STATSIGNAL

Water Meter Interface
Technical Specifications

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Change History

✶ Revision 0.2

- Changed Microprocessor & Radio Models
- Changed Temperature Requirements – paragraph 14.1
- Added Submersion requirements - paragraph 14.3

✶✶ Revision 0.2 – Update

- Updated Microprocessor Requirements – paragraph 7.1
- Added Microprocessor's Operational requirements – paragraph 7.1.1

- Updated RF Radio requirements – paragraph 7.2.1
- Updated Antennae Requirements – paragraph 7.2.2
- Updated Communication with Test System – paragraph 7.3
- Updated Communication with Installation Maintenance System – paragraph 7.4
- Updated Communication Over the Internet – paragraph 7.5

Table of Contents

Table of Contents

1.   Scope

This document is providing the technical specifications for a "Badger" Water Meter Interface that shall be utilized to provide Automatic Meter Reading capability at sites where automatic meter reading may be incorporated.

2.   Unit Description

The Water Meter Interface shall be comprised of a single Texas Instruments MSP430 series microprocessor, dual wire interface with an 8-bit counter to interface with the water meter, a SS 5494 RF Transceiver, a serial programming link connection, and a power supply.
The Water Meter Interface shall accumulate, and, on command, transmit the total Water meter pulses directly (or indirectly) to a Site Controller.
The Meter Interface SHALL NOT function as a Repeater.

3.   Definitions

ANSI - American National Standards Institute.
An organization which promulgates standards on various technical topics.

ASCII - American Standard Code for Information Interchange

ASME - American Society of Mechanical Engineers(International)

Battery Back-Up Function - That function providing operational power for a piece of equipment in the absence of AC Mains (Primary AC Power) by use of a Secondary Battery or some other energy storage device such as a super capacitor.

CCITT - Comite Consultatif Internationale de Telegraphique et Telephonique (Consultative Committee on International Telephone and Telegraphy). Recently renamed the ITU-T.
An organization which promulgates various standards for telephony including modems and facsimile.

CFR - Code of Federal Regulations

CFR Title 47 - The Section of the Code of Federal Regulations, which is promulgated by the FCC.

Classified Location - A location designated by NFPA Codes as being a hazardous location because of danger of explosion.

CRC - Cyclic Redundancy Check Sum - A number which is the remainder of dividing (modulo two division) the message as a large number by the generating polynomial. This check sum is used to detect transmission errors in communications links in order to request a transmission be repeated until received correctly.

Digital Subscriber Line (DSL) - A data communications technology that offers faster Internet connection than a standard analog connection.

EIA - Electronic Industries Alliance - An organization composed of various manufacturers and developers of electronic equipment that, as a part of its function, promulgates standards on various topics. ANSI/TIA/EIA-232-D, the Electrical interface for modems, is the most notable of the standards.

ETL - ETL SEMKO, a division of Intertek Testing Services, a company that provides recognized third party testing services to UL and NFPA standards and Lists products as conforming to those standards and usable in the application for which it is listed. ETL does not promulgate standards such as UL does.

FCC - Federal Communications Commission

GMT - Greenwich Mean Time. The time in Greenwich, England, that is used as a standard time. In some cases, this time may also be referred to as "Zulu" time and noted with the addition of a "Z" to the time notation.

Hot Terminal - The manned terminal located at the Host Site responsible for the monitoring of, and taking required actions for, alarm/emergency signals received from the Site Controller(s).

IEC - Commission Electrotechnique Internationale (International Electrotechnical Commission)
An international standards promulgating committee which publishes standards on various Electrical, information technology and mechanical subjects.

IEEE - Institute of Electrical and Electronic Engineers,Inc.
A professional organization which also promulgates standards

used in industry.

Installation Maintenance System - A system operating on a small
personal computer and using a RF transmitter/receiver, which
verifies and maps RF communication between devices and provides
said information to an Internet Service Provider.

ISA - Instrument Society of America
An international society for instrumentation and control.

