existing two wire AMR installations instead of requiring utilities to access the meter to install a new three-wire system. This results in a fast, efficient and reliable connection at minimal cost.

OPERATION

The FlexNet SmartPoint M2 receives input from the meter register and remotely sends data to a walk-by/drive-by or fixed base collection device. The SmartPoint M2 easily migrates from walk-by/drive-by to fixed base by simply installing a Base Station.

In walk-by/drive-by mode, the SmartPoint M2 collects data and awaits an activation signal from the Vehicle Gateway Basestation (VGB) or Hand-Held Device (HHD). Upon signal receipt, it transmits readings, the meter identification number and any alarms.

As a fixed-base endpoint, the SmartPoint M2 interacts with one or more strategically placed Base Station located in the utility service area. Top of the hour readings and other diagnostics are instantly forwarded to the Regional Network Interface (RNI) at time of transmission. The FlexNet system provides unmatched reliability by using expansive tower receiver coverage of metering end points, data/message redundancy, fail over back up provisions and operation on FCC primary use (unshared) RF spectrum.

POWERFUL TRANSMISSION, FLEXIBLE PLATFORM

The SmartPoint M2 offers several advantages that control both deployment and lifetime operation costs. It's powerful, industry leading two watt transmitter broadcasts over large distances and minimizes collection infrastructure. And once the SmartPoint M2 is installed, its migratable, two-way system platform can be updated without requiring personnel to visit each meter and/or inconveniencing customers.

ADDITIONAL SMARTPOINT M2 FEATURES

The SmartPoint M2 obtains hourly readings and can monitor continuous flow over a programmable period of time, alerting the utility to leak conditions. In addition, the SmartPoint M2 stores up to 840 consumption intervals (35 days of hourly consumption), providing the utility with the ability to extract detailed usage profiles for consumer information and dispute resolution. The SmartPoint M2 also incorporates a two-port design, allowing the utility to connect multiple registers and ancillary devices (such as acoustic monitoring) to a single SmartPoint. This results in a compact installation that saves time, space and money – without reducing system performance.

SPECIFICATIONS

SERVICE	Wall mounted (non-pit/non-submersible) installation interfacing the utility meter to the Sensus FlexNet system.
PHYSICAL CHARACTERISTICS	Width: 5 9/16" x Height: 5 1/2" x Depth: 3"
WEIGHT	1.13 lbs/18.08 oz
COLOR	Tan
FREQUENCY RANGE	900 – 950 MHz, 8000 channels X 6.25 kHz steps
MODULATION	Proprietary Narrow Band
MEMORY	Non-Volatile
POWER	Lithium Thionyl Chloride batteries
APPROVALS	**US:** FCC CFR 47: Part 90, Part 24D, Part 101C, Part 15 Licensed operation **Canada:** Industry Canada (IC) RSS-134, RSS-119, RSS-210
OPERATING TEMPERATURE	- 22° F to +185° F - 30° C to + 85° C
OPTIONS	Dual or single port availability; TouchCoupler only, wired only
INSTALLATION ENVIRONMENT	The 510M is designed for side-of-home applications where it is not subject to submergence.
COMPATIBILITY	**TouchCoupler and Wired Version:** Sensus Encoded Registers Badger ADE water registers and MasterMeter AccuLinx **Wired Version Only:** Elster Encoder (Sensus protocol) and Neptune ARB VI (ProRead). Hersey Translator
WARRANTY	20 years – Based on six transmissions per day. Refer to Sensus G-500 for warranty.

8601 Six Forks Road, Suite 700
Raleigh, NC 27615
1-800-638-3748
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FlexNet SmartPoint

Installation Instructions for Model 510M - Non Pit Unit

IMPORTANT

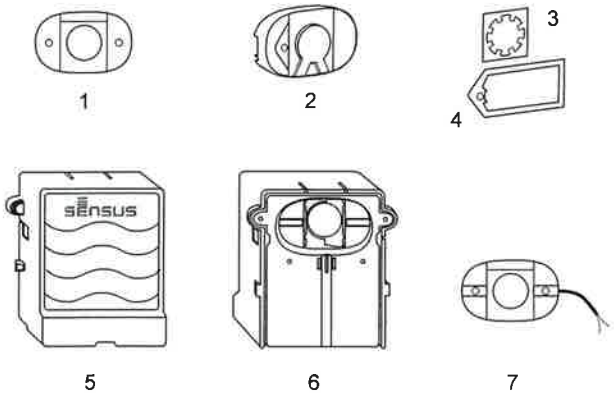
The following information contains installation instructions for the Sensus Model 510M SmartPoint.

Note: This installation sheet is only for installation of the Sensus Model 510M. For instructions on installing other AMI devices, please request and refer to the individual installation instruction for those devices.

GENERAL INFORMATION

The Model 510M SmartPoint is designed for non pit, non submersible applications and is available for both a single port and dual port operation. The Model 510M should be mounted outdoors where it is not subject to submergence and to maximize performance in fixed base applications. The Model 510M is not intended for outdoor meter pits or vaults. The unit can be installed with either a TouchCoupler connection or wire connection. Please refer to the Aquasense water-compatibility document, WAMDS-40000, for compatibility and AMI-495 for programming instructions.

DEFINITIONS



1. Sensus TouchPad
2. TouchPad Cover Assembly Complete
3. TouchPad Fastener
4. TouchPad Cover Locking Clip
5. Model 510 Radio (Front View)
6. Model 510 Radio TouchCoupler Enabled Assembly (Rear View with TouchPad Cover)
7. TouchPad Extension Assembly

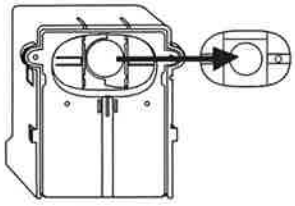
RECOMMENDED TOOLS AND MATERIALS

- Wire stripping tool
- Screwdriver - Small standard head for terminal connections
- Power drill and bit (1/4")
- 8 x 1" sheet metal screws
- TouchPad extension cable
- Seal wire (optional)

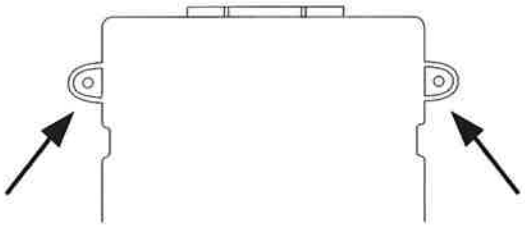
TOUCHCOUPLER - INSTALLATION INSTRUCTIONS

SINGLE PORT – TOUCHCOUPLER INSTALLATION

1. Perform a TouchRead on TouchPad(s) to insure TouchRead to the encoder works.
2. Taking a completely assembled Model 510M SmartPoint and TouchCoupler Spacer with TouchPad Cover, align the TouchPad Cover over an installed Sensus TouchPad.
3. Place the unit over the TouchPad and press firmly until secure.



4. For additional support (optional), remove the front cover and pre-drill the holes designed to fasten the unit to the wall. (Holes indicated in diagram below.) Secure the unit to the wall with screws. Once secured, replace front cover of unit.

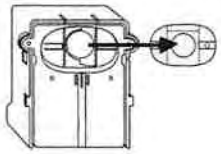


5. Once the unit is closed and secured, begin the activation process. (Refer to AMI-495 for programming instructions).
6. For security (optional), a seal wire may be used on the bottom of the unit for tamper evidence.
7. Coil excess wire and then secure to the body of the meter or service line in a presentable manner.

SINGLE PORT – REMOTE TOUCHCOUPLER INSTALLATION

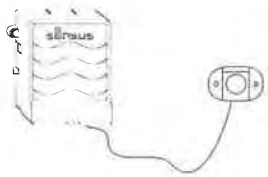
Remote TouchCoupler installations are an option when a direct TouchCoupler (Sensus only) connection cannot be completed due to physical limitations Before proceeding with the installation of a remote TouchCoupler application, be sure to find a location free from obstacles that would interfere with the connection from the TouchPad Cover to the transmitter.

1 Perform a TouchRead on TouchPad to insure TouchRead to the encoder works
2 Remove current TouchPad
3 Replace current TouchPad with TouchPad extension assembly



4 Connect current TouchPad to wires extending from the TouchPad extension assembly
5 Mount current TouchPad in a location free from obstruction for SmartPoint to be mounted over it
6 Perform TouchRead to verify integrity of wiring
7 Taking a completely assembled 510M TouchCoupler SmartPoint, place over the Sesus TouchPad and press firmly to secure
8 For additional support (optional), remove the front cover and predrill the holes designated to fasten to the wall (Holes shown in diagram below) Secure the unit to the wall with screws and snap on the front cover.

9 Once all the connections are complete, snap on the front cover and for tamper prevention place a seal wire on the bottom of the unit
10 Once the unit is secured, begin the activation process (Refer to AMI-495 for programming instructions)

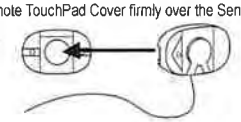


DUAL PORT – TOUCHCOUPLER INSTALLATION

1 Perform a TouchRead on TouchPad(s) to insure TouchRead to the encoder works
2 For new installations of dual ports, find a suitable location for an installation where two TouchPads can be installed that will be free from interference The optimum distance should be less than 12"; otherwise wires may require field splicing (For existing TouchPad connections when a second port is added, select a location for the second TouchPad installation that will be free from interference)
3 Determine which of the two TouchPads will use the TouchPad Cover only and which will use the TouchCoupler unit as the primary connection

Note: If TouchPad is not already installed, install TouchPad allowing enough room for the TouchPad Cover to be securely placed over the installed TouchPad

4 Place the remote TouchPad Cover firmly over the Sensus TouchPad until secured

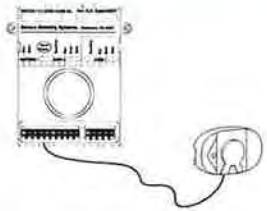


5 Place the SmartPoint over the second TouchPad location and press firmly until the unit is secured to the TouchPad. For additional support (optional), pre-drill the holes designed to fasten the unit to the wall Secure the unit to the wall with screws

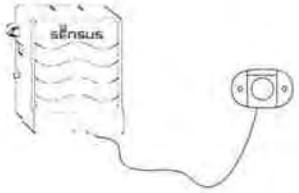
Note: If not already installed, install the second TouchPad allowing enough room to connect the transmitter to the TouchPad

6 Strip wires prior to inserting into terminal strip
7. Connect the wires from the TouchPad Cover to the coordinating port terminals in the SmartPoint labeled TouchCoupled

Note: Red and black wires are non-polarized



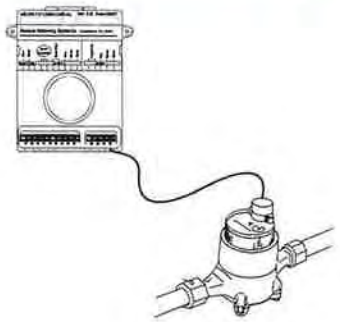
8 Once all the connections are complete, snap on the front cover and for tamper prevention place seal wire on bottom of unit
9 Once the unit is closed and secured, begin the activation process (Refer to AMI-495 for programming instructions)



SINGLE AND DUAL PORT – WIRED INSTALLATION

1 Place the SmartPoint at the location for installation With the front cover removed, mark the location to pre-drill the holes designed to fasten the unit to the wall (Holes shown in figure below)

2 Remove the SmartPoint from the wall and use a 1/4" drill bit to pre-drill the fastener holes
3 Place the unit on the wall and align the pre-drilled holes with the fastener locations
4 Secure the unit to the wall with screws
5 Strip wires prior to inserting into terminal strip
6. Connect the wires from the register to the coordinating port terminals in the SmartPoint



Note: See the encoder wiring reference chart for proper color-coded wiring connections. Badger, Neptune and Elster registers must be wired directly to a 510M port and not through a MultiRead module connected to the 510M

Encoder wiring reference

SmartPoint Terminal	Sensus Register	Badger ADE	Neptune ProRead	Elster Encoder
Black	Black	Black	Green	Black
Red	Red	Red	Black	Green
Green	Green	Green	Red	Red

7. Once all terminal connections are complete, snap on the front cover and for tamper prevention place seal wire on bottom of unit
8 Once the unit is closed and secured, begin the activation process (Refer to AMI-495 for programming instructions.)

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FCC COMPLIANCE

This equipment has been tested and found to comply with the limitations for a Class B digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with these instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio and television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving device
- Increase the separation between the equipment and receiver
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected
- Consult the dealer or an experienced radio/TC technician

Warning!

No party shall make any modifications or changes to the Sensus Model 510M transmitter (the equipment) without express written consent of Sensus. Doing so could result in the equipment becoming non-compliant with the requirements of the Federal Communications Commission Rules CFR47 part 15 and could void the user's authority to operate the equipment.

For more information, visit us at sensus.com

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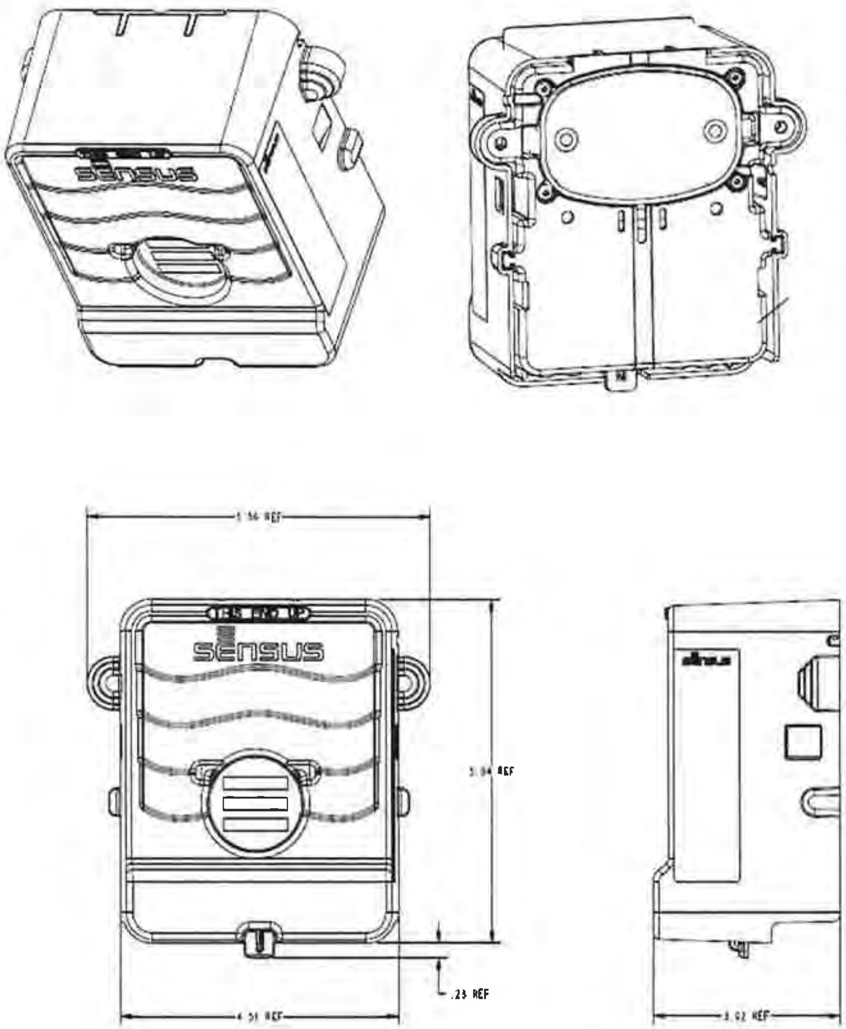

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Model 510

Assembly Complete

3D PART FILE: U90039

U-90039-D

Description

Model 520M – Pit Set

The FlexNet SmartPoint M2 is a radio transceiver that provides water utilities inbound and outbound access to water measurement and ancillary device diagnostics via radio signal. The SmartPoint 520M is designed for submersible, pit-set environments. With its migratable, two-way communication ability, the M-Series SmartPoint functions as a walk-by/drive-by endpoint, fixed base endpoint, or combination of the two. This flexibility increases utility data collection capabilities and streamlines operations.

