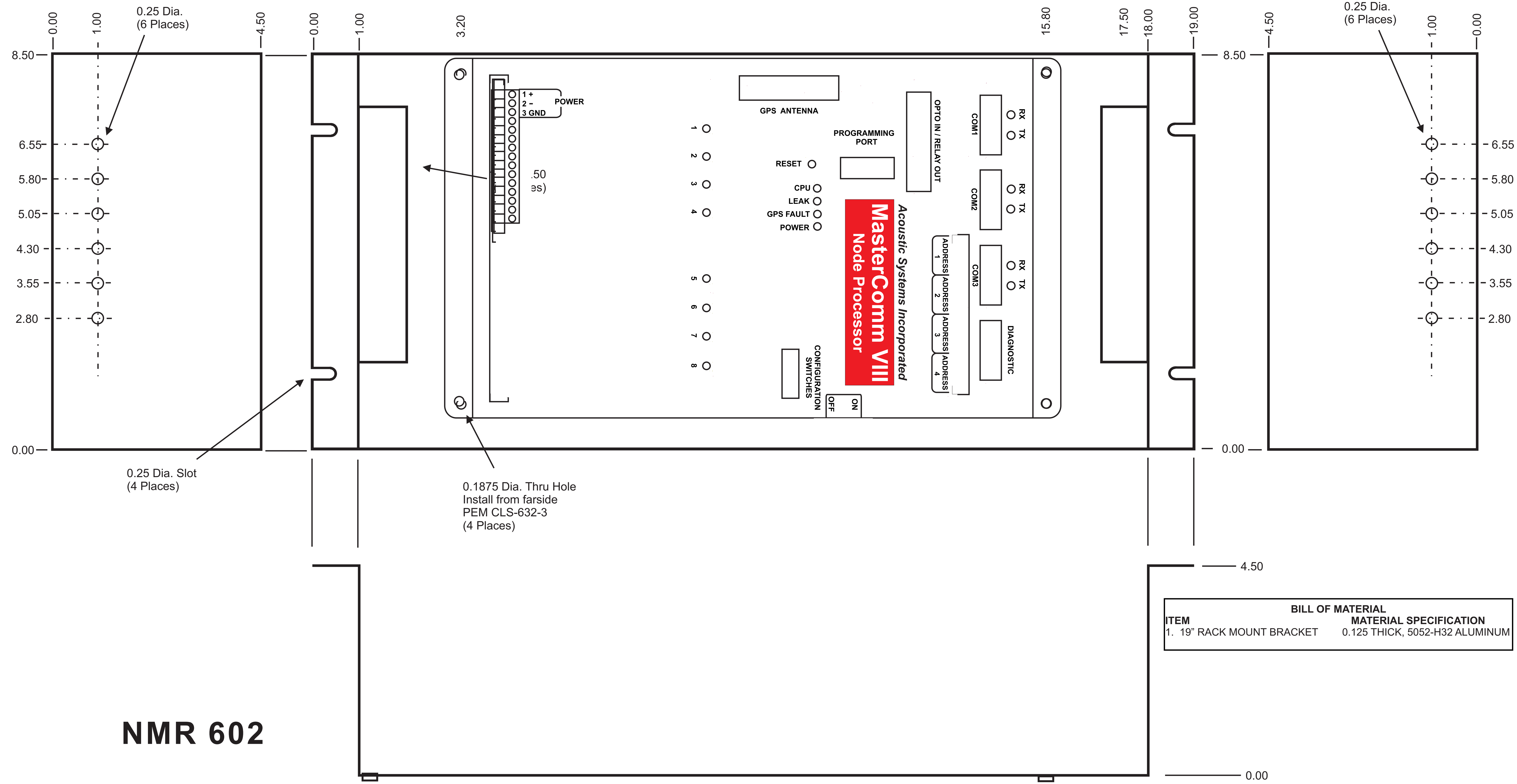


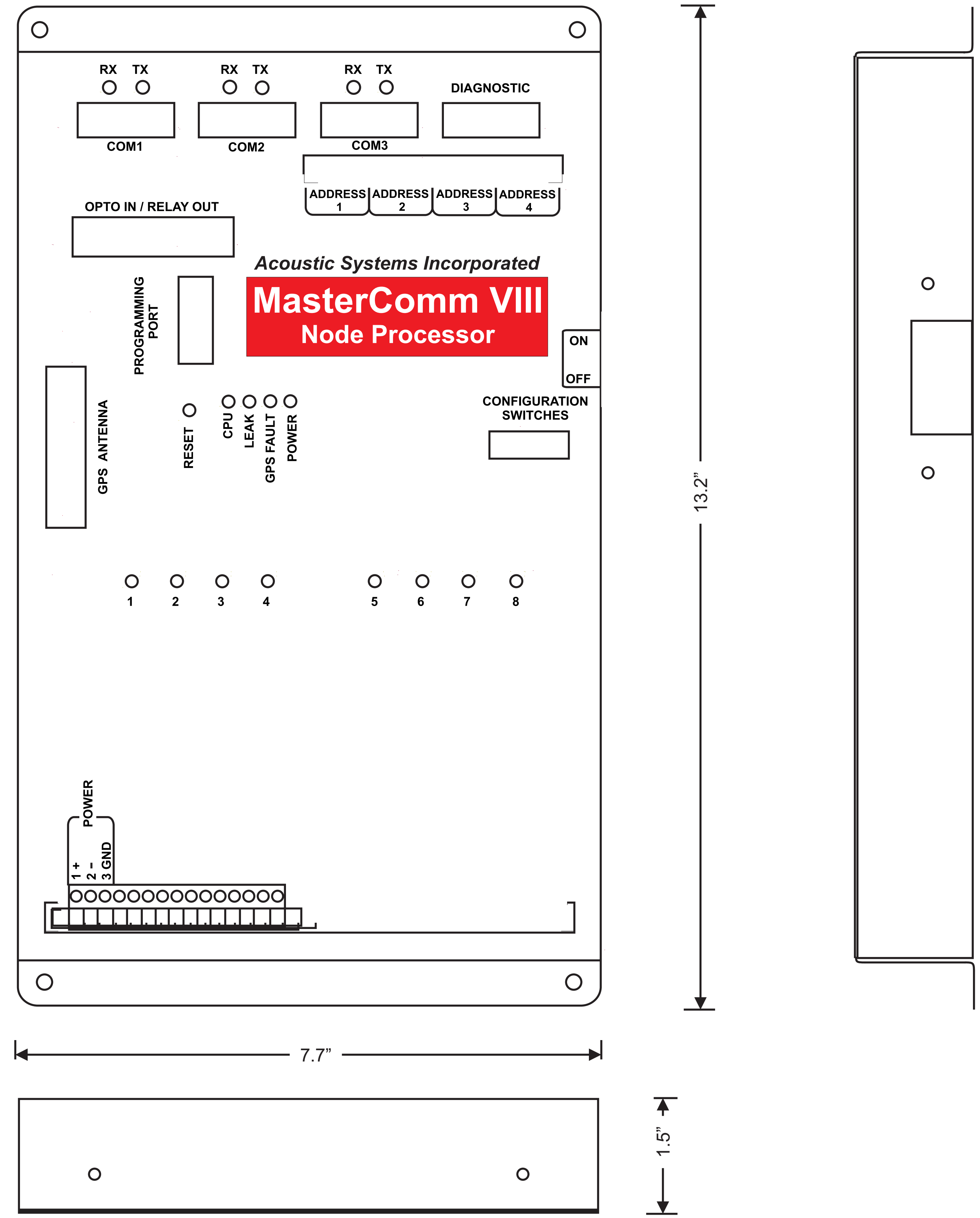
NMR 602

4C TECHNOLOGIES PO #P7-1722-GCC
ARAMCO AREA CLASSIFICATION PHASE II
PIPELINE UPGRADE
BI-10-03096

BILL OF MATERIAL

ITEM	MATERIAL SPECIFICATION
1. 19" RACK MOUNT BRACKET	0.125 THICK, 5052-H32 ALUMINUM

UNLESS OTHERWISE SPECIFIED 1. TOLERANCE INCHES .X = ±.03 .XX = ±.015 .XXX = ±.005; MILLIMETERS .X = ±.8 .XX = ±.4 .XXX = ±.15 2. ANGULAR ± 00 30' 3. ALL DIMENSIONS ARE IN INCHES OR INCHES (MILLIMETERS). 4. TOLERANCES ARE NON-ACCUMULATIVE. 5. CONCENTRICITY .015 TIR. 6. MACHINED INSIDE CORNERS .02 R MAX	MATERIAL 0.125 THICK, 5052-H32 ALUMINUM FINISH POWER COATING SEMI-GLOSS BLACK, FILL & SMOOTH PEM STUDS, INSERTS AND FASTENERS	Acoustic Systems Incorporated TITLE MASTERCOMM VIII 19" Rack Mount Bracket
SURFACE FINISH 125 ✓ REMOVE BURRS AND SHARP EDGES	SCALE 1 : 2 SHEET 1 OF 1	DATE 31 JULY 2007 PART NUMBER 400.1029-00 REV A



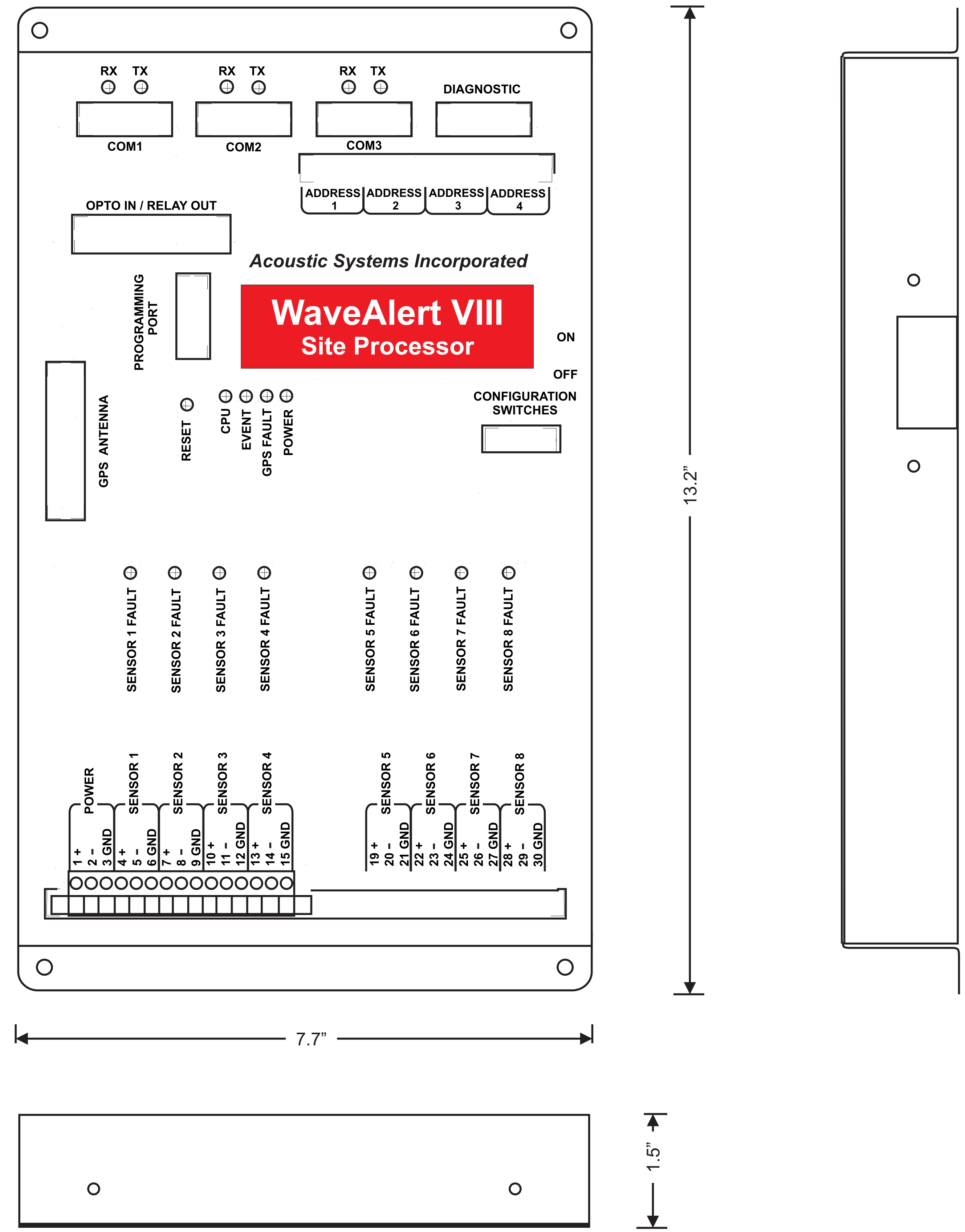
BILL OF MATERIAL	
ITEM	**MATERIAL SPECIFICATION**
1. MasterComm VIII Node Processor	Electronic Hardware