Intentional Radiator - An electronic system that intentionally
(by design) radiates radio frequency energy in order to perform
its functions.

Internet - A global information system that

> (1)   Is logically linked together by a globally
>   unique address space based in the Internet
>   Protocol (IP) or its subsequent extensions
>   and/or follow ONS;
>
> (2)   Is able to support communications using the
>   Transmission Control Protocol/Internet Protocol
>   (TCP/IP) or its subsequent extensions and/or
>   follow ONS, and/or other IP compatible
>   protocols;
>
> (3)   Provides, uses, or makes accessible, either
>   publicly or privately, high level services
>   layered on the communications and related
>   infrastructure described herein. [From the
>   Federal Networking Council (FNC), an
>   organization chartered by the United States
>   government]

ITU-T - International Telecommunication Union-Telecommunications
(nee CCITT, see above).

NEC - National Electrical Code (NFPA 70, 1999)

NFPA - National Fire Protection Association
This organization is a publisher of safety codes which are used by UL in the generation of their standards and are passed
as having the force of law by various local jurisdictions.

Personal Safety/Security Devices - Devices performing safety or
security functions such as fire or intrusion alarms or medical

or panic alarms.

Primary Battery - A non-rechargeable battery that is generally
the primary source of power for some circuit or device.

Repeater or Repeater Function - An item of equipment which may
operate as a radio frequency repeater by receiving a
transmission from one device and passing it to a second device
by retransmitting the message, or some slightly changed version
thereof.

Symmetric Digital Subscriber Line (SDSL) - The digital
subscriber line technology that provides the same bandwidth in
both directions, upstream and downstream.

Secondary Battery - A rechargeable battery. As the battery is
charged, an external power source is available making the
Secondary Battery the secondary source of power for a circuit or
device.

Safety System - A system comprised of Personal Safety Devices.

TCP/IP - Transmission Control Protocol/Internet Protocol
Refer to various ITU-T (formerly CCITT) standards and
specifications.

Test System - A system used only in the factory to test
components (i.e., printed circuit boards) for the Transceiver/RF
Repeater, Water Meter Interface, Smoke Detector Communication
Device, and Personal Security Device (FOB).

TIA - Telecommunications Industry Association - A part of EIA.

UDP - User Datagram Protocol (Refer to STD-6, RFC-768)

UL - Underwriters Laboratories, Inc.
A non-profit organization that publishes equipment safety
Standards and tests and lists such equipment, which meets those
standards.

Unintentional Radiator - An electronic system that
unintentionally radiates radio frequency energy as a result of
the use of digital design techniques in order to perform its
functions.

4.   Trademark Registrations

ASME	–	The registered Trademark representing the American Society of Mechanical Engineers International
Atmel	–	The registered Trademark representing Atmel Corporation
AVR	–	A registered Trademark for a family of small microprocessors owned by Atmel Corporation
ETL	–	A registered Trademark owned by Intertek Testing Services (also a Listing Mark)
FERRUPS	–	A registered Trademark owned by Best Power Technology, Inc.
IEEE	–	The registered Trademark representing the Institute of Electrical and Electronic Engineer, Inc.
ISA	–	The registered Trademark representing the Instrument Society of America
Linux	–	The registered Trademark representing Linus Torvalds
Motorola	–	A registered Trademark representing Motorola,Inc.
NFPA	–	The registered Trademark representing the National Fire Protection Association
Red Hat	–	The registered Trademark representing Red Hat Software, Inc.
RF Monolithics	–	The registered Trademark representing RF Monolithics, Inc.
UL	–	The registered Trademark representing Underwriters Laboratories, Inc. (also a Listing Mark)

5.   Applicable Regulatory and Other Agency Documents and Standards

CFR Title 47, Part 15, Subpart B	–	(for Unintentional Radiators)
CFR Title 47, Part 15, Subpart C	–	(for Intentional Radiators)
CFR Title 47, Part 68	–	(Requirements for Telephony Equipment connecting to the Public Telephone Network)