Features

TOUCHCOUPLER DESIGN

The SmartPoint M2 utilizes TouchCoupler, the patented Sensus inductive coupling communication platform to interface with the encoded meter. With TouchCoupler, the SmartPoint M2 can connect to the meter using existing two wire AMR installations instead of requiring utilities to access the meter to install a new three-wire connection. This results in a fast, efficient and reliable connection at minimal cost.

OPERATION

The FlexNet SmartPoint M2 receives input from the meter register and remotely sends data to a walk-by/ drive-by or fixed base collection device. The SmartPoint M2 easily migrates from walk-by/drive-by to fixed base by simply installing a Base Station.

In walk-by/drive-by mode, the SmartPoint M2 collects data and awaits an activation signal from the Vehicle Gateway Basestation (VGB) or Hand-Held Device (HHD). Upon signal receipt, it transmits readings, the meter identification number and any alarms.

As a fixed-base endpoint, the SmartPoint M2 interacts with one or more strategically placed Base Stations located in the utility service area. Top of the hour readings and other diagnostics are instantly forwarded to the Regional Network Interface (RNI) at time of transmission. The FlexNet system provides unmatched reliability by using expansive tower receiver coverage of metering end points, data/message redundancy, fail over back up provisions and operation on FCC primaryuse (unshared) RF spectrum.

POWERFUL TRANSMISSION, FLEXIBLE PLATFORM

The SmartPoint M2 offers several advantages that control both deployment and lifetime operation costs. It's powerful, industry leading two watt transmitter broadcasts over large distances and minimizes collection infrastructure. And once the SmartPoint M2 is installed, its migratable, two-way system platform can be updated without requiring personnel to visit each meter and/or inconveniencing customers.

ADDITIONAL SMARTPOINT M2 FEATURES

The SmartPoint M2 obtains hourly readings and can monitor continuous flow over a programmable period of time, alerting the utility to leak conditions. In addition, the SmartPoint M2 stores up to 840 consumption intervals (35 days of hourly consumption), providing the utility with the ability to extract detailed usage profiles for consumer information and dispute resolution. The SmartPoint M2 also incorporates a two-port design, allowing the utility to connect multiple registers and ancillary devices (such as acoustic monitoring) to a single SmartPoint. This results in a compact installation that saves time, space and money - without reducing system performance.

SPECIFICATIONS

SERVICE	Pit set installation interfacing the utility meter to the Sensus FlexNet system. Unit requires 1.75" diameter hole in pit lid; fits pit lid thicknesses up to 1.75"
PHYSICAL CHARACTERISTICS	Width: 4.43" x Height: 5.09" x Depth: 3"
WEIGHT	1.0 lbs/16.0 oz
COLOR	Black
FREQUENCY RANGE	900 – 950 MHz, 8000 channels X 6.25 kHz steps
MODULATION	Proprietary Narrow Band
MEMORY	Non-Volatile
POWER	Lithium Thionyl Chloride batteries
APPROVALS	**US:** FCC CFR 47: Part 90, Part 24D, Part 101C, Part 15 Licensed operation **Canada:** Industry Canada (IC) RSS-134, RSS-119, RSS-210
OPERATING TEMPERATURE	- 22° F to +185° F - 30° C to + 85° C
OPTIONS	Dual or single port availability; TouchCoupler only, wired only, Nicor connection
INSTALLATION ENVIRONMENT	100% condensing, water submersible
COMPATIBILITY	**TouchCoupler and Wired Version:** Sensus Encoded Registers Badger ADE water registers and MasterMeter AccuLinx **Wired Version Only:** Elster Encoder (Sensus protocol) and Neptune ARB VI (ProRead). Hersey Translator
WARRANTY	20 years – Based on six transmissions per day. Refer to Sensus G-500 for warranty.

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Raleigh, NC 27615
1-800-638-3748
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FlexNet SmartPoint

Installation Instructions for Model 520M - Pit Set Unit

IMPORTANT

The following information contains installation instructions for the Sensus Model 520M SmartPoint.

Note: This installation sheet is only for installation of the Sensus Model 520M. For instructions on installing other AMR/AMI devices, please request and refer to the individual installation instruction for those devices.

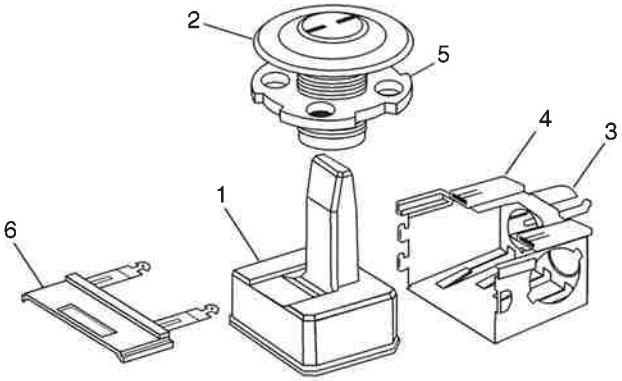
GENERAL INFORMATION

The Model 520M is designed for pit set environments and is available for both a single port and dual port operation. The Model 520M is designed to maximize performance in a fixed base environment. In order to achieve maximum performance, the Model 520M must be installed through the pit lid. The unit can be installed with either a TouchCoupler connection or wire connection.

TYPE	COMPATIBILITY
TouchCoupler and Wired Version	Sensus ECRII and ICE water registers
Wired Version Only	Badger ADE, Elster Encoder (Sensus protocol), Neptune ARB VI (ProRead)

Please refer to AMI-495 for programming instructions.

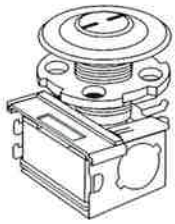
DEFINITIONS



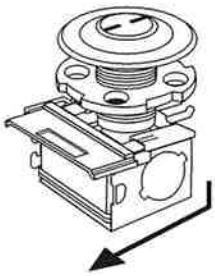
1. HDPE Radio
2. Pit Lid Housing
3. TouchCoupler TR/PL Adaptor (TouchCoupler enabled units only)
4. Boot
5. Pit Locking Nut
6. Boot Locking Clip

TOUCHCOUPLER - INSTALLATION INSTRUCTIONS

STEP 1. DISASSEMBLE 520 UNIT

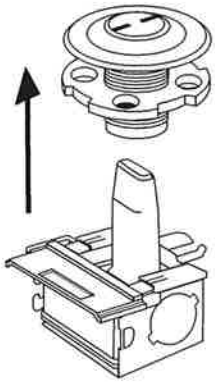


1. Disassemble the Model 520 SmartPoint unit to begin the installation procedure. Unlock the radio device by pressing down on the two tabs on the Boot Locking Clip facing the port side connections. Once the tabs are depressed, slide the Boot Locking Clip out until the Pit Lid Housing is released from the Boot.



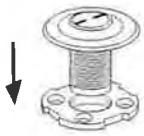
Boot Locking Clip - Push Down and Out

2. Slide the Pit Lid Housing off of the Boot and Boot Locking Clip assembly.



Pit Lid Housing slides off of HDPE Radio

3 Remove the Pit Locking Nut from the underneath of the Pit Lid Housing by turning the nut counter clockwise



Pit Locking Nut Screws off of Pit Lid Housing

STEP 2 INSERTING THE PIT LID HOUSING

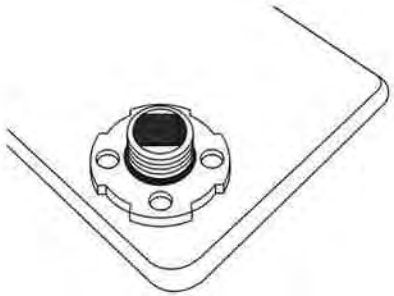
Place the Pit Lid Housing thru the pre-drilled hole in the top of the Pit Lid

Pit Lid Housing Inserted Through Pit Lid (Top View)

Pit Lid Housing inserted Through Pit Lid (Bottom View)

STEP 3 SECURING THE PIT LID HOUSING

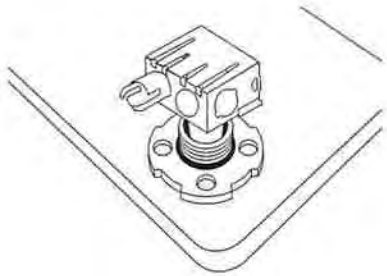
Place the Pit Locking Nut at the bottom of the Pit Lid Housing aligning the Pit Locking Nut with the shaft of the Pit Lid Housing Tighten the Pit Locking Nut by turning clockwise until the unit is firmly secured against the bottom of the Pit Lid (see picture below)



Securing the Pit Lid Housing to the Pit Lid

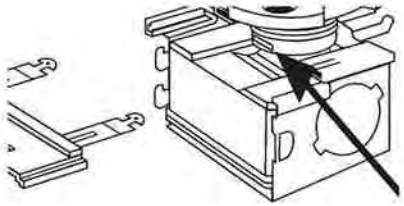
STEP 4 INSERTING THE RADIO DEVICE

1. Insert the HDPE Radio with Boot attached into the cavity of the Pit Lid Housing (see picture below)



Insertion of the HDPE Radio and Boot into the Pit Lid Housing

2 Slide the Boot Locking Clip into the Boot while assuring alignment between the slot located on the bottom of the Pit Lid Housing and the Boot Locking Clip is achieved



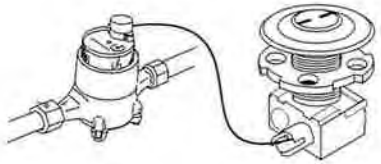
3. To secure the unit, slide the Boot Locking Clip into the Boot until the Boot Locking Clip rests in the slot located on the bottom of the Pit Lid Housing and the Boot Locking Clip is engaged and locked

TOUCHCOUPLER INSTALLATION INSTRUCTIONS

1 Perform a TouchRead on TR/PL sensor to insure TouchRead to the encoder works

2 Grasp the TR/PL sensor and place into Port 1 of the TouchCoupler TR/PL Adaptor until secured (see picture below)

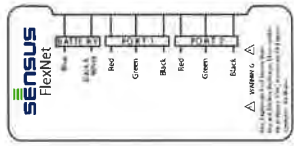
3 Repeat process into Port 2 if needed



SINGLE AND DUAL PORT WIRED INSTALLATION

Recommended Tools and Materials:

- 3M Scotchlok®UY-2 butt connector "gel-caps"
- 3M Scotchlock®E-9Y stepped jaw crimping tool with wire cutter
- Wire stripping tool
- Three conductor solid wire (Sensus specification)



1 Strip approximately 2" off the outer jacket of the encoder wire cable The wire colors for each unit should be green, red and black

2 The red, green and black wires must be gel-capped individually Insert the corresponding wires, as indicated in the encoder wiring reference below, into the gel-cap with the color button of the gel-cap facing away (This provides a better view of wire positions inside the clear plastic gel-cap enabling the installer to see the wires are completely and properly inserted)

Encoder wiring reference

SmartPoint Terminal	Sensus Register	Badger ADE	Neptune ProRead	Elster Encoder
Black	Black	Black	Green	Black
Red	Red	Red	Black	Green
Green	Green	Green	Red	Red

3. Using gel-cap pliers, squeeze the gel-cap. This will splice the two wires and release the waterproof gel to seal the connection The splice can be checked by pulling gently on the gel-cap while holding the wires to be sure they are tight and secure Repeat this process for the remaining two wire connections

Note: If any of the wire connections are not being used they should be capped at the end with a gel-cap This is to prevent wire damage due to water intrusion via wicking through the exposed wire ends

Badger, Neptune and Elster registers must be wired directly to a 520M port and not through a MultiRead module connected to the 520M.

4 Coil and secure excess cable to the body of the meter or service line in a presentable manner

FCC COMPLIANCE

This equipment has been tested and found to comply with the limitations for a Class B digital device, pursuant to Part 15 of the FCC rules These limits are designed to provide reasonable protection against harmful interference in a residential installation This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with these instructions, may cause harmful interference to radio communications However, there is no guarantee that interference will not occur in a particular installation If this equipment does cause harmful interference to radio and television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving device
- Increase the separation between the equipment and receiver
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected
- Consult the dealer or an experienced radio/TC technician

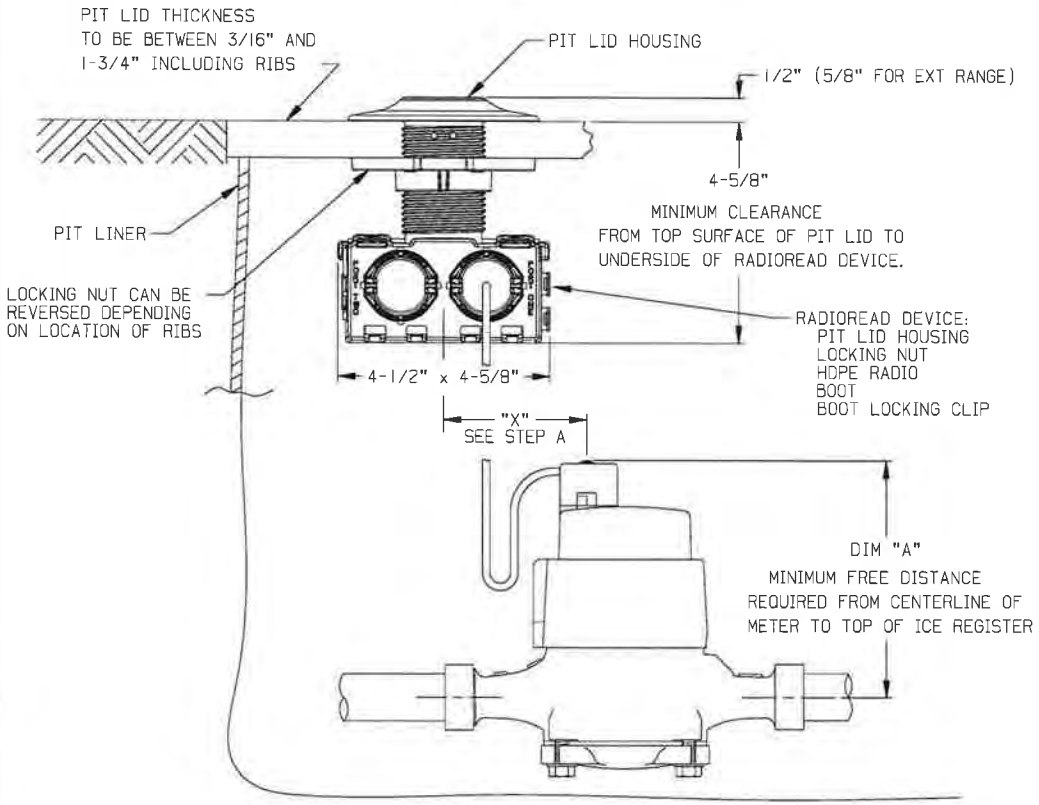
Warning!

No party shall make any modifications or changes to the Sensus Model 520M transmitter (the equipment) without express written consent of Sensus Doing so could result in the equipment becoming non-compliant with the requirements of the Federal Communications Commission Rules CFR47 part 15 and could void the user's authority to operate the equipment.

sensus

For more information, visit us at sensus.com

8601 Six Forks Road, Suite 700
Raleigh, NC 27615
1-800-638-3748



SIDE VIEW OF TYPICAL METER
PIT INSTALLATION

SR METERS

METER SIZE	DIM"A"
5/8"	4-1/2
3/4"	5
1"	5-1/2
1-1/2"	6
2"	7

SR II METERS

METER SIZE	DIM"A"
5/8"	5-1/2
3/4"	5-1/2
1"	6-1/2

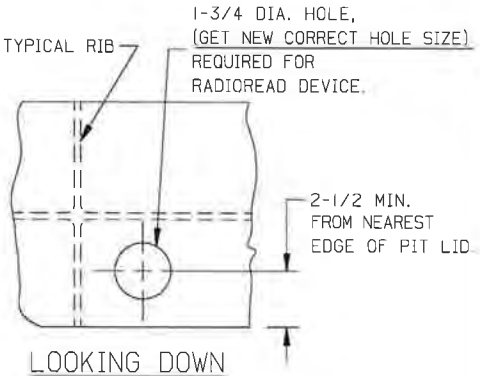
INSTALLATION INSTRUCTIONS

STEP A : LOCATING AND DRILLING HOLE - (IF NOT CURRENTLY IN PIT LID):

DRILL 1-3/4"DIA (GET NEW CORRECT HOLE SIZE) HOLE THROUGH PIT LID - CLEARING UNDERSIDE RIBBING.