PN: 030.2008-00

NMR 602

4C TECHNOLOGIES PO #P7-1722-GCC
ARAMCO AREA CLASSIFICATION PHASE II
PIPELINE UPGRADE
BI-10-03096

UNLESS OTHERWISE SPECIFIED	MATERIAL	Acoustic Systems Incorporated
1. TOLERANCE INCHES .X = ±.03 .XX = ±.015 .XXX = ±.005; MILLIMETERS .X = ±.8 .XX = ±.4 .XXX = ±.15 2. ANGULAR ± 00 30' 3. ALL DIMENSIONS ARE IN INCHES OR INCHES (MILLIMETERS). 4. TOLERANCES ARE NON-ACCUMULATIVE. 5. CONCENTRICITY .015 TIR. 6. MACHINED INSIDE CORNERS .02 R MAX	14 Gauge 304 Stainless Steel FINISH Unpainted smooth #4 brushed finish	TITLE MASTERCOMM VIII DIMENSIONS
SURFACE FINISH 125 ✓ — REMOVE BURRS AND SHARP EDGES	SCALE NONE — SHEET 1 OF 1	DATE 31 JULY 2007 — PART NUMBER 400.1051-00 — REV A

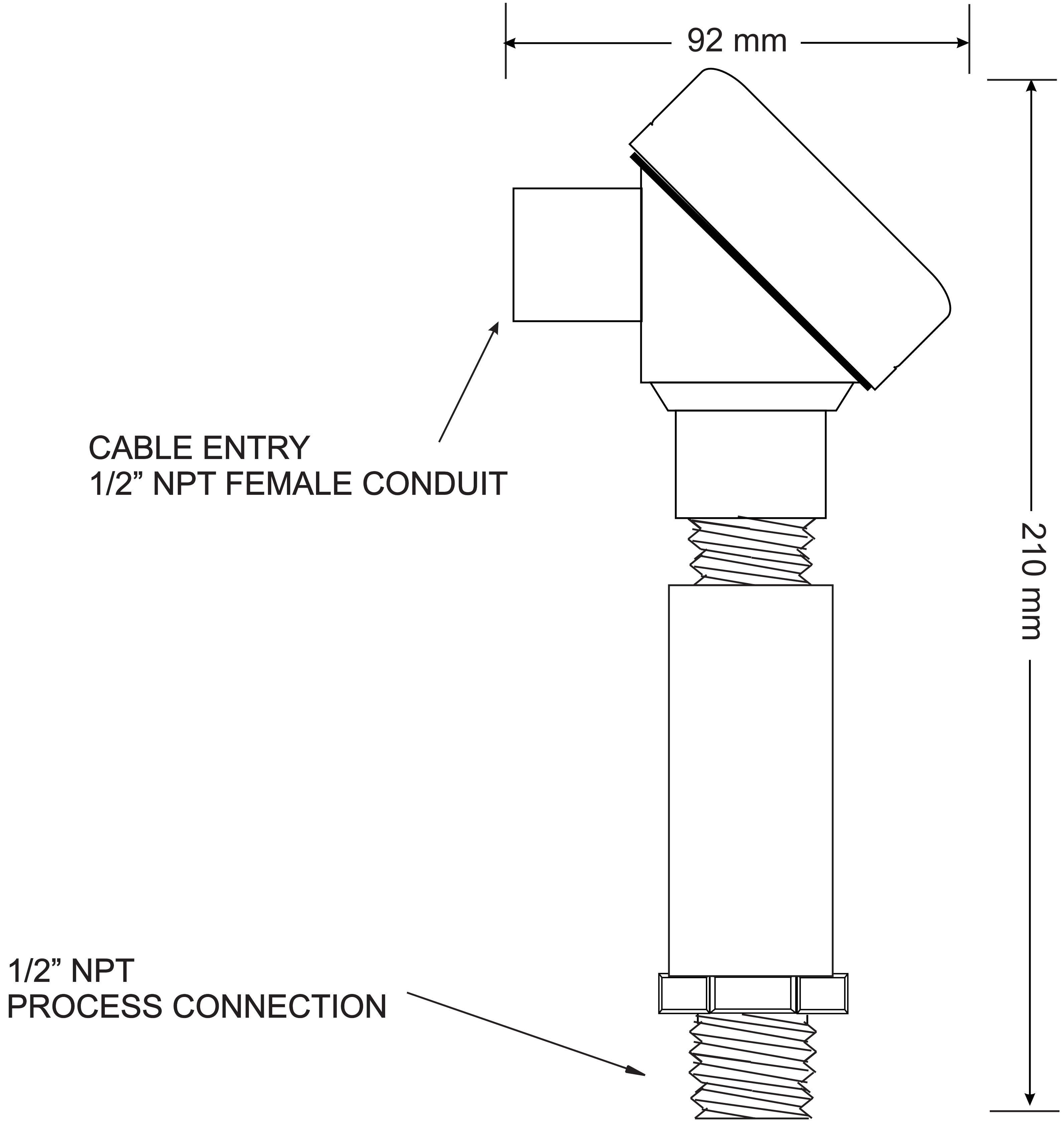


BILL OF MATERIAL	