IEC 6SS5494-4 Parts 2, 3, & 4 – (International Standards for Electromagnetic Compatibility)

IEEE C62.36 – (Standards for Lightning and Impulse Noise Protection for Communications Lines)

IEEE C62.41 – (Standards for Lightning and Impulse Noise Protection for AC Mains Connections)

NEC – National Electrical Code (see NFPA 70)

NFPA 70, 1999 – (Latest Edition of the National Electrical Code (NEC))

NFPA 72, 1999 – (Latest Edition of Nation Fire Alarm Code)

NFPA 110, 1999 – (Standard for Emergency and Standby Power Systems)

NFPA 111, 2001 – (Standard on Stored Electrical Energy, Emergency and Standby Power Systems)

UL 50 – Enclosures for Electrical Equipment

UL 294 – The Standard for Access Control System Units

UL 365 – The Standard for Police Station Connected Burglar Alarm Units and Systems

UL 603 – Standard for Power Supplies for use with Burglar Alarm Systems

UL 609 – The Standard for Local Burglar-Alarm Units and Systems

UL 611 – The Standard for Central-Station Burglar-Alarm Systems

UL 636 – The Standard for Holdup Alarm Units and Systems

UL 639 – The Standard for Intrusion-Detection Units

UL 681 – Standard for Installation and Classification of Burglar and Holdup Alarm Systems

UL 827 – Standard for Central-Stations for Watchman, Fire-Alarm and Supervisory Services

UL 1023	- The Standard for Household Burglar-Alarm System Units
UL 1037	- The Standard for Antitheft Alarms and Devices
UL 1076	- The Standard for Proprietary Burglar Alarm Units and Systems
UL 1481	- The Standard for Power Supplies for Fire Protection Signaling Systems
UL 1610	- The Standard for Central-Station Burglar-Alarm Units
UL 1635	- The Standard for Digital Alarm Communicator System Units
UL 1641	- The Standard for Installation and Classification of Residential Burglar Alarm Systems
UL 1950	- Safety of Information Technology Equipment Including Electrical Business Equipment
UL 1981	- Central Station Automation Systems

6. Applicable StatSIGNAL Systems Documents

9000075	- SOS OEA Packet Message Protocol (RF)
9000089	- Water Meter Interface Theory of Operation
9000090	- Repeater Function Theory of Operation
9000091	- Model SS5494 Transceiver/RF Repeater (Previously the Site Controller RF-RS232 Converter) Theory of Operation
9000092	- Water Meter Interface Installation Procedures
9000094	- Personal Security Device (FOB) Theory of Operation
9000095	- Model SS5494 Transceiver/RF Repeater Design Specifications
9000096	- Internet Service Provider (ISP) Design Specifications
9000097	- Hot Terminal (HT) Design Specifications
9000098	- Entry Point (EP) Design Specifications

7.   Detailed Description of Unit

7.1   Microprocessor

The Water Meter Interface shall use a 16-bit TI MSP 430 Series microprocessor having a minimum 16K program memory space to store the device function's program as well as the program of the device in which it resides.

Additionally, it shall have a minimum of 256 bytes of RAM for message storage not used for any other purpose.

7.1.1   Operational Characteristics

The following operational characteristics shall be applicable to the TI-MSP 430 Microprocessor, used by the Water Meter Interface:

Absolute Maximum Ratings

Operating Temperature	-40°C to $+85^{o}$C
Storage Temperature	
Programmed	-40°C to $+85^{o}$C
Un-programmed	-55°C to $+150^{o}$C
Operating Voltage	4.1 VDC Maximum

Electrical Characteristics

I/O Pin Current	2 mA Maximum
VCC	1.8 VDC to 3.6 VDC

Physical Characteristics

Re-programmable FLASH Memory	16K Bytes
Internal SRAM Memory	512 Bytes
FLASH Data Memory	256 Bytes

7.1.2   Data to be Stored

7.1.2.1   Application Program

The application program shall be stored

in FLASH memory of the microprocessor.
The application program shall be stored
(loaded) by either the Test System or,
if need arises, by the Installation
Maintenance System.