1. WHEN LOCATING THE HOLE, DETERMINE THE REQUIRED VERTICAL CLEARANCE TO AVOID INTERFERENCE OF THE RADIOREAD DEVICE AND THE METER (DIM X).
2. THE HOLE CENTER MUST BE 2-1/2" MINIMUM FROM THE OUTSIDE EDGE OF THE PIT LID FOR CLEARANCE OF THE DEVICE'S TOP FLANGE. SEE THE NOTE ON RIB CLEARANCE.

NOTE: THE CENTER OF THE HOLE MUST BE AT LEAST 1" FROM UNDERNEATH RIBS UNLESS THE RIB SPACING ALLOWS THE NUT TO TIGHTEN AGAINST THE OPEN SIDE OF MORE THAN ONE RIB.



LOOKING DOWN
ON TYPICAL METER PIT LID

STEP B : INSTALLING RADIOREAD DEVICE:

1. INSERT PIT LID HOUSING THROUGH PIT LID HOLE (FROM ABOVE) AND TIGHTEN SECURELY IN PLACE WITH PLASTIC LOCKING NUT.
2. INSERT THE HDPE RADIO ASSEMBLY (WITH BOOT ATTACHED) INTO THE CAVITY OF THE PIT LID HOUSING AND SNAP IN THE BOOT LOCKING CLIP
3. EXCESS WIRE SHOULD BE COILED LOOSELY (NOT TIED) IN METER PIT, ALLOWING SLACK FOR PIT LID REMOVAL.

MORE INFORMATION ON THE INTERNET:

1. FOR DETAILED DATA AND INSTALLATION INFORMATION SEE WWW.SENSUS.COM
   WWW.SENSUS.COM/PRODUCT_OIE_3.ASP
   WWW.SENSUS.COM/PRODUCT_OIE_4.ASP

AT	CHANGE NOTICE NO	DATE

PROD RELEASE

sensus

450 N Gallatin Avenue
Uniontown PA 15401
USA

SENSUS RADIOREAD SYSTEM
PIT LID DEVICE INSTALLATION

SCALE	1/2	DATE
DR. BY	MSW	06-05-06
CH. BY		
AP. BY		

SHEET 1 OF 1

UM-8114-C

Thomas Galuska
Sr. Product Manager
NA – Water

8601 Six Forks Road
Suite 300
Raleigh, NC 27615 USA

T: 919-376-2641
F: 919-424-8971
tom.galuska@sensus.com
www.sensus.com

SENSUS
The Measure of the Future

June 11, 2014

Ken Resca
New York State Dept of Public Service
3 Empire State Plaza Albany, New York
12223-1350

Dear Mr. Resca,

The NEC Class 1 / Division 1 is a standard associated with gas products and additional products used in environments that are exposed to volatile / explosive gases. The Water M2 radios under review were not designed for that environment since these devices are for water applications and therefore Sensus did not require NEC Class 1 / Division1 qualification. Our Gas M2 radios do meet Class 1 / Division 2 requirements.

The Water M2 radios do meet all FCC and Industry Canada requirements as indicated on the radio itself – FCC ID: SDBWFL2 / MODEL: WFL2A and IC: 2220A-WFL2. The model numbers indicated refer specifically to this compliance.

If you have any additional questions please don't hesitate to contact me.

Sincerely,

Tom Galuska

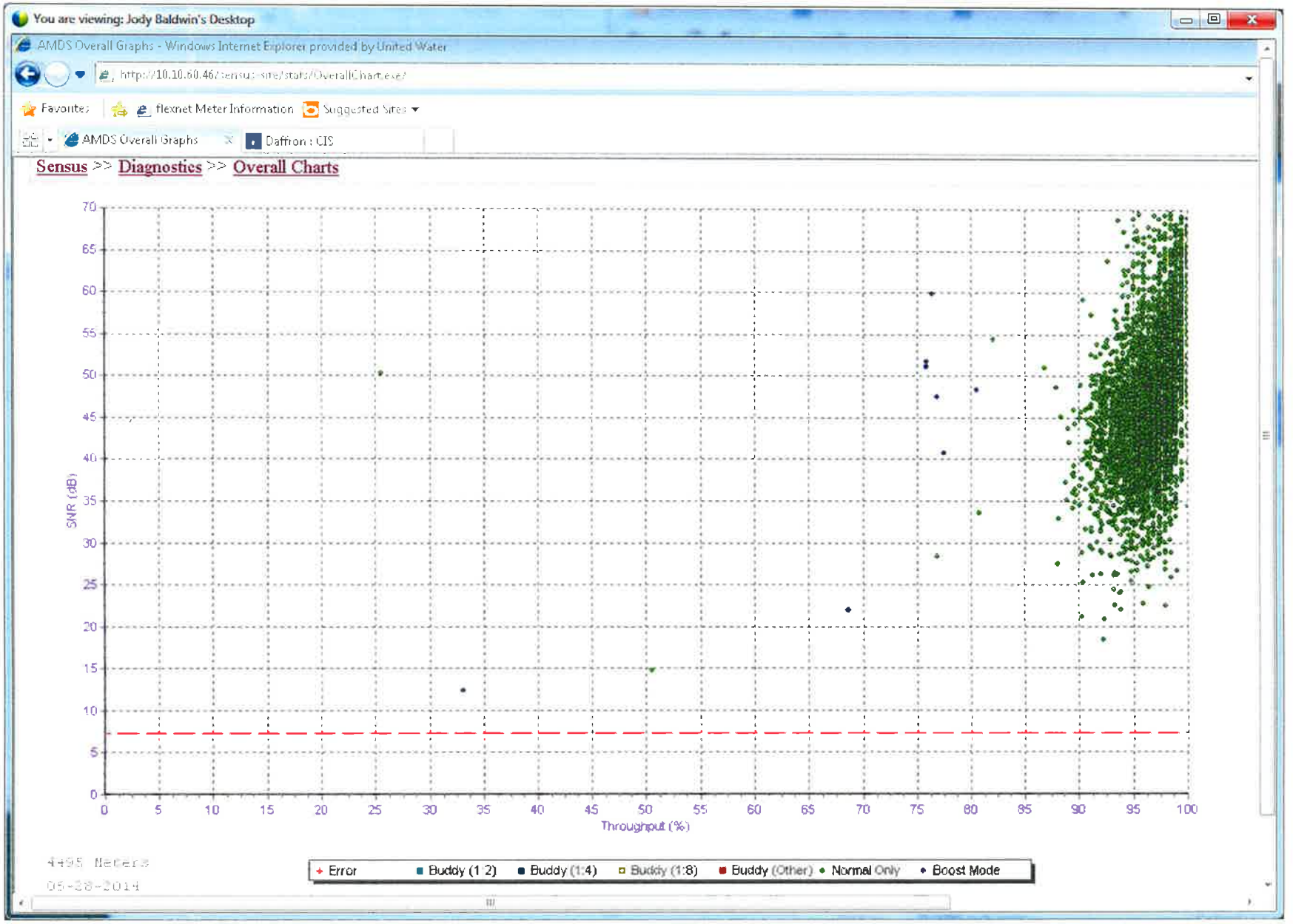
Tom Galuska
Senior Product Manager – NA – Water

Cc: J. Wilton
C. Teehan
T. Maselko
J. Shugarts

APPENDIX- B UNITED WATER TEST DATA

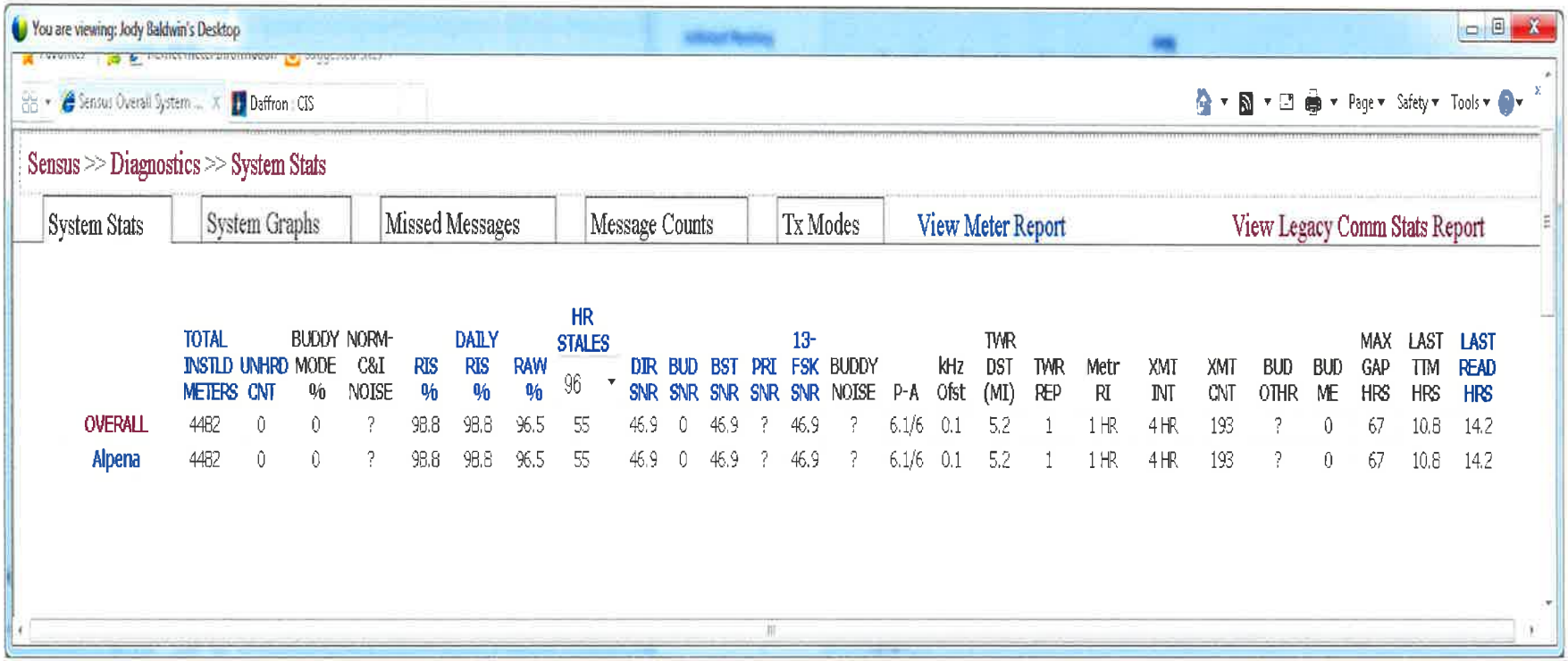
Sensus FlexNet System Performance in United Water Alpena Michigan - 5/29/2014

Signal to Noise Ratio for every endpoint – 4495 total (production and those in the office) meters & endpoints in this United Water system in Michigan. Virtually every endpoint is transmitting above 90% throughput. *Boost* and *Buddy Mode* is available in the Sensus system to allow very distant meters to still successfully transmit into system as seen in Figure 1.


You are viewing: Jody Baldwin's Desktop
AMDS Overall Graphs - Windows Internet Explorer provided by United Water
Favorites
flexnet Meter Information
Suggested Sites
AMDS Overall Graphs
Daffron : CIS
Sensus >> Diagnostics >> Overall Charts
SNR (dB)
Throughput (%)
4495 Meters
09-28-2014
Error
Buddy (1:2)
Buddy (1:4)
Buddy (1:8)
Buddy (Other)
Normal Only
Boost Mode

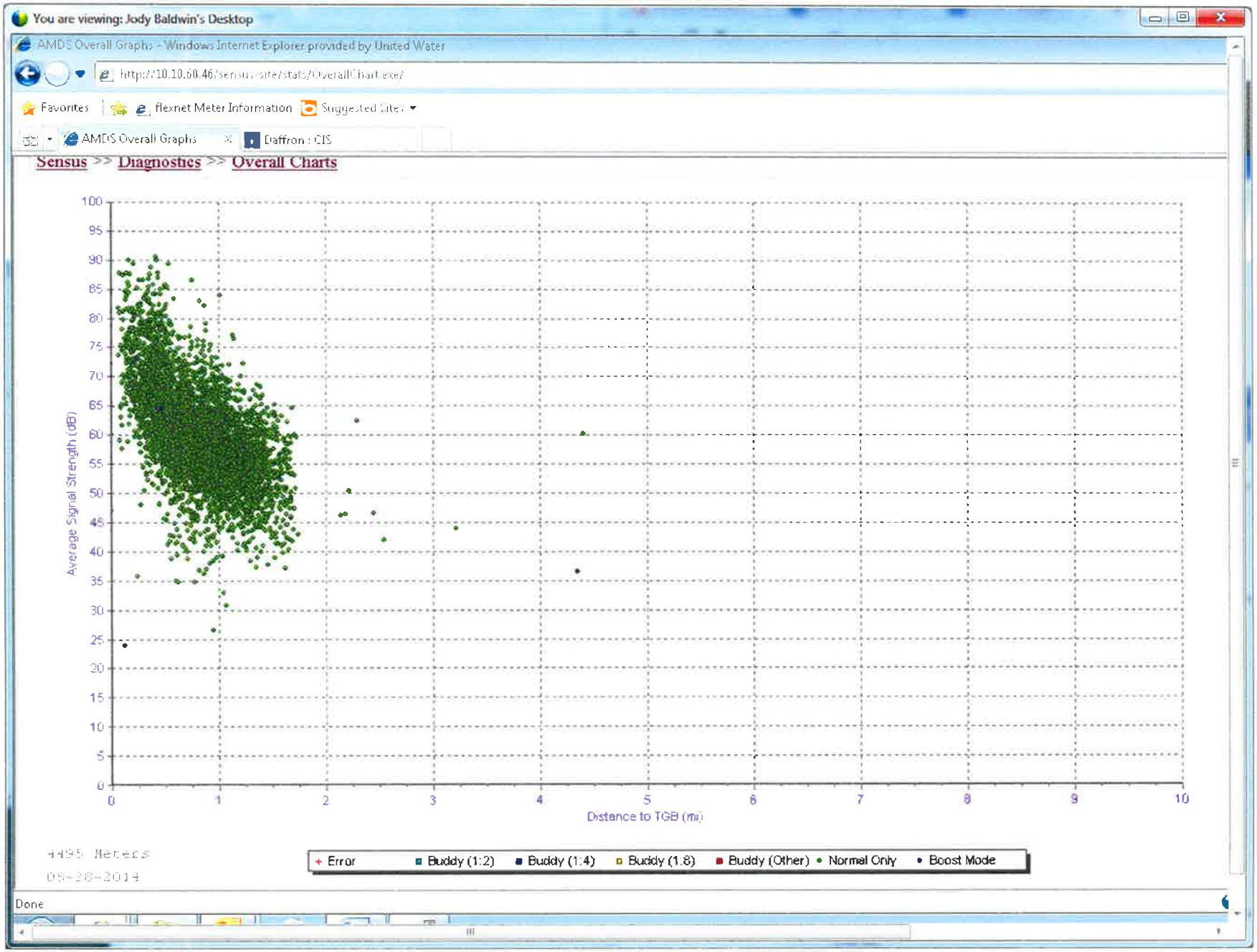
Read Interval success for every endpoint, 24 reads per day, of 98.8%

Online (production) meters = 4482 * 24 reads per day = 107568 hourly reads per day so the system has heard 98.8% of the hourly reads: 106277 hourly reads out of 107568 possible.