ITEM	**MATERIAL SPECIFICATION**
1. WaveAlert VIII Site Processor	Electronic Hardware

PN: 030.2009-XX
NMR 602

4C TECHNOLOGIES PO #P7-1722-GCC
ARAMCO AREA CLASSIFICATION PHASE II
PIPELINE UPGRADE
BI-10-03096

UNLESS OTHERWISE SPECIFIED 1. TOLERANCE INCHES .X = ±.03 .XX = ±.015 .XXX = ±.005; MILLIMETERS .X = ±.8 .XX = ±.4 .XXX = ±.15 2. ANGULAR ± 00 30' 3. ALL DIMENSIONS ARE IN INCHES OR INCHES (MILLIMETERS). 4. TOLERANCES ARE NON-ACCUMULATIVE. 5. CONCENTRICITY .015 TIR. 6. MACHINED INSIDE CORNERS .02 R MAX	MATERIAL Aluminum FINISH **Textured Black Powder Coating**	Acoustic Systems Incorporated TITLE WAVEALERT VIII DIMENSIONS	
SURFACE FINISH 125 ✓ / REMOVE BURRS AND SHARP EDGES	SCALE NONE / SHEET 1 OF 1	DATE 31 JULY 2007 / PART NUMBER 400.1062-00	REV A