7.1.2.2   Device Identification and Address Data

The Device Identification and Address
data, a string of six bytes, shall be
stored in FLASH. This data string shall
be assigned at time of installation or
production in accordance with the
Device Address and Identification
Specification. The Water Meter
Interface shall have a "Device
Identification" of 84_{Hex}.

7.1.1.3   Up-Stream Addresses

One or two up-stream addresses shall be
stored in FLASH when received from the
Site Controller. These addresses shall
be utilized to transmit messages in
response to commands issued by the Site
Controller.

7.1.1.4   Totalizer

The totalizer shall consist of Five
Bytes of binary coded decimal data (ten
digits) that represent the total number
of pulses detected by the 8-bit counter
interfaces from a predefined (assigned)
starting number.

The assigned starting number may be
loaded into FASH e time of
installation. The starting number
shall be zero when the Water Meter
Interface is manufactured.

The totalizer (five bytes) shall be
maintained in the microprocessor's RAM.

Whenever a low battery condition is
detected, the totalizer count shall be
automatically loaded into FLASH by the
microprocessor.

7.2   Communication with Transceiver/RF Repeater

The Water Meter Interface shall communicate with a
Repeater (or the SS5494 Transceiver/RF Repeater) via a
RF Link described in the following paragraphs:

7.2.1   Radio Frequency Communications

The Water Meter Interface shall use StatSignal
SS5494 radio link (half duplex) operating at a
radio frequency of 916.5 MHz with bit speed of
4,800 bps and a data bit speed of 2,400 bps with
Manchester Encoding

The SS5494 radio/Transceiver shall provide stable
RF and detector gain without any special
shielding or decoupling provisions.

The following operational characteristics shall
be applicable to the SS5494 Radio/Transceiver
used by the Water Interface:

Absolute Maximum Ratings

Power Supply and All	-0.3V to +4.0V
Input/Output Pins	
Temperature	
Non-Operating	-50°C to $+100^{o}$C
Soldering (10 Seconds)	$+230^{o}$C

Electrical Characteristics

Operating Frequency	916.3 to 916.7 MHz
Modulation Type	On-Off Keyed (OOK)
Data Rate	2,400 bps

Receiver Performance

Input Current (3VDC Supply)	1.8 mA Maximum
Input Signal for 10^{-4} BER,	25 C -98 dBm
Rejection, +/-30 MHz	55 dB Minimum

Transmitter Performance

Peak Input Current (3 VDC Supply)	12 mA Maximum
Peak Output Power	0.75 mW
Turn On Time	12 usec Maximum
Turn Off Time	6 usec Maximum
Sleep to Receive Switch Time	200 usec
Sleep Mode Current	5 uA Maximum
Transmit to Receive Switch Time	200 usec
Receive to Transmit Switch Time	12 usec
Power Supply Voltage Range	+2.7 to +3.5 VDC
Operating Ambient Temperature	-40°C to $+85^{\circ}$C

The CENTRON Meter Interface shall conform to the requirements of SOS OEA Packet Message Protocol (RF), Document number 9000075, in all respects.

7.2.2   Antenna

The Water Meter Interface shall use an antenna, with an impedance range of 35 to 72 ohms resistive, along with a series matching coil and a shunt matching/ESD protection coil, shall be mounted on the printed circuit board to provide RF signal reception and transmission.

7.3   Communication with Test System

Communication with the Test System shall be via a 5-wire JTAG connector, using the standard TI software and serial programmer to program the software at a speed of 1.0kbytes/second.

7.4 Communication with Installation Maintenance System

Communication with the Installation Maintenance System shall use an RF connection utilizing the SS5494 radio link at a frequency of 916.5 and a speed rate of 2400bps. This shall be done using the StatSignal standard SOS-OEA protocol.