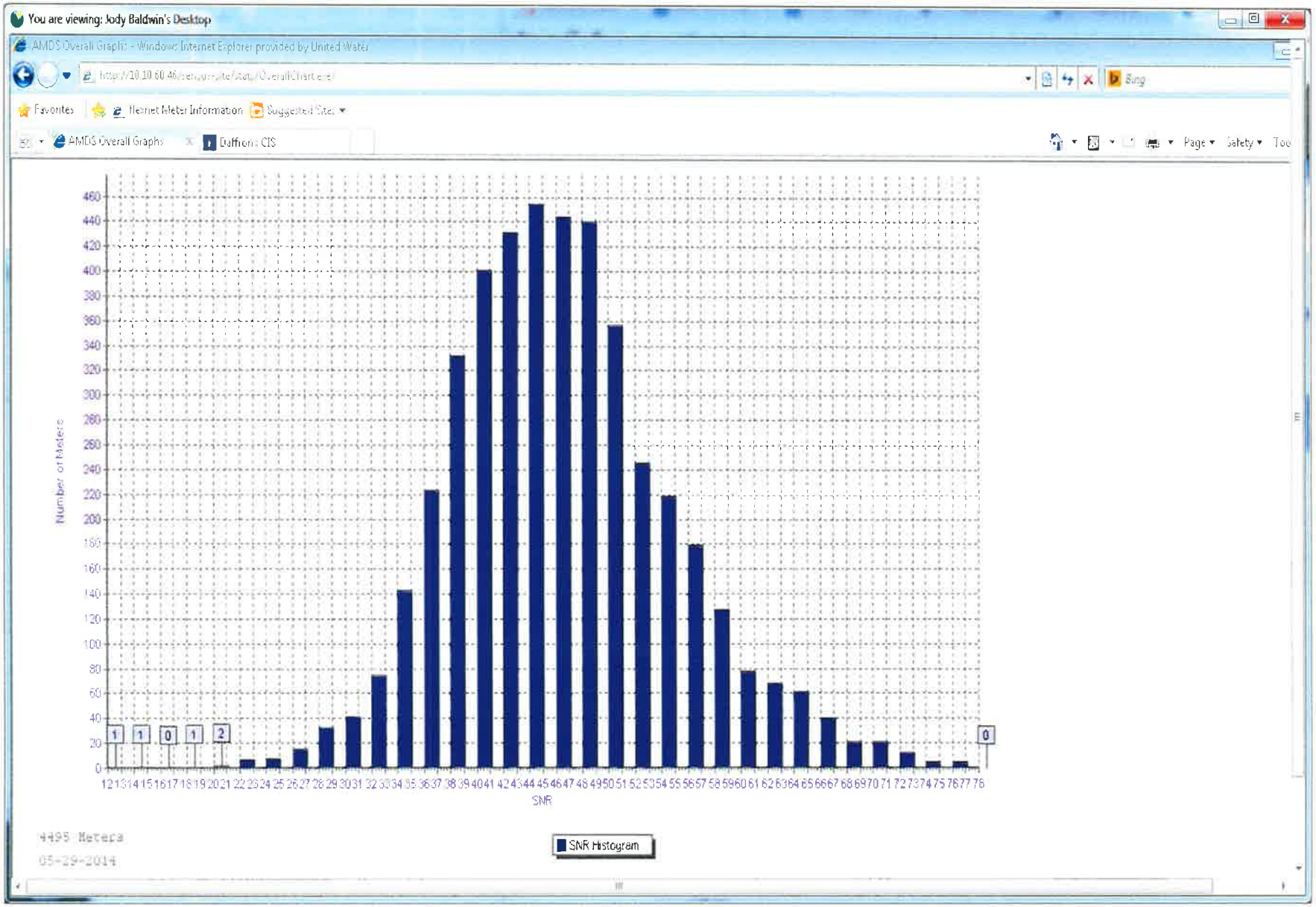


	TOTAL INSTLD METERS	UNHRD CNT	BUDDY MODE %	NORM-C&I NOISE	RIS %	DAILY RIS %	RAW %	HR STALES 96	DIR SNR	BUD SNR	BST SNR	PRI SNR	13-FSK SNR	BUDDY NOISE	P-A	kHz Ofst	TWR DST (MI)	TWR REP	Metr RI	XMT INT	XMT CNT	BUD OTHR	BUD ME	MAX GAP HRS	LAST TTM HRS	LAST READ HRS
OVERALL	4482	0	0	?	98.8	98.8	96.5	55	46.9	0	46.9	?	46.9	?	6.1/6	0.1	5.2	1	1 HR	4 HR	193	?	0	67	10.8	14.2
Alpena	4482	0	0	?	98.8	98.8	96.5	55	46.9	0	46.9	?	46.9	?	6.1/6	0.1	5.2	1	1 HR	4 HR	193	?	0	67	10.8	14.2

This graph shows the transmission range in miles of the endpoints. Some endpoints are transmitting up to 4+ miles. In this system, most endpoints are installed under 2 miles from the collectors but still others are 2, 3, or ever 4 miles away from the collector and still successfully transmit in.


You are viewing: Jody Baldwin's Desktop
AMDS Overall Graphs - Windows Internet Explorer provided by United Water
http://10.10.60.46/sensus/site/stats/OverallChart.exe/
Favorites
flexnet Meter Information
Suggested Sites
AMDS Overall Graphs
Daffron : CIS
Sensus >> Diagnostics >> Overall Charts
Average Signal Strength (dB)
Distance to TGB (mi)
4495 Meters
05-28-2014
Error
Buddy (1:2)
Buddy (1:4)
Buddy (1:8)
Buddy (Other)
Normal Only
Boost Mode
Done

System's signal to noise ration by meter/endpoint count. Even meter/endpoints at the far left side of the chart are heard by the system:


You are viewing: Jody Baldwin's Desktop
AMDS Overall Graph - Windows Internet Explorer provided by United Water
Favorites
Hemet Meter Information
AMDS Overall Graphs
Daffron CIS
Number of Meters
SNR
4495 Meters
05-29-2014
SNR Histogram

The Sensus system shows all meters/endpoints in Google Earth enabling a geospatial view of meter/endpoint assets. Clicking on a meter/endpoint or collector (in red) shows asset information.


Grant St
S Jefferson St
S Brooke St
Google earth

APPENDIX C - SENSUS TEST DATA

Sensus FlexNet System Test Data performed by Sensus

The Measure of the Future

NA 2 WAY RADIO

Design Verification Test Report

By

Percept Technology Labs

PRODUCT TEST AND COMPLIANCE EXPERTS

4888 Pearl East Cir. #110
Boulder, Colorado 80301
303.444.7480
.percept.

Revision History:

Version	Date	Comments
0.1	1/26/10	Initial Draft

Approved

Percept Technology Labs shall have no liability of any kind to person or property, including special or consequential damages, resulting from Percept Technology Labs providing the services covered by this report.	
QA Manager: Paul Williams	Date: 1/26/10

TABLE OF CONTENTS

FIGURES

TABLES

1 Introduction

1.1 Scope

The "Sensus NA 2 WAY Radio Test Report" document defines required test equipment and the test process to perform Design Verification Testing on the **Sensus FlexNet SmartPoint model 520X**.

The tests and procedures defined in this document were developed, performed and maintained by Percept Technology Labs, Inc. or Sensus.

1.2 Description

Sensus FlexNet SmartPoint model 520X (aka: NA 2 WAY Radio) is a pit set radio signal device which permits off site meter reading via licensed radio signal in a pit set or vault environment.

Figure 1: NA 2 WAY RADIO

1.3 Dependencies

The NA 2 WAY Radios (May be referred to as EUT or **Sensus FlexNet SmartPoint model 520**) and water meters supplied by Sensus, are representative of the configuration being investigated.

1.4 Company Restricted Information

This document contains confidential and restrictive information. Reproduction of this document outside of Sensus or Percept Technology Labs, Inc. is prohibited without consent.

1.5 Reference Documents

- NA 2 Way Radio Reliability test plan v9.doc
- Tenny Environmental Chamber User Guide
- ISTA Procedure 2A
- Qualmark Modified Halt Report # T26996
- Sensus NA2W Model 520 Derating Report Version 1.0

1.6 Abbreviations / Acronyms

ISTA – International Safe Transit Association

2 Criteria

2.1 Entrance Criteria

The following list of Equipment Under Test (EUT) is representative of the final product.

- 6 NA 2 WAY Radios – (aka: **Sensus FlexNet SmartPoint model 520)**
- **Sensus Water meters**

2.2 Exit Criteria

- Completion of testing.
- Final Report

3 Executive Summary

NA 2 WAY Reliability –TC–10.1 Operational Temperature/Humidity Extremes

The NA 2 WAY radios completed the Operational Temperature/Humidity Extremes testing with the following minor issues. The radios continued to transmit at each temperature/humidity that was tested.

1. It was observed that when at the cold temperature (-30° C) the radio's transmit occurred at an interval of greater than 1 minute.

Table 1: TX Interval (-30° C)

TX ID	TX #	Average TX Time (Min)
13000554	8	2
13000555	7	2.2
13000580	5	3.2
13000581	3	5
13001150	1	>19
13001151	5	3.2

2. Two instances occurred (TX ID: 13001150/13001151) that the radio reported a meter read failure (TX ID: 13001151 at baseline temperature and TX ID:13001150 at -30°C). This issue was only observed 1 time for each TX ID.

NA 2 WAY Reliability –TC–10.2 Non-Operational Temperature Extremes

The NA 2 WAY radios successfully completed the Non-Operational Temperature Extremes testing with no issues. The radios continued to transmit before and after the Non-Operational Temperature Extremes testing was performed with no meter read failures.

NA 2 WAY Reliability –TC–10.3 Thermal Cycling

The NA 2 WAY radios successfully completed the Thermal Cycling test with no issues. The radios continued to transmit before and after Thermal Cycle testing was performed with no meter read failures.

NA 2 WAY Reliability –TC–10.X Operational Vibration

The NA 2 WAY radios successfully completed the Operational Vibration testing with no issues. The radios continued to transmit during all vibration testing. No meter read failures were observed.

NA 2 WAY Reliability –TC–10.4 Package Vibration Transportation

The NA 2 WAY radios successfully completed the Package Vibration Transportation testing. The devices remained operational before and after testing.

NA 2 WAY Reliability –TC–10.5 Package Drop – Shock

The NA 2 WAY radios successfully completed the Packaging Drop-Shock testing. The devices remained operational before and after testing.

The following issues were observed with the shipping container supplied by Sensus.

1. The manufacture seam is starting to split. If the shipping container splits open product will no longer be contained and increases the chances of damaged product (See figure 24).
2. The TouchCoupler TR/PL Adaptor Prongs were pushed through the inside cardboard divider. This issue has the potential to crack of break the TouchCoupler TR/PL prongs (See figure 25).

NA 2 WAY Reliability –TC–20.1 HALT Testing

Thermal Step Stress:

1. On ramp from –20 to –30°C, and during –30 dwell, infrequent status reporting on unit #3. Continued testing.
2. At –40°C, unit #3 stopped reporting completely. Continued testing.
3. At –50°C, all units stopped reporting except #3. Unit #3 reported only 3 times during the dwell. Functional limit.
4. After a 30 minute dwell at 20°C, all units returned to normal.

Rapid Thermal Transitions:

- None

Vibration Step Stress:

- None

Combined Environment:

- None

NA 2 WAY Reliability –TC–20.5 Stress Analysis / Component Derating

Thermal Derating Results

1. No components were found to be thermally overstressed at nominal lab ambient Conditions.

2. 12 components were found to be thermally overstressed at the maximum operational temperature of 85°C. However, in each case this is due to the components being rated at 85°C maximum operating temperature.

Electrical Derating Results

1. No components were found to be electrically overstressed.

4 NA 2 WAY Reliability–TC–10 Design Verification Test

4.1 NA 2 WAY Reliability –TC–10.1 Operational Temperature/Humidity Extremes

Objective:

Verify functionality over the specified operating temperature and humidity ranges.

Test Date:

11/30/09 – 12/2/09

Test Equipment:

Tenny Environmental Chamber
Model #: T20RS-1.5
S/N: 27544-03
Calibration Due: 3/17/2010
IBM Thinkpad Laptop
NA2W Message Utility Software
Version: 0.0.1.28
3 NA 2 WAY Radios
Model # 520
TX ID: 13000554, 13000555, 13000580, 13000581, 13001150, 13001151
Sensus Command Link
Model #: CL 100
S/N: CL50202297

Test Setup:

Three (3) NA 2 WAY radios and 6 water meters were used for this test. The radios were placed inside of the environmental chamber and the water meters were placed outside of the environmental chamber.

Method:

Test Sequence:

1. Perform Pre Operational Verification Procedure
2. Ramp thermal chamber to 20% RH while holding 21°C
3. Ramp thermal chamber to -30°C at 20°C per hour (humidity uncontrolled).
4. Hold at condition for 4 hours to stabilize equipment.
5. Perform Operational Verification During Testing
6. Ramp thermal chamber to 85°C at 20°C per hour while holding 65%RH.
7. Hold at condition for 4 hours to stabilize equipment.
8. Perform Operational Verification During Testing
9. Ramp thermal chamber to 70°C at 20°C per hour while ramping to 95%RH.
10. Hold at condition for 4 hours to stabilize equipment.
11. Perform Operational Verification During Testing
12. Ramp thermal chamber to 20% RH while holding 70°C
13. Hold at condition for 4 hours to stabilize equipment.
14. Perform Operational Verification During Testing

15. Ramp thermal chamber to 21°C at 20°C per hour while holding 20% RH.
16. Hold at condition for 4 hours to stabilize equipment.
17. Perform POST Operational Verification Procedure

Exit Criteria:

Complete test method defined above.

Results:

The NA 2 WAY radios completed the Operational Temperature/Humidity Extremes testing with the following minor issues. The radios continued to transmit at each temperature/humidity that was tested.

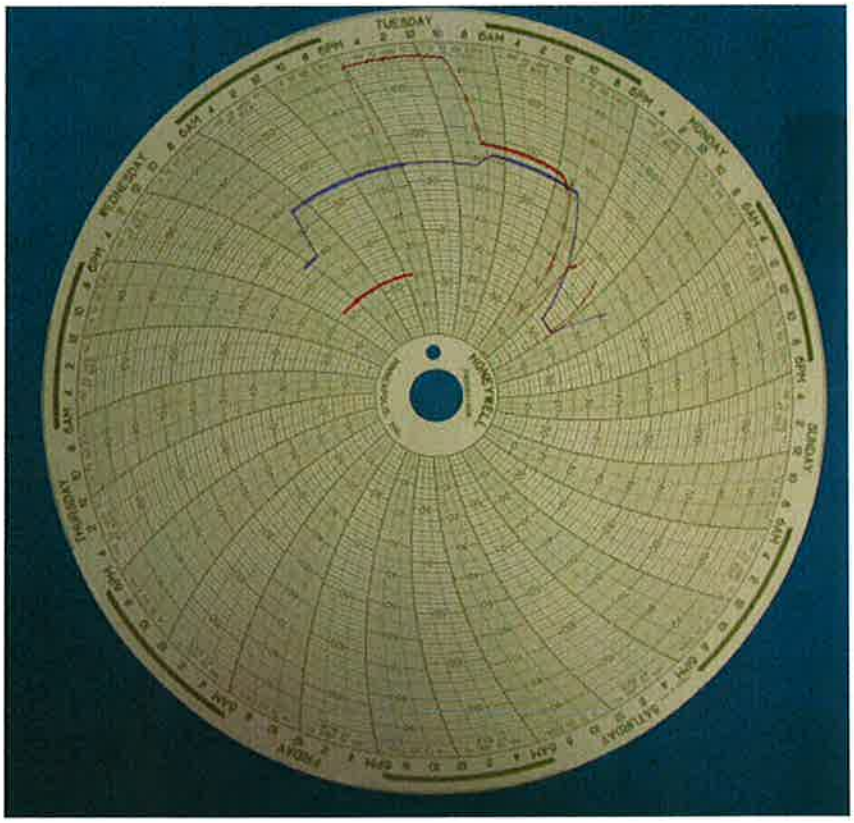
1. It was observed that when at the cold temperature (-30° C) the radio's transmit occurred at an interval of greater than 1 minute.