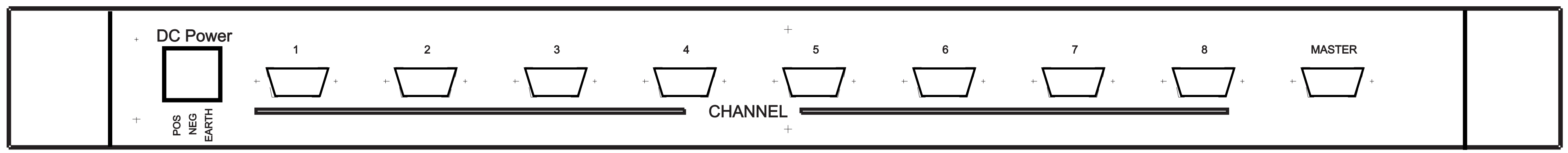


Notes:
1. Explosion proof for Class I Division 1 Groups A, B, C, D; Class II Division 1 Groups E, F, G; Class III
2. Factory Sealed, conduit seal not required
3. NACE MR0175 compliant
4. NEMA 4X (IP67) ingress protection

NMR 602

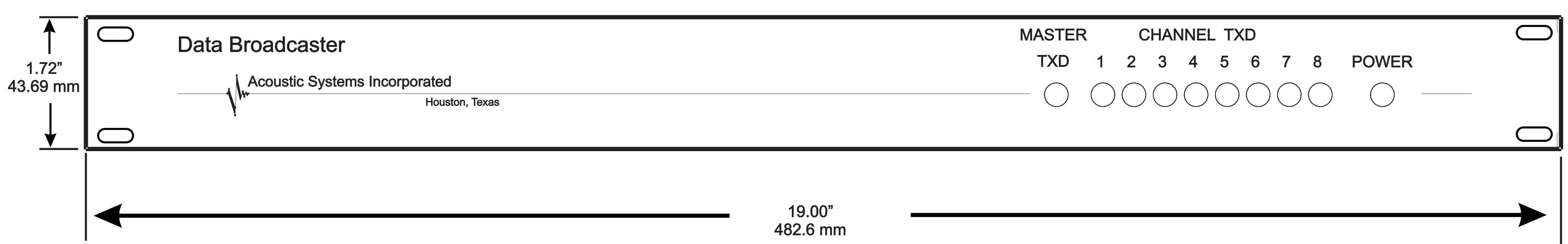
4C TECHNOLOGIES PO #P7-1722-GCC
ARAMCO AREA CLASSIFICATION PHASE II
PIPELINE UPGRADE
BI-10-03096

UNLESS OTHERWISE SPECIFIED 1. TOLERANCE INCHES .X = ±.03, .XX = ±.015, .XXX = ±.005; MILLIMETERS .X = ±.8, .XX = ±.4, .XXX = ±.15 2. ANGULAR ± 00 30' 3. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED. 4. TOLERANCES ARE NON-ACCUMULATIVE. 5. CONCENTRICITY .015 TIR. 6. MACHINED INSIDE CORNERS .02 R MAX	MATERIAL 316 STAINLESS STEEL SENSOR LOW COPPER ALUMINUM JUNCTION BOX	Acoustic Systems Incorporated
	FINISH	TITLE Ex Acoustic Sensor Assembly Dimensions
SURFACE FINISH 125 ✓ — REMOVE BURRS AND SHARP EDGES	SCALE NONE — SHEET 1 OF 1	DATE 24 JULY 2007 — PART NUMBER 433-1038-00 — REV A