7.5 Communication over the Internet

Communication over the Internet shall be via an always-on connection, using an RF connection utilizing the SS5494 radio link at a frequency of 916.5 and a speed rate of 2400bps. This shall be done using the StatSignal standard SOS-OEA protocol.

7.6 Operational Description

The Water Meter Interface shall perform the following operations:

7.6.1 Count Meter Pulses

The Water Meter Interface shall use an 8-bit binary counter to count meter pulses. The Water Meter Interface shall consider any pulse of 10 milliseconds or more in durations to indicate consumption. The meter pulses count shall be totalized and stored in RAM (or in FLASH if low battery condition is detected) for later recovery.

7.6.2 Message Transmission

The Water Meter Interface, using the SS5494 radio link, shall transmit data in response to commands issued by the Site Controller. Message transmission and acknowledgement shall be in accordance with the requirements established in SOS OEA Packet Protocol (RF), Document Number 9000075.

7.6.3   Power Supply

The power supply for the Water Meter Interface shall consist of two (2) BR-A 3V "Lithium" batteries to provide operational power for the water meter microprocessor and RF transceiver circuits.

8.   Firmware

The firmware for the microprocessor utilized by the Water Meter Interface shall be written in assembly language.

9.   Commands

The Water Meter Interface shall respond to, or generate, the following command messages:

9.1   Device Install Command (0x80) Command

The command "80" shall be used to notify the Site Controller when a new device is attempting to install itself into the network. When a new device is first powered up, it shall broadcast this command once every hour for 24 hours or until the Site Controller responds with a Command 43. The Command 43 is used to load the device's Upstream-Address Table with either all zeros (for an non-repeating device) or a valid upstream address (for a device acting as a repeater). Once the Upstream-Address Table is loaded with something other than all FF's, the device installation is complete. Any device shall be forced to re-install itself by writing all FF's into its Upstream-Address Table using Command 43.

9.2   Broadcast Wake-up Beacon (0x50) Command

This command, shall be placed in a message by the Site Controller, and used to force a device to broadcast a wake-up beacon signal. The wake-up beacon shall be used to place one or more "sleeping" devices into their normal operating state (awake). Two parameters must be sent with this command in the data area of the packet:

aaaaaaaaaaaa   - target device address (6 bytes)

tt   - beacon duration in seconds (1 byte)

Note: If the first byte of the target address is **F0h**, then all devices, which hear the broadcast, shall wake-up.

9.3   Device Sleep (0x60) Command

This command shall be sent by the Site Controller to place a device into power-down or "sleep" mode. The purpose of this function is to conserve power in low-power or battery-powered devices. The device shall remain in "sleep" mode until it detects the presence of a wake-up beacon.

Note: If the first byte of the TO address is F0h, then all devices which hear the broadcast shall go to sleep.
If the device will not receive the command **"60"** from the Site Controller, it shall automatically go to sleep (5) five minutes (default)after it received the Broadcast Wake-up Beacon (0x50) command.

9.4   Positive Acknowledge (0x01) Command

This command message shall be placed in a message that is transmitted by the Model SS5494 Transceiver/RF Repeater back to a Water Meter Interface. This command message shall be used to acknowledge receipt of a message that is received, by the Transceiver/RF Repeater, directly from that Water Meter Interface.