Table 2: TX Interval (-30° *C)*

TX ID	TX #	Average TX Time (Min)
13000554	8	2
13000555	7	2.2
13000580	5	3.2
13000581	3	5
13001150	1	>19
13001151	5	3.2

2. Two instances occurred (TX ID: 13001150/13001151) that the radio reported a meter read failure (TX ID: 13001151 at baseline temperature and TX ID:13001150 at -30°C). This issue was only observed 1 time for each TX ID.

Figure 2: Operational Temperature/Humidity Extremes Environmental Chart.



- Red = Humidity
- Blue = Temperature

4.2 NA 2 WAY Reliability –TC–10.2 Non-Operational Temperature Extremes

Objective:

Verify functionality after exposure to the specified Non-operating temperature range.

Test Date:

12/2/09 – 12/4/09

Test Equipment:

Tenny Environmental Chamber
Model #: T20RS-1.5
S/N: 27544-03
Calibration Due: 3/17/2010
IBM Thinkpad Laptop
NA2W Message Utility Software
Version: 0.0.1.28
3 NA 2 WAY Radios
Model # 520
TX ID: 13000554, 13000555, 13000580, 13000581, 13001150, 13001151
Sensus Command Link
Model #: CL 100
S/N: CL50202297

Test Setup:

Three (3) NA 2 WAY radios and 6 water meters were used for this test. The radios were placed inside of the environmental chamber and the water meters were placed outside of the chamber.

Method:

Step 1: Perform Pre Operational Verification Procedure
Step 2: Ramp thermal chamber to -40°C at 20°C per hour.
Step 3: Hold at temp for 8 hours to stabilize equipment.
Step 4: Ramp thermal chamber to 85°C at 20°C per hour.
Step 5: Hold at temp for 8 hours to stabilize equipment.
Step 6: Ramp thermal chamber to nominal temp at 20°C per hour.
Step 7: Hold at temp for 8 hours to stabilize equipment.
Step 8: Perform POST Operational Verification Procedure

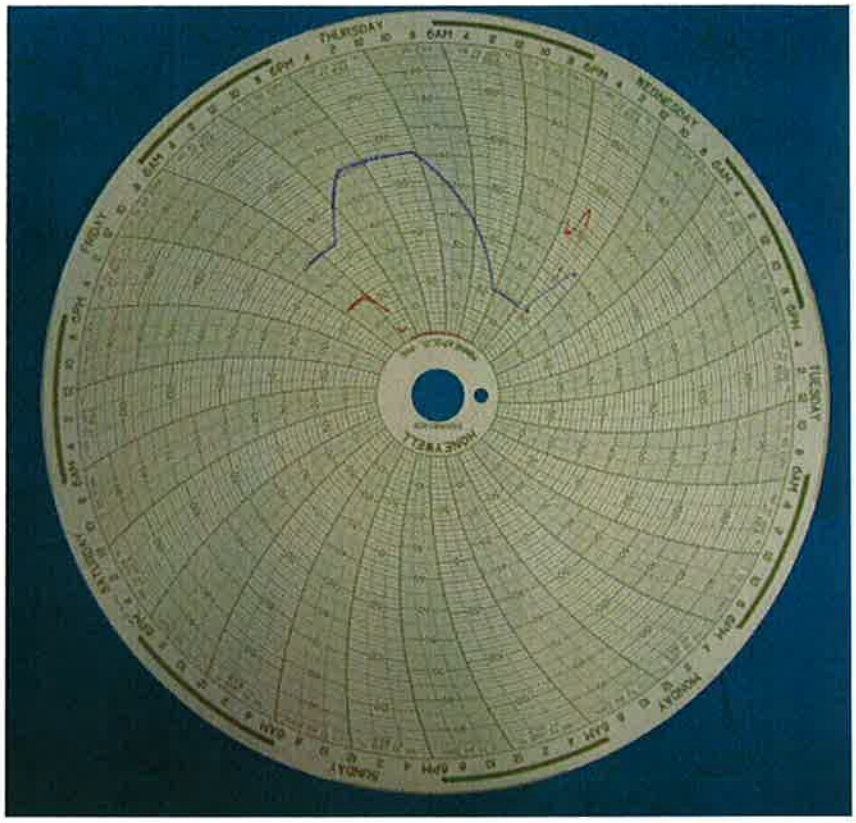
Exit Criteria:

Complete test method defined above.

Results:

The NA 2 WAY radios successfully completed the Non-Operational Temperature Extremes testing with no issues. The radios continued to transmit before and after the Non-Operational Temperature Extremes testing was performed with no meter read failures.

Figure 3: Non-*Operational Temperature Extremes Environmental Chart.*



- Red = Humidity
- Blue = Temperature

4.3 NA 2 WAY Reliability –TC–10.3 Thermal Cycling

Objective:

Verify functionality after exposure to the specified thermal temperature cycles.

Test Date:

12/4/09 – 12/9/09

Test Equipment:

Tenny Environmental Chamber
Model #: T20RS-1.5
S/N: 27544-03
Calibration Due: 3/17/2010
IBM Thinkpad Laptop
NA2W Message Utility Software
Version: 0.0.1.28
3 NA 2 WAY Radios
Model # 520
TX ID: 13000554, 13000555, 13000580, 13000581, 13001150, 13001151
Sensus Command Link
Model #: CL 100
S/N: CL50202297

Test Setup:

Three (3) NA 2 WAY radios and 6 meters were used for this test. The radios were placed inside of the environmental chamber and the meters were placed outside of the environmental chamber.

Method:

Step 1: Perform Pre Operational Verification Procedure
Step 2: Ramp thermal chamber to -30°C at 60°C per hour.
Step 3: Hold at temp for 8 hours to stabilize equipment.
Step 4: Ramp thermal chamber to 70°C at 60°C per hour.
Step 5: Hold at temp for 8 hours to stabilize equipment.
Step 8: Repeat steps 2 – 5 five (5) times
Step 6: Ramp thermal chamber to nominal temp at 20°C per hour.
Step 7: Hold at temp for 8 hours to stabilize equipment.
Step 9: Perform POST Operational Verification Procedure

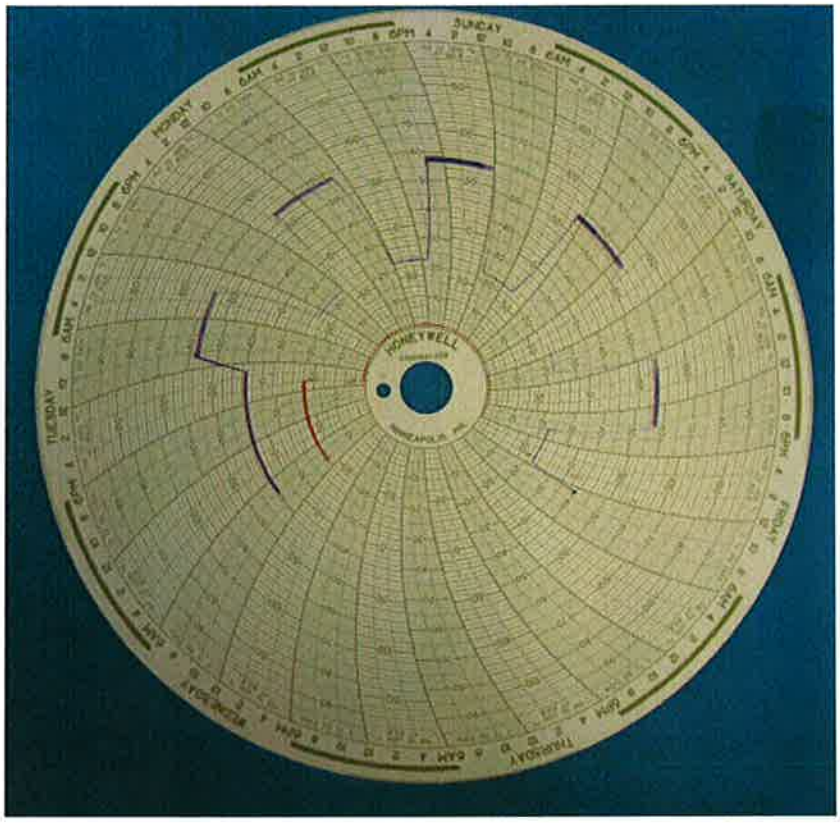
Exit Criteria:

Complete test method defined above.

Results:

The NA 2 WAY radios successfully completed the Thermal Cycling test with no issues. The radios continued to transmit before and after Thermal Cycle testing was performed with no meter read failures.

Figure 4: Thermal Cycling *Environmental Chart.*



- Red = Humidity
- Blue = Temperature

4.4 NA 2 WAY Reliability –TC–10.X Operational Vibration

Objective:

Verify functionality during exposure to application vibration profile.

Test Date:

1/21/10

Test Equipment:

Unholtz-Dickie Vibration Test System
- Shaker:
  - Model #: S452-LP
  - S/N: 95
- Amplifier:
  - Model #: SA15
  - S/N: 2937
- Accelerometer:
  - Model #: 10B10T
  - S/N: 4927
  - Calibration Due: 1/12/2011

IBM Thinkpad Laptop
NA2W Message Utility Software
- Version: 0.0.1.28

3 NA 2 WAY Radios
- Model # 520
- TX ID: 13000554, 13000555, 13000580, 13000581, 13001062, 13001063

Sensus Command Link
- Model #: CL 100
- S/N: CL50202297

Test Setup:

Three (3) NA 2 WAY radios and 5 meters were used for this test. The radios were securely attached to the vibration table head expander (1 at a time) and the meters placed next to the vibration table.

Method:

Test Sequence: Repeat for X, Y & Z axis orientations (See figures 18, 19, 20), Swept Sine Vibration: 0.5g RMS, 30 to 350Hz, 30 minutes each axis.

1. Perform Operational Verification Procedure
2. Monitor function during test
3. Perform Operational Verification Procedure

Exit Criteria:

Complete test method defined above.

Results:

The NA 2 WAY radios successfully completed the Operational Vibration testing with no issues. The radios continued to transmit during all vibration testing. No meter read failures were observed.

Figure 5: Operating Vibration (TX ID 13000555/554 – X Axis).

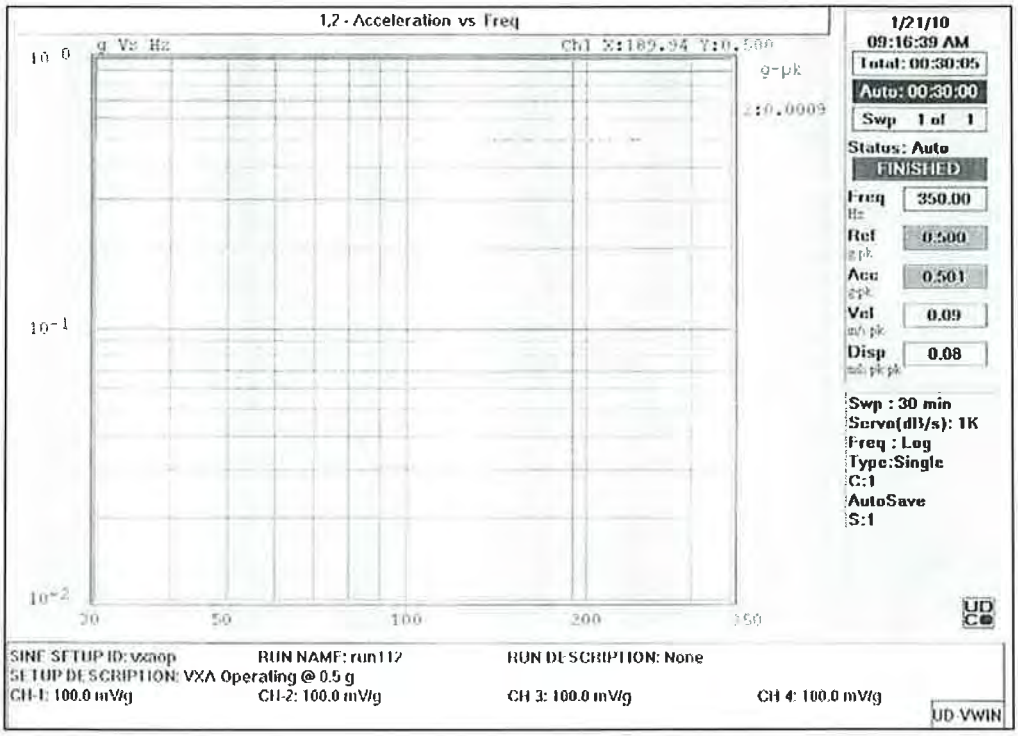


Figure 6: Operating Vibration (TX ID 13000555/554 – Y Axis).

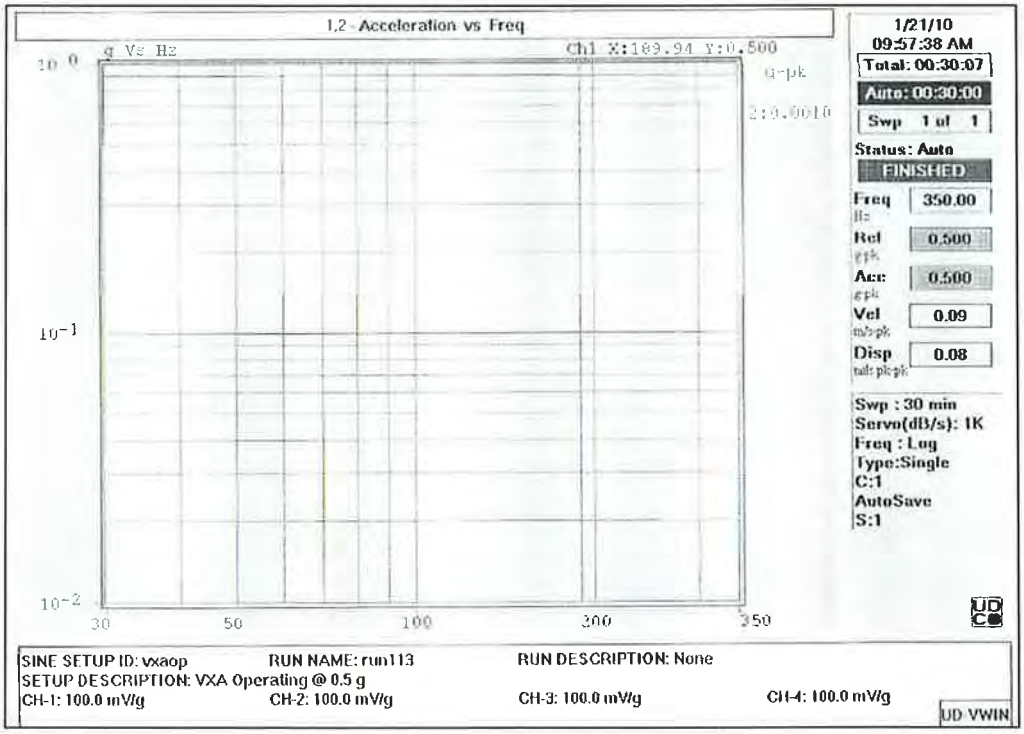


Figure 7: Operating Vibration (TX ID 13000555/554 – Z Axis).

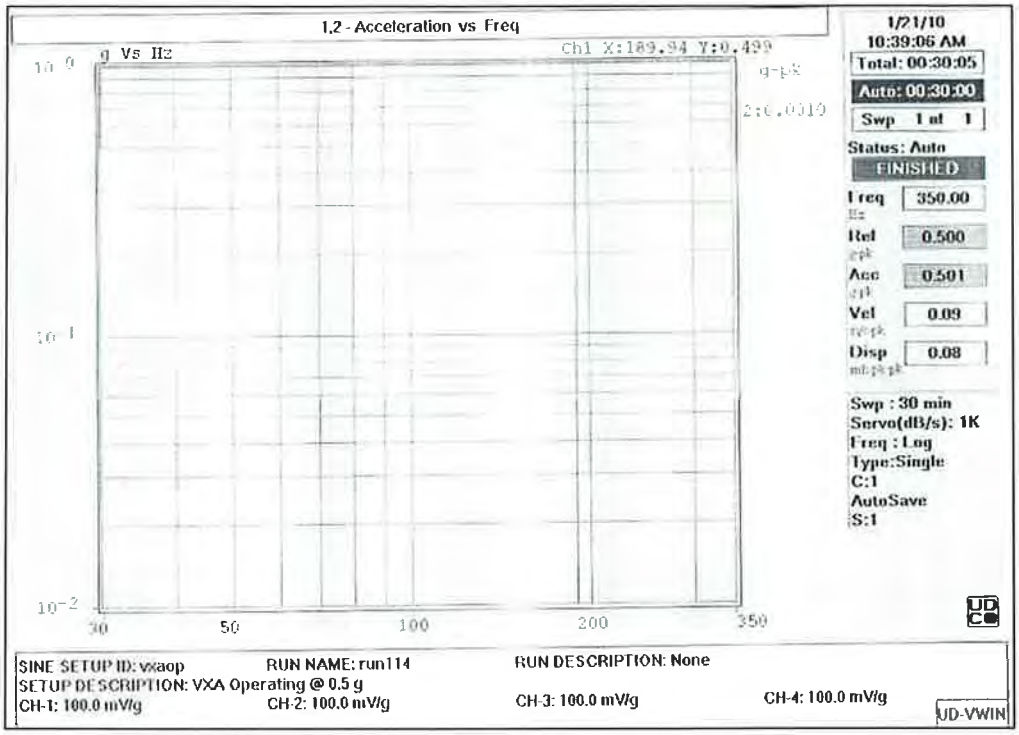


Figure 8: Operating Vibration (TX ID 13000580/581 – X Axis).

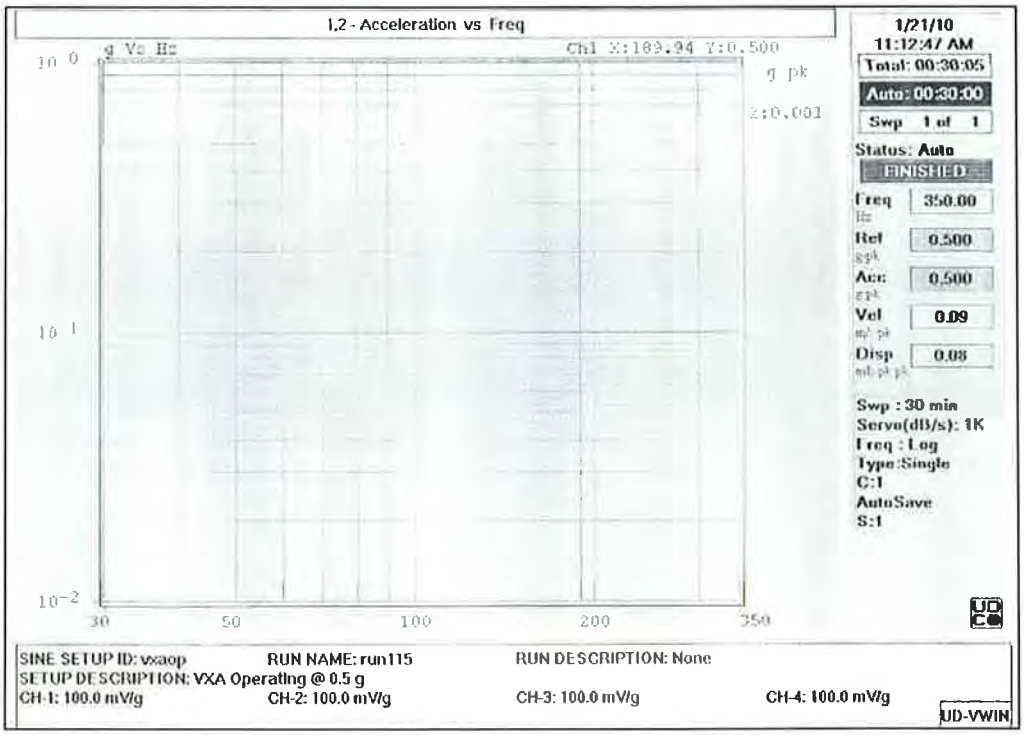


Figure 9: Operating Vibration (TX ID 13000580/581 – Y Axis).

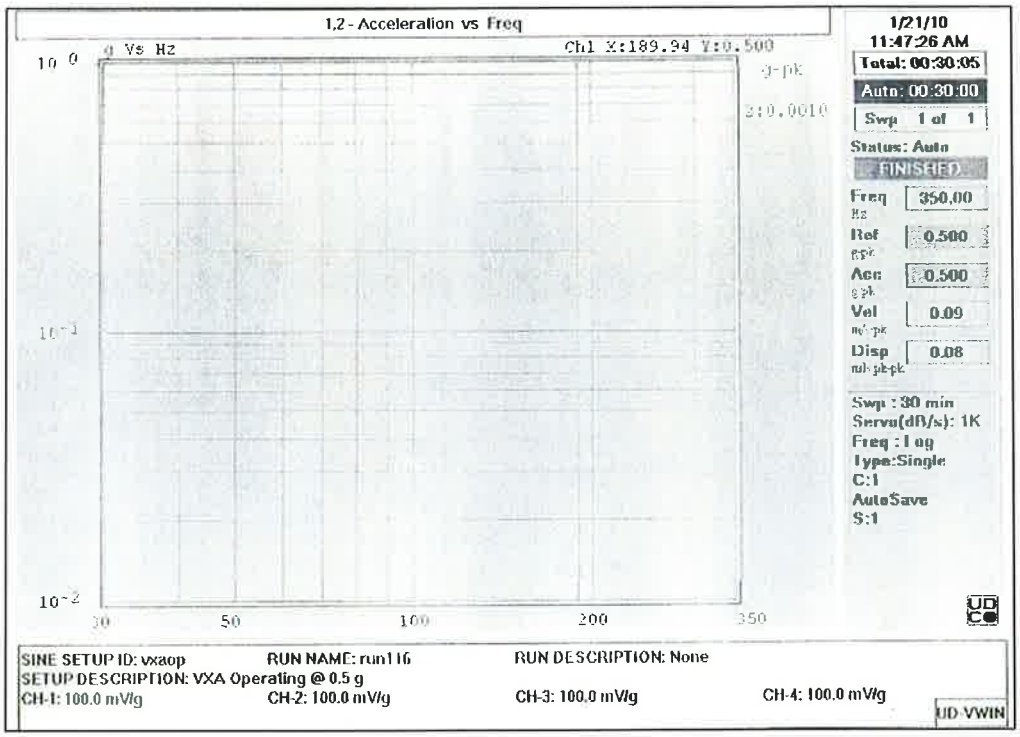


Figure 10: Operating Vibration (TX ID 13000580/581 – Z Axis).

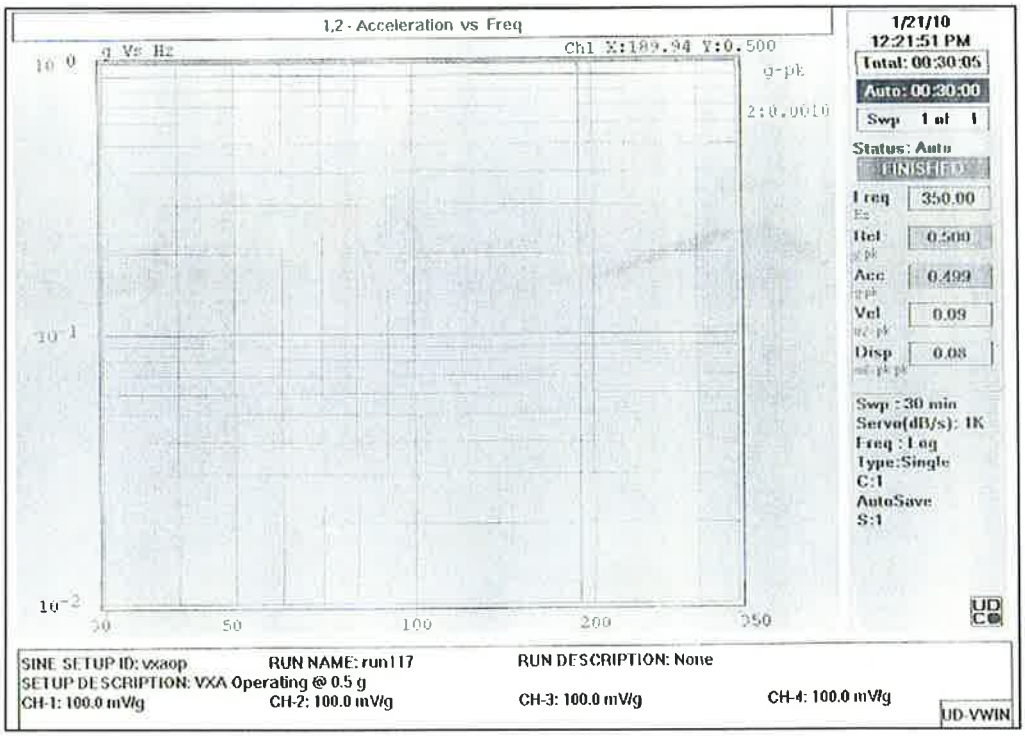


Figure 11: Operating Vibration (TX ID 13001062/1063 – X Axis).

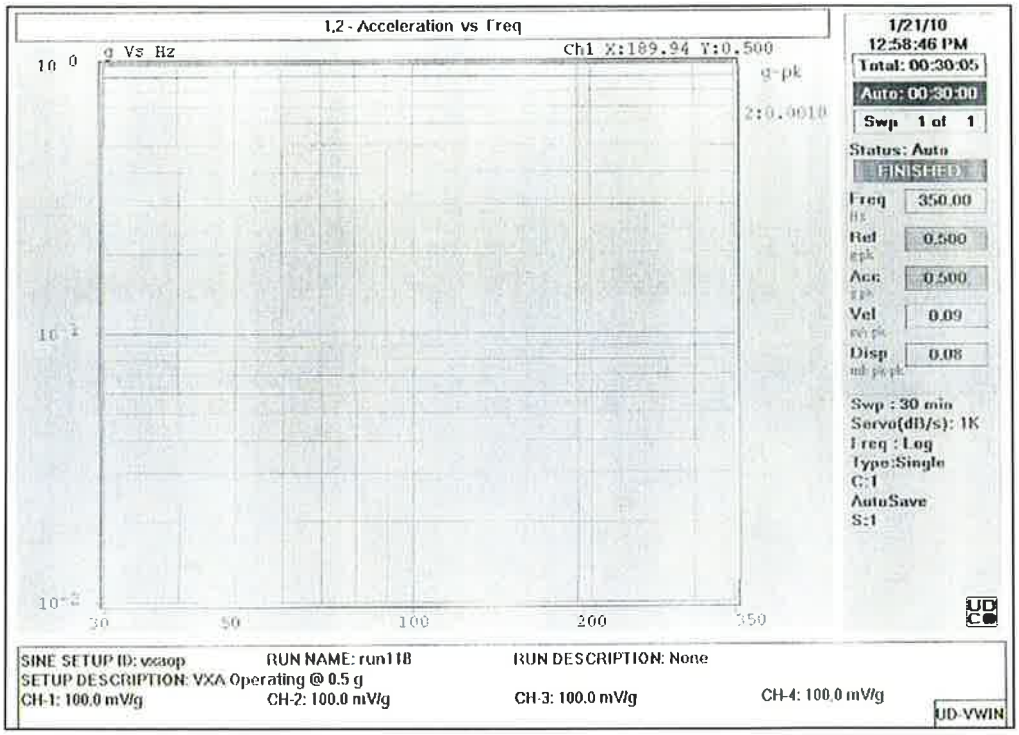


Figure 12: Operating Vibration (TX ID 13001062/1063 – Y Axis).

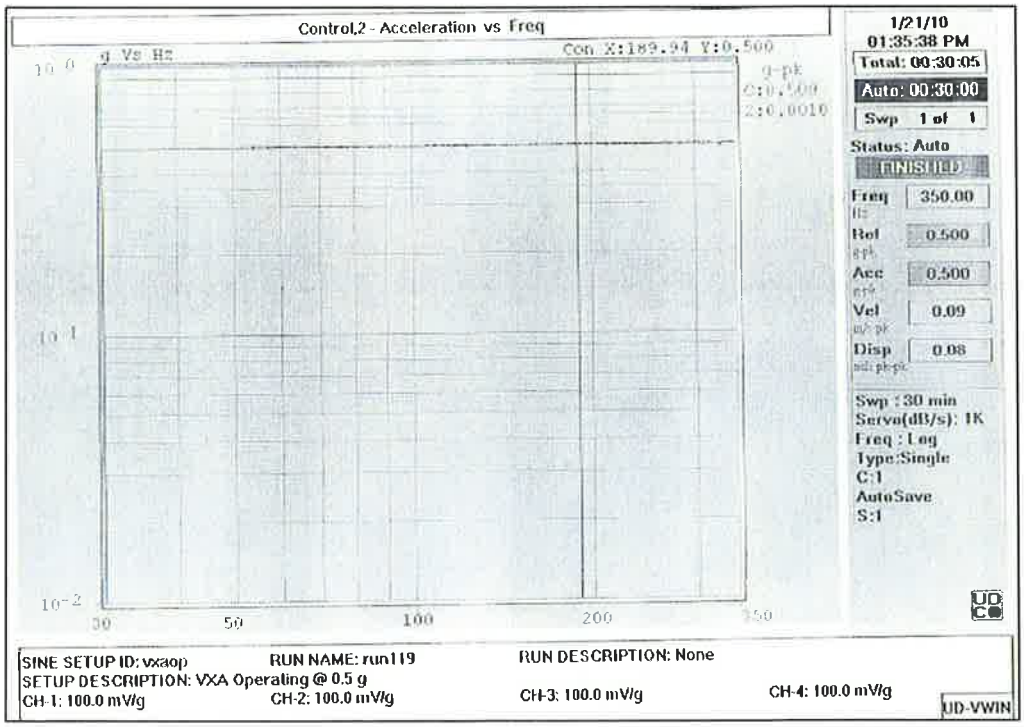
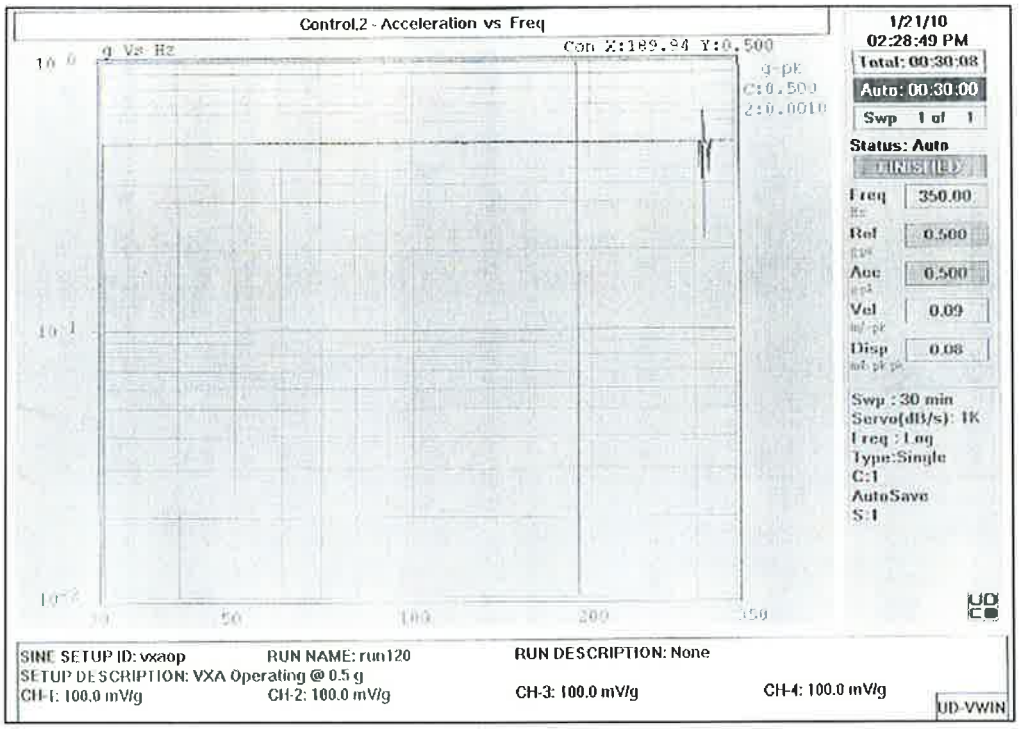


Figure 13: Operating Vibration (TX ID 13001062/1063 – Z Axis).