9.5   Read Status (0x10) Command

The Site Controller shall place this command in a message. The command is a request for the Water Meter Interface's current status. The Water Meter Interface shall respond to this command by sending eight (8) bytes (five "totals" bytes and three "status" bytes) of information, which shall represent its current status.
 The five "totals" bytes shall consist of binary encoded decimal numbers that represent the ten digits of the current totalizer reading. The information contained in these eight bytes shall be as follows:

Totals Bytes 1-5 (Meter Reading)

```
        Byte 5 -    Decimal Count of Ticks (Most
                    Significant Byte)
        Byte 4 -    Decimal Count of Ticks
        Byte 3 -    Decimal Count of Ticks
        Byte 2 -    Decimal Count of Ticks
        Byte 1 -    Decimal Count of Ticks (Least
                    Significant Byte)


                 Status Byte 1


        Bit 7 -     Not Used
        Bit 6 -     Not Used
        Bit 5 -     Not Used
        Bit 4 -     Not Used
        Bit 3 -     Not Used
        Bit 2 -     Low Battery
        Bit 1 -     Not Used
        Bit 0 -     Not Used
```

The Error Byte is cleared when the Electric
Meter Interface responds to a Read Status Command.

```
                 Status Byte 2

        Bit 7 -     Current Reading of the 8-bit counter
        Bit 6 -     Current Reading of the 8-bit counter
        Bit 5 -     Current Reading of the 8-bit counter
        Bit 4 -     Current Reading of the 8-bit counter

        Bit 3 -     Current Reading of the 8-bit counter
        Bit 2 -     Current Reading of the 8-bit counter
        Bit 1 -     Current Reading of the 8-bit counter
        Bit 0 -     Current Reading of the 8-bit counter


                 Status Byte 3 (Retry Byte)

        Bit 7 -     Not Used
        Bit 6 -     Not Used
        Bit 5 -     Not Used
        Bit 4 -     Not Used
        Bit 3 -     Up-Stream Retry Counter (MSB)
        Bit 2 -     Up-Stream Retry Counter
        Bit 1 -     Up-Stream Retry Counter
```

Bit 0 -   Up-Stream Retry Counter (LSB)

9.6   Load Up-Stream Addresses (0x43) Command

This command, placed in a message by the Site
Controller, shall be used to load the primary and
secondary up-stream device addresses. After the device
will initialize, the Site Controller shall load the
primary and secondary up-stream device addresses with
(0) zeroes.
To force reinitialailization the Site Controller shall
reload the primary and secondary up-stream device
addresses with FF.

9.7   Response to Load Commands (0x43)

The response to any Load Command (0x43) received from
the Site Controller shall be a "Status Message". That
message shall consist of two status bytes. Information
contained in the Status Bytes shall be as follows:

        Status Byte 1

   Bit 7 -   Not Used
   Bit 6 -   Not Used
   Bit 5 -   Upstream Addresses Loaded (Bit set in
                 response to "0x43" Command.
                 Bit not set in response to "0x41" and
                 "0x42" Commands.)
   Bit 4 -   Not Used
   Bit 3 -   Not Used
   Bit 2 -   Not Used
   Bit 1 -   Not Used
   Bit 0 -   Not Used

        Status Byte 2 (Retry Byte)

   Bit 7 -   Not Used
   Bit 6 -   Not Used
   Bit 5 -   Not Used
   Bit 4 -   Not Used
   Bit 3 -   Not Used
   Bit 2 -   Not Used
   Bit 1 -   Not Used

Bit 0 –   Not Used

9.8   Tamper Alarm

The Water Meter Interface shall detect inappropriate
movement of the meter. When detecting any inappropriate
movement the Byte 1 bit 4 shall be set.
Upon next "read status" command received from the Site
Controller, this information shall be reported and then
cleared.

When detecting any inappropriate movement followed by
power failure, the device shall immediately initiate a
tamper message using its Up-stream address, as
specified in the SOS OEA Protocol, document # 9000075.

The meter interface shall provide the means for Holdup
to complete this communication.

10.   Communications Actions

The Water Meter Interface shall perform its communications
functions in accordance with the protocol established in the SOS
OEA Packet Message Protocol (RF) Specification, and as follows:

10.1   Acknowledgement Required

Acknowledgements, either positive or negative, shall be
required for all command messages processed by a Water
Meter Interface. Acknowledgements may take many forms,
and are addressed in the SOS OEA Packet Message
Protocol (RF) Specification.