4.5 NA 2 WAY Reliability –TC–10.4 Package Vibration Transportation

Objective:

Verify functionality after exposure to the shipping vibration profile.

Test Date:

1/21/10

Test Equipment:

Unholtz-Dickie Vibration Test System
- Shaker
  - Model #: S452-LP
  - S/N: 95
- Amplifier
  - Model #: SA15
  - S/N: 2937
- Accelerometer
  - Model #: 10B10T
  - S/N: 4927
  - Calibration Due: 1/12/2011

IBM Thinkpad Laptop
NA2W Message Utility Software
- Version: 0.0.1.28

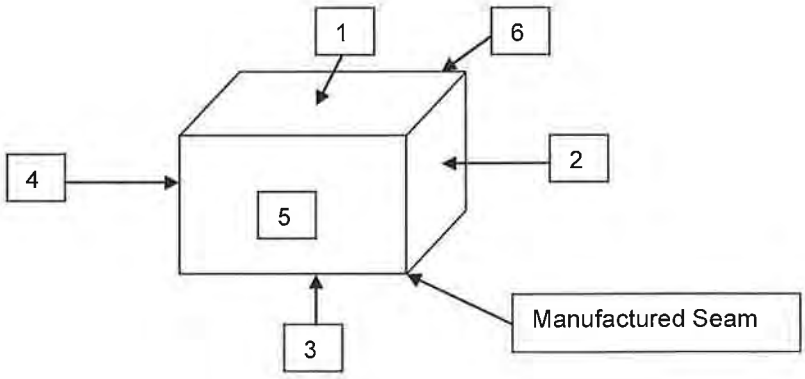
3 NA 2 WAY Radios
- Model # 520
- TX ID: 013000564, 013000546, 013000570, 013000571

Sensus Command Link
- Model #: CL 100
- S/N: CL50202297

Test Setup:

The shipping container (Box) consists of a single walled corrugated cardboard box that is 17" x 14.5" x 16.25" (Height, Width, Depth). The shipping container is capable of holding 27 NA 2 WAY Radios (9 radios per layer) with 3 layers separated by a piece of single walled corrugated cardboard. Three (3) NA 2 WAY radios and 4 water meters were used for this test. The radios were tested to confirm operation. The water meters were disconnected from the radios and then the radios were placed into the shipping container with the remaining space filled with cork board to make the shipping container weight (Approx. 28 lbs) the same as if it were full of radios (See figure 21). The shipping container was marked as follows:

Figure 14: Face Identification



Box numbering is dependent on location of manufactured seam:

1 = Top
2 = Right Side
3 = Bottom
4 = Left Side
5 = Front
6 = Rear

Method:

Test Sequence: (Random Vibration)

1. Perform Pre Operational Verification Procedure
2. The packaged NA 2 WAY radios were placed on the vibration table which has rails attached to keep shipping container contain on the table (Face 3).
3. Random vibration was performed for 30 minutes
4. The shipping container was rotated and vibration performed for 10 minutes (face 1)
5. The shipping container was rotated and vibration performed for 10 minutes (face 2)
6. The shipping container was rotated and vibration performed for 10 minutes (face 5)
7. Perform POST Operational Verification Procedure

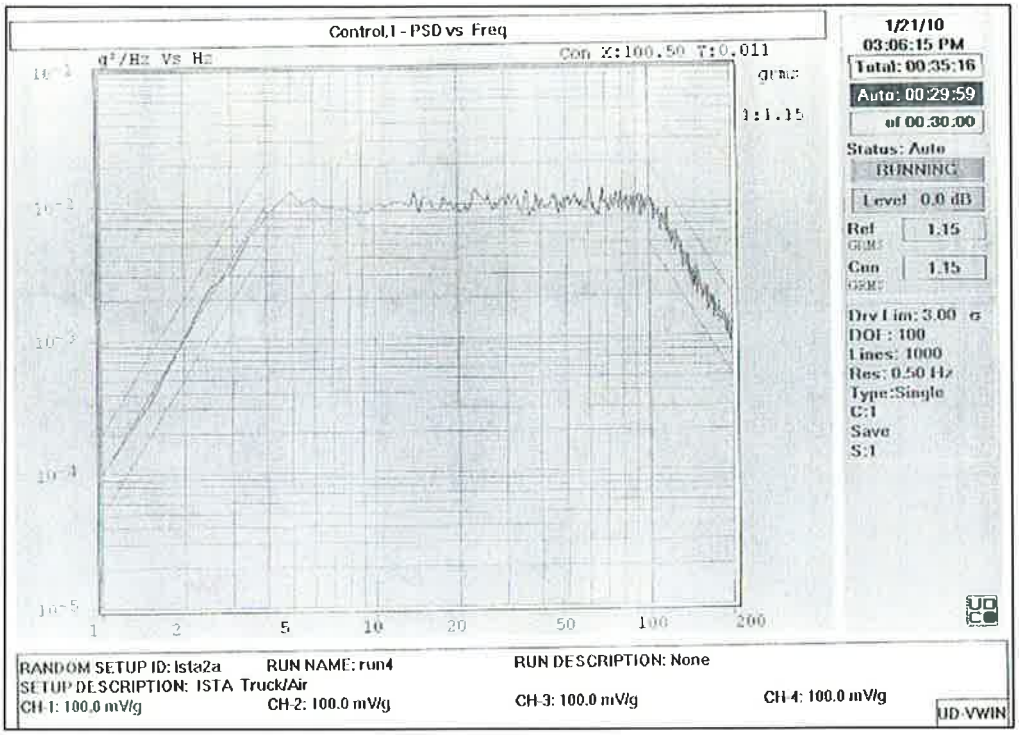
Exit Criteria:

Complete test method defined above.

Results:

The NA 2 WAY radios successfully completed the Package Vibration Transportation testing. The devices remained operational before and after testing was completed.

Figure 15: Operating Vibration Profile (TX ID 13001062/1063 – Z Axis).



4.6 NA 2 WAY Reliability –TC–10.5 Package Drop - Shock

Objective:

Verify functionality after exposure to the shipping shock profile.

Test Date:

1/22/10

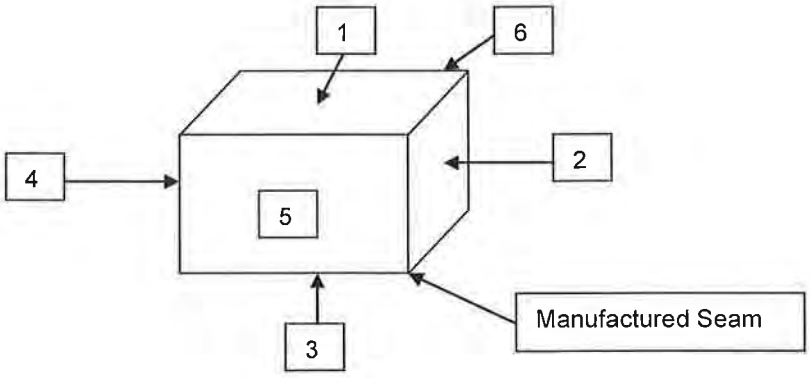
Test Equipment:

Lansmont Drop Tester
Model #: PDT-S
S/N: M-12641
IBM Thinkpad Laptop
NA2W Message Utility Software
Version: 0.0.1.28
3 NA 2 WAY Radios
Model # 520
TX ID: 013000564, 013000546, 013000570, 013000571
Sensus Command Link
Model #: CL 100
S/N: CL50202297

Test Setup:

The shipping container (Box) consists of a single walled corrugated cardboard box that is 17" x 14.5" x 16.25" (Height, Width, Depth). The shipping container is capable of holding 27 NA 2 WAY Radios (9 radios per layer) with 3 layers separated by a piece of single walled corrugated cardboard. Three (3) samples were used for the package drop test. The radios were tested to confirm operation and then placed into the shipping container with the remaining space filled with cork board to make the shipping container equivalent weight (Approx. 28 lbs) as if it were full of radios. The shipping container was marked as follows:

Figure 16: Face Identification



Box numbering is dependent on location of manufactured seam

1 = Top
2 = Right Side
3 = Bottom
4 = Left Side
5 = Front
6 = Rear

Method:

The weight of the shipping container (when full is approx. 28 lbs) and the drop height for that weight is 32".

Test Sequence:

1. Perform Pre Operational Verification Procedure
2. Drop 2-3-5 corner
3. Drop shortest edge radiating from 2-3-5 corner
4. Drop next longest edge radiating from 2-3-5 corner
5. Drop longest edge radiating from 2-3-5 corner
6. Drop one of smallest faces
7. Drop opposite face
8. Drop one of the medium faces
9. Drop opposite medium face
10. Drop one of the largest faces
11. Drop opposite large face
12. Perform POST Operational Verification Procedure

Exit Criteria:

Complete test method defined above.

Results:

The NA 2 WAY radios successfully completed the Packaging Drop-Shock testing, devices remained operational before and after testing was completed.

The following issues were observed with the shipping container supplied by Sensus.

1. The manufacture seam is starting to split. If the shipping container splits open product will no longer be contained and increases the chances of damaged product (See figure 24).
2. The TouchCoupler TR/PL Adaptor Prongs were pushed through the inside cardboard divider. This issue has the potential to crack of break the TouchCoupler TR/PL prongs.

5 NA 2 Way Reliability– TC 20 - Life Testing

5.1 NA 2 WAY Reliability –TC–20.1 HALT Testing

Objective:

The product was subjected to the stresses to uncover design and/or process weaknesses within the temperature and vibration ranges specified. These stresses included thermal dwells, rapid temperature transitions, vibration and combined environments.

Test Date:

1/5/10-1/8/10

Test Equipment:

Description	Manufacturer	Model	S/N	Cal Due
Test Chamber	Qualmark	Typhoon 4.0	Beta1	5/1/09
Chamber thermocouples Note 1	Omega	C03-T-60	N/A	N/A
Spectrum Analyzer Note 2	Nat'l	Qualmark		
ICP Power Supply	PCB	483C	483C05	8/2010
Accelerometer channel 1	Dytran	3030B5	8419	6/10
Accelerometer channel 2	Dytran	3032M9	2336	11/10
Accelerometer channel 3	Dytran	3032M9	2332	8/10
Accelerometer channel 4	Dytran	3023M23	4495	2/10
Accelerometer channel 5	Dytran	3023M23	4495	2/10
Accelerometer channel 6	Dytran	3023M23	4495	2/10

Test Setup:

The product was tested 3 units at a time. The product was secured using aluminum extrusions and all thread rods. For additional detail refer to document "Qualmark Modified HALT Report T26996".

Set	Serial Number	Part Number	Date in test	Tests Performed			
				Thermal	Rapid	Vibe	Combined
1	013000580	NA2W	1/5/10	X	X	X	X
2	013000554	NA2W	1/5/10	X	X	X	X
3	0130001150	NA2W	1/5/10	X	X	X	X

Method:

Temperature step testing in 10°C steps to a minimum of –75 and a maximum of 80°C, rapid thermal stresses of 5°C/min, 10°C/min and 15°C/min between those extremes.
Vibration stresses to 30 Grms, in 5 Grms steps, and a final combined environment that included rapid thermal stresses and vibration step stresses within the limits specified. For additional detail refer to document "Qualmark Modified HALT Report T26996".

Exit Criteria:

Complete test method defined above.

Results:

Thermal Step Stress

The product was subjected to cold thermal step stress beginning at +20°C, with the temperature decreasing in 10°C increments. Once the control thermocouple reached the setpoint temperature, the product dwelled at that setpoint for 20 minutes Upon completion of cold thermal step stress the product was returned to ambient and remained there until full functionality was verified. Hot thermal step stress began at a setpoint temperature of +30°C with the temperature increasing in 10°C increments. Once the control thermocouple reached the setpoint temperature, the product dwelled at that setpoint for 20 minutes. The results of thermal step stress testing are summarized in Table 7.

Table 3: Thermal Steps

Setpoint (°C)	Functional Test Results	Notes
+20	Pass	
+10	Pass	
0	Pass	
-10	Pass	
-20	Anomaly	1
-30	Anomaly	1
-40	Fail	2
-50	Fail	3
+20	Pass	4
+30	Pass	
+40	Pass	
+50	Pass	
+60	Pass	
+70	Pass	
+80	Pass	
+85	Pass	
+20	Pass	

Notes:

1. On ramp from –20 to –30°C, and during –30 dwell, infrequent status reporting on unit #3. Continued testing.
2. At –40°C, unit #3 stopped reporting completely. Continued testing.
3. At –50°C, all units stopped reporting except #3. Unit #3 reported only 3 times during the dwell. Functional limit.
4. After a 30 minute dwell at 20°C, all units returned to normal.

Temperatures were recorded at several points on the product during testing. The temperatures recorded at each location at each setpoint during thermal step stress are shown in Table 4.

Table 4: *Temperatures During Thermal Step Stress (°C)*

Setpoint	*TC1*	*TC2*	*TC3*
+20	20.1	19.7	19.1
+10	11.1	10.6	10.7
0	1	.4	.7
-10	-8.9	-9.6	-9.1
-20	-19.1	-19.7	-19.2
-30	-29.1	-29.6	-29.2
-40	-39.6	-39.9	-39.4
-50	-49.9	-50.1	-49.2
+20	19.2	20.1	19.3
+30	28.9	29.8	28.9
+40	38.9	39.8	38.8
+50	48.8	49.7	48.6
+60	58.6	59.5	58.3
+70	68.7	69.5	68.1
+80	78.5	79.4	78
+85	84	84.6	83.2

Rapid Thermal Transitions

Rapid Thermal Transitions The device under test was subjected to 9 temperature cycles from −30°C to +65°C at transition rates of 5, 10 and 15 °C/min. Dwell time at each setpoint was five (5) minutes. The average thermal transition rate was set to meet customer specifications. Air temperature limits were set to−80°C and +100°C to prevent excessive overshoot. The results of rapid thermal transitions are summarized in Table 5.

Table 5: *Rapid Thermal Transition Results*

Cycle	*Setpoint (°C)*	*Functional Test Results*
20		Pass
1	85	Pass
transition		Pass
1	-30	Pass
transition		Pass
2	85	Pass
transition		Pass
2	-30	Pass
transition		Pass
3	85	Pass
transition		Pass
3	-30	Pass
transition		Pass
4	85	Pass
transition		Pass
4	-30	Pass
transition		Pass
5	85	Pass
transition		Pass
5	-30	Pass
transition		Pass
6	85	Pass
transition		Pass
6	-30	Pass
transition		Pass
7	85	Pass
transition		Pass
7	-30	Pass
transition		Pass
8	85	Pass
transition		Pass
8	-30	Pass
transition		Pass
9	85	Pass
transition		Pass
9	-30	Pass
transition		Pass
	20	Pass

Vibration Step Stress

Vibration Step Stress was performed at ambient temperature (+20°C). The device under test was subjected to vibration step stress beginning at a setpoint of 5 Grms with the vibration setpoint increasing in 5 Grms increments at 10 minute intervals. Testing was stopped when setpoint reached 30 Grms, per customer's test specification. The results are summarized in Table 6.

Table 6: *Vibration Step Stress Results*

Setpoint (Grms)	*Functional Test Results*
5	Pass
10	Pass
15	Pass
20	Pass
25	Pass
30	Pass

Vibration levels, in Grms, were recorded at several points on the product during testing. The bandwidth for product response measurements was from 12Hz to 5,000 Hz using a spectrum analyzer with a digital filter at 5,000 Hz. The measurements are summarized in Table 7.