10.2   Retries

The Water Meter Interface shall retransmit (retry) the
response message whenever a "positive acknowledgement"
is not received within the established fixed time out
period.

10.2.1   Retry Counters

A Water Meter Interface shall have one retry

counter. It shall be a four-bit counter that
counts the number of retries for the current
up-stream operation. The counter shall be reset
after has been reported and acknowledged.

    10.2.2   Retry Byte

The Retry Byte shall consist of the following:

Bits 0 - 3   Up-stream retry counter value
                    with Bit 3 being most
                    significant.

10.3   Time Outs

    10.3.1   Fixed Time Out

A fixed time out of twenty-five (25)
milliseconds shall result in a "negatively
acknowledged" transmission attempt if the Water
Meter Interface does not hear the preamble of
the command message being retransmitted by the
next repeater in the path.

This time out shall be reset (begin again) and
have a value of one (1) second should another
unit seize the channel before a positive
acknowledgement can be received.

    10.3.2   Random Time Out

Where the protocol calls for a Random Time Out
to be generated, that time shall be the value
(in milliseconds) of a free running counter
read when required.

11. Target Cost and Quantity

In quantities of 1,000,000 per year, the cost per unit to
manufacture a Water Meter Interface shall not exceed $30.00.

This cost does not include installation in a meter housing.

12. Meter Installation Design

The Water Meter Interface shall be designed for installation in a **Badger RTR Meter Model** that is produced by a, **Badger Meter manufacturer**. Printed Circuit board and mounting shall be designed for this class of meters only.

13. Application of UL Standards and NEC

The Water Meter Interface, when installed, shall conform to the requirements of UL 50 and UL 414 as well as NFPA 70 (NEC). In referring to UL 414, the design and installation of the Water Meter Interface shall not, in any manner, result in the Meter Socket not conforming to that Standard. A third party testing firm such as UL or ETL shall judge such conformance to UL Standards. A third party testing firm shall also judge conformance with NFPA 70 although the final approval for each installation shall rest with "the authority having jurisdiction" as defined in NFPA 70.

14. Environmental Requirements

The fully packaged Water Meter Interface shall operate correctly in all respects in the following environments:

14.1   Temperature and Humidity

The Water Meter Interface shall operate from -40°C to $+85^{\circ}$C at all humidities from 0 to 100 percent relative and condensing.

14.2   Electrical

14.2.1   Electro-Static Discharge

The Water Meter Interface shall continue to operate correctly during repeated electro-static discharges of all voltage levels from 1,000 to 25,000 volts at 0.1 joules maximum energy for air discharge and 1,000 to 8,000 volts at 0.1 joules maximum energy for direct contact discharge.

14.2.2   Radiated Noise

The Water Meter Interface shall continue to
operate correctly under both horizontally and
vertically polarized, specific frequency,
radiated Electrical fields of 200 volts per
meter from a frequency of 10,000 Hz to at least
1 Ghz.

14.3   Submersion

The Water Meter Interface shall continue to operate
correctly when submersed into minimum 6" of water.

15. Agency Approvals and Conformance to Operational Standards

In addition to the UL Standards and NFPA Codes mentioned above,
the Water Meter Interface shall be "Verified" by its
manufacturer to conform to the requirements of CFR Title 47,
Part 15, Subpart B (for Unintentional Radiators) as a Class A
Digital Device. The Water Meter Interface shall be
"Certificated" by the FCC as conforming to the requirements of
CFR Title 47, Part 15, Subpart C (for Intentional Radiators).
The terms "Verified," "Manufacturer's Verification," and
"Certificated" are used as defined in CFR Title 47, Part 15.

16. Connection to Other Equipment

The connection of other equipment to the Water Meter Interface
is not permitted under any circumstances unless such connection
is described in this Specification.

17. Life and Failure Rate

The Water Meter Interface shall be designed for a field return
rate of one-half of one percent or less annually for the first
10 years of use. This failure rate does not include
mistreatment or vandalism.