Table 7: Vibration Levels Measured During Vibration Step Stress (Grms)

Chamber Setpoint	*Channel 1 12Hz-5kHz*	*Channel 2 12Hz-5kHz*	*Channel 3 12Hz-5kHz*	*Channel 4 12Hz-5kHz*	*Channel 5 12Hz-5kHz*	*Channel 6 12Hz-5kHz*
5	4.84	3.04	2.57	1.54	.97	2.06
10	10.39	8.64	6.64	4.5	4.41	6.82
15	16.21	13.63	10.66	7.24	7.75	11
20	21.5	18.28	13.72	8.87	12.34	13.84
25	26.34	24.93	15.82	11.55	17.7	18.68
30	31.43	31.12	19.7	13.31	21.22	22.49

Combined Environment

The product was subjected to temperature cycles from -30°C to +80°C at an average thermal transition rate of 15°C per minute combined with vibration. Vibration began at a setpoint of 5 Grms and was increased in 5 Grms increments at the end of each thermal cycle. Dwell time at each setpoint was 10 minutes. The results are summarized in Table 8.

Table 8: Combined Environment Results

Cycle	Temp °C	Vibe Grms	Functional Test Results
	+20	0	Pass
1	+85	5	Pass
1	-30	5	Pass
2	+85	10	Pass
2	-30	10	Pass
3	+85	15	Pass
3	-30	15	Pass
4	+85	20	Pass
4	-30	20	Pass
5	+85	25	Pass
5	-30	25	Pass
6	+85	30	Pass
6	-30	30	Pass
	+20	0	

5.1 NA 2 WAY Reliability –TC–20.5 Stress Analysis / Component Derating

Objective:

The practice of limiting thermal, electrical and mechanical stresses on parts to levels below their specified rating is called derating. For a product to operate reliably one significant factor is the degree to which the components are derated in the application.

Test Date:

1/5/10-1/8/10

Test Equipment:

Fluke model Ti40 thermal Imager (Calibration due 12/02/10)

Test Setup:

One NA 2 Way radio was disassembled.

Method:

Thermal and electrical derating analysis was performed on the components of the subject product. This is done to determine level of stress for each of the components in the Bill of Materials (BOM) provided by the customer. These stress levels are then evaluated against a standard and exceptions noted. Engineering judgment must be applied to the results of this analysis to determine if any changes to components are required.

Exit Criteria:

Complete test method defined above.

Results:

Thermal Derating Results

- No components were found to be thermally overstressed at nominal lab ambient Conditions.
- 12 components were found to be thermally overstressed at the maximum operational temperature of 85°C. However, in each case this is due to the components being rated at 85°C maximum operating temperature.

Electrical Derating Results

- No components were found to be electrically overstressed.

Figure 17: *Environmental Test Setup*

Figure 18: NA 2 WAY Reliability –TC–10.4 Operational Vibration *(X axis)*

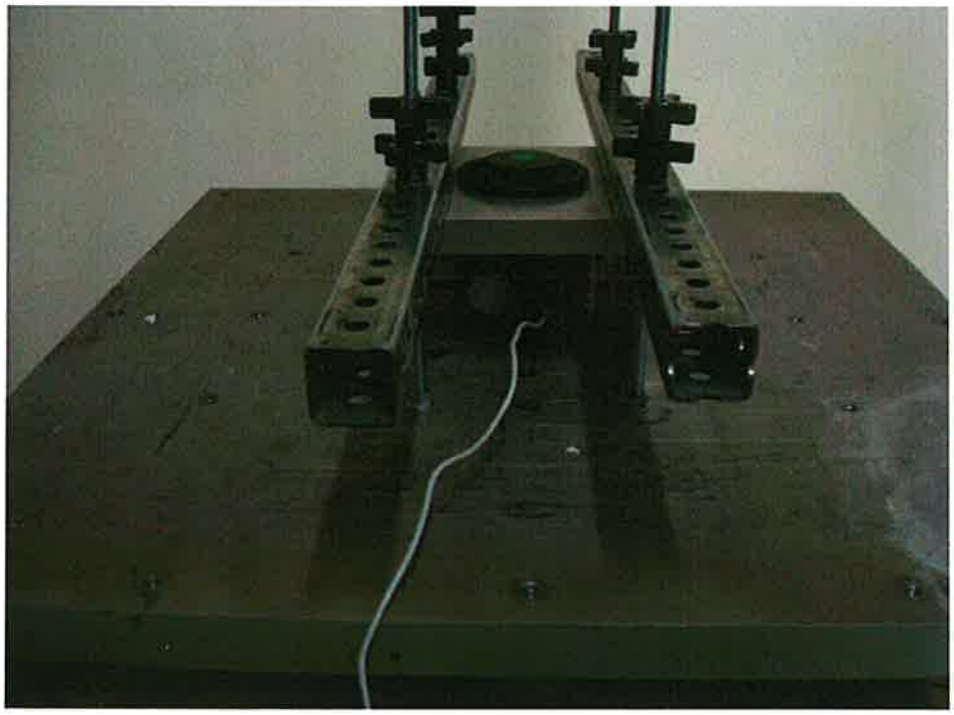


Figure 19: NA 2 WAY Reliability –TC–10.4 Operational Vibration *(Y axis)*

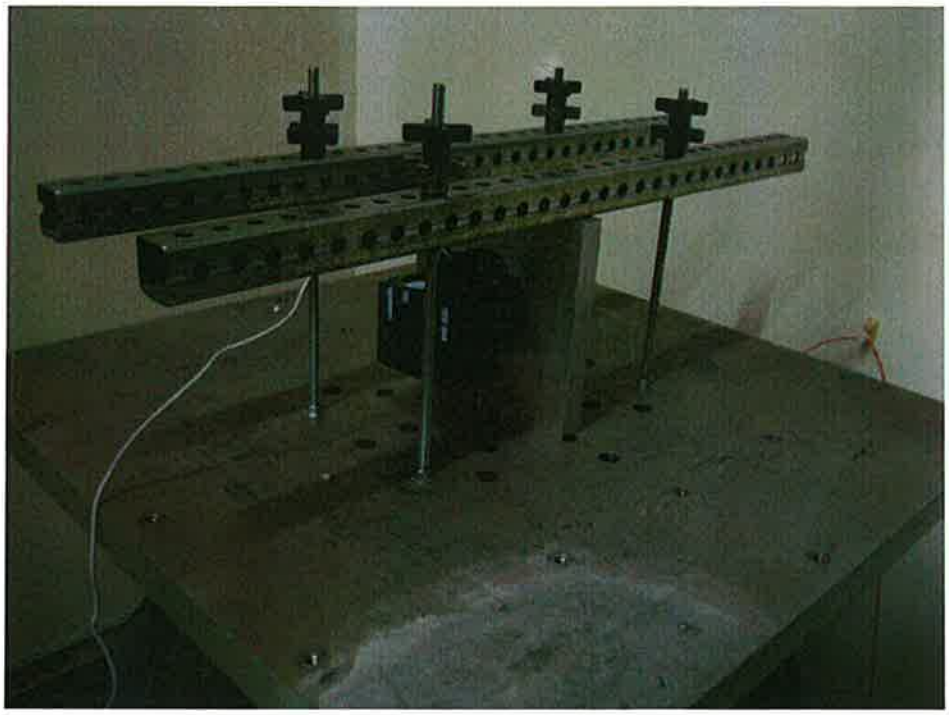


Figure 20: NA 2 WAY Reliability –TC–10.4 Operational Vibration *(Z axis)*

Figure 21: Shipping Container

Figure 22: Packaging Vibration

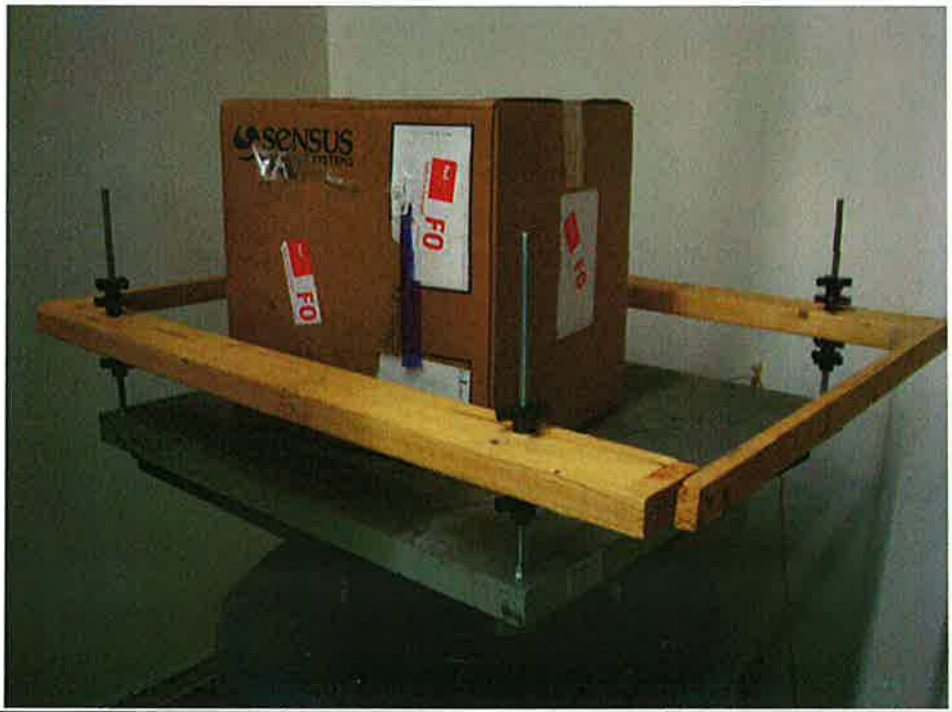


Figure 23: Packaging Drop – Shock (2-3-5 corner drop)

Figure 24: Shipping container (Seam Split – 2-3-5 corner)

Figure 25: *TouchCoupler TR/PL Adaptor Prongs*

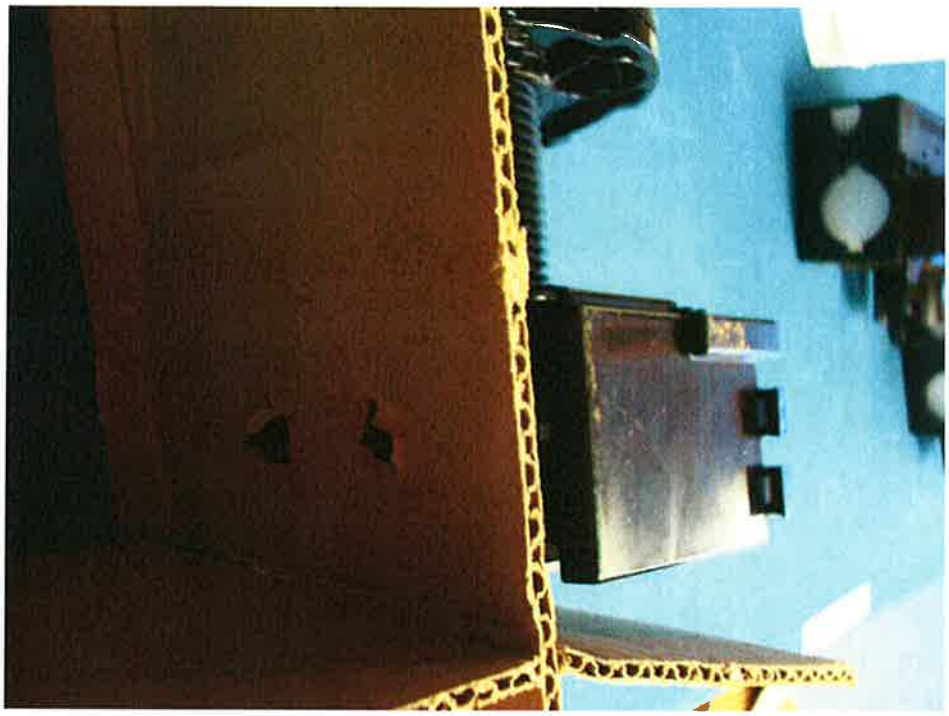
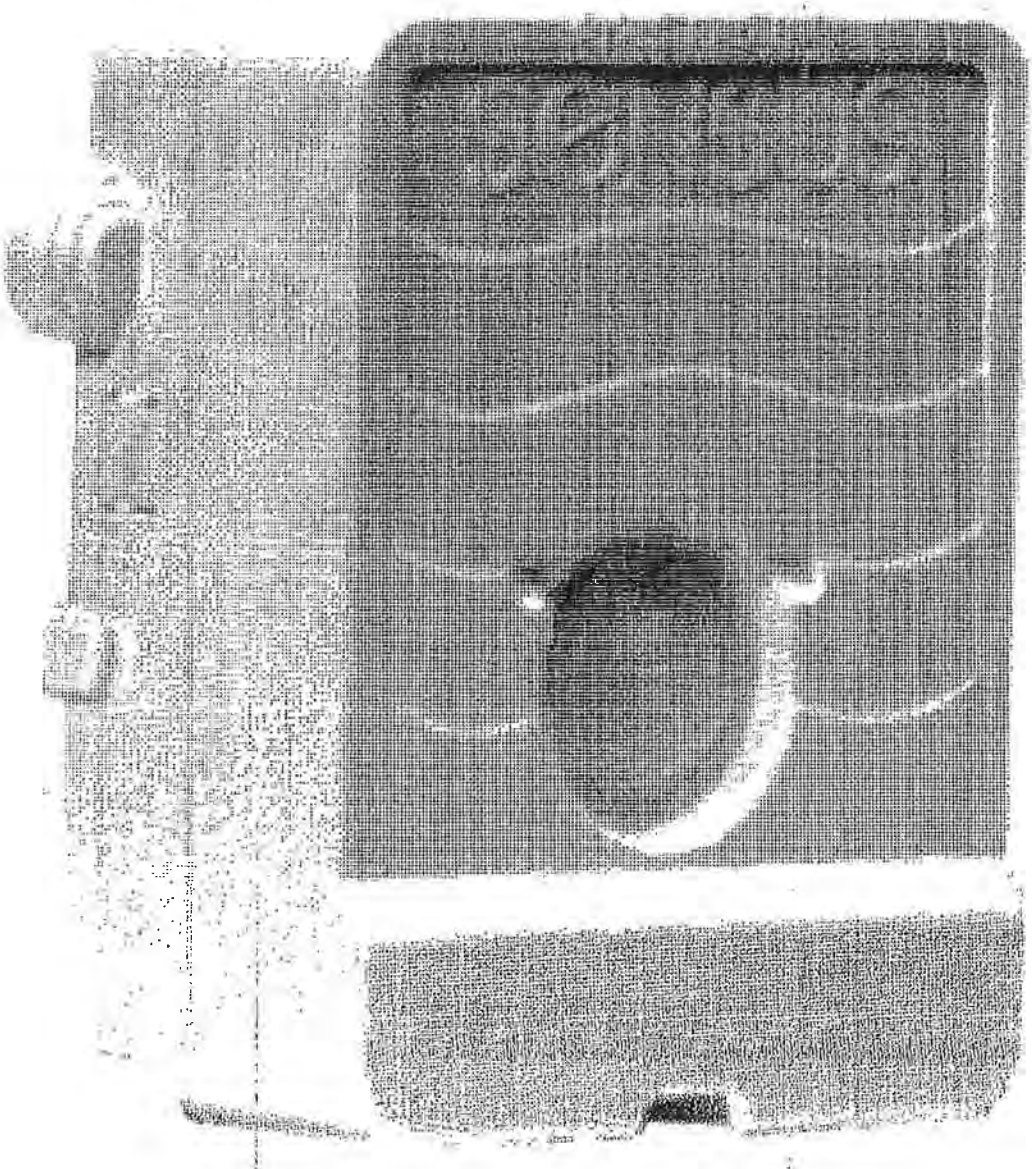


Figure 26: Sensus Command Link

APPENDIX D – 510M AND 520M

PHOTOGRAPHS

SENSUS 510M



SENSUS 520M