REAR VIEW

TOP VIEW



FRONT VIEW

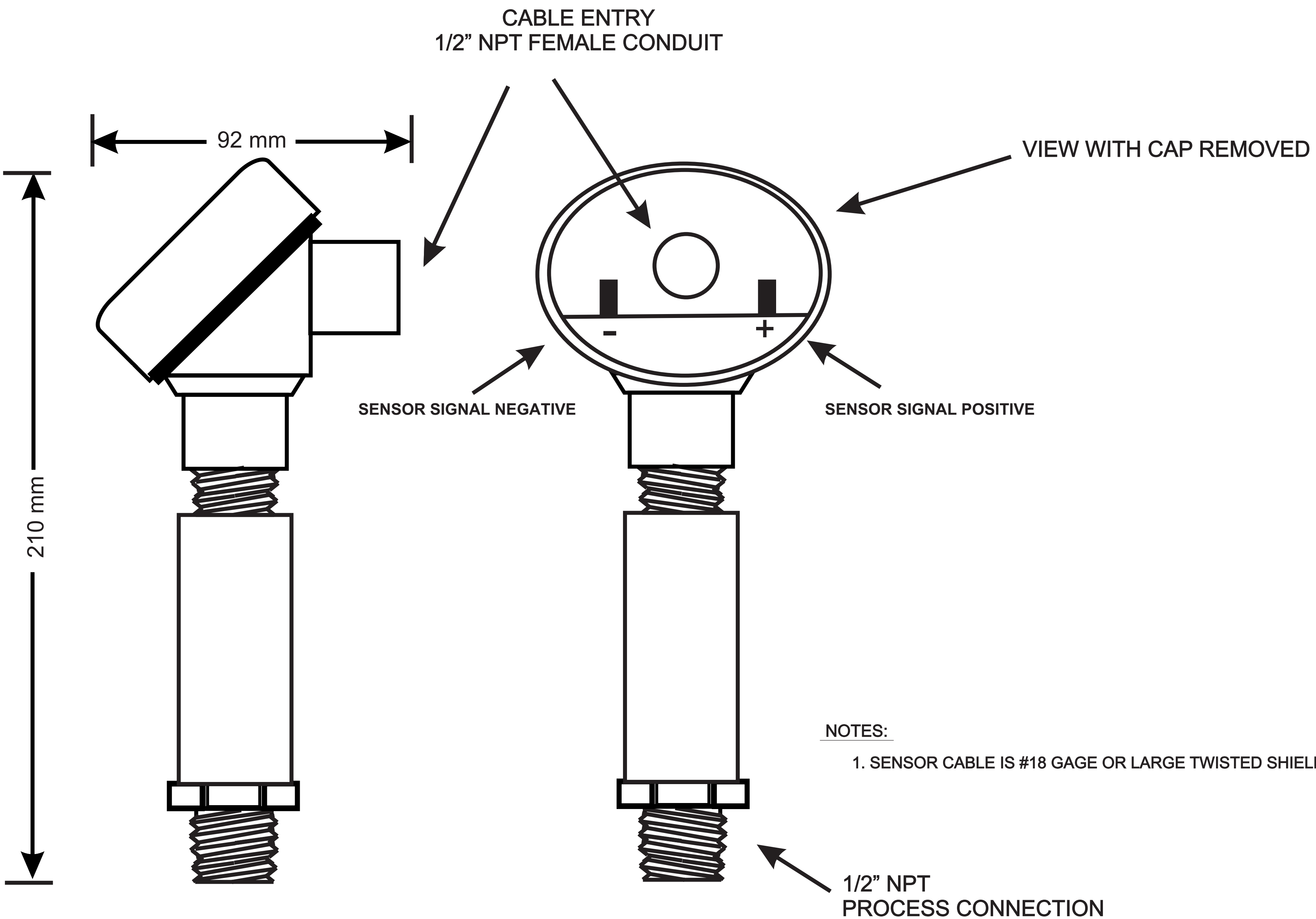
PN: 030.1510-01

NMR 602

4C TECHNOLOGIES PO #P7-1722-GCC
ARAMCO AREA CLASSIFICATION PHASE II
PIPELINE UPGRADE
BI-10-03096

BILL OF MATERIAL	
ITEM	**MATERIAL SPECIFICATION**
1. Data Broadcaster	Electronic Hardware

UNLESS OTHERWISE SPECIFIED 1. TOLERANCE INCHES .X = ±.03, .XX = ±.015, .XXX = ±.005; MILLIMETERS .X = ±.8, .XX = ±.4, .XXX = ±.15 2. ANGULAR ± 00 30' 3. ALL DIMENSIONS ARE IN INCHES OR INCHES (MILLIMETERS). 4. TOLERANCES ARE NON-ACCUMULATIVE. 5. CONCENTRICITY .015 TIR. 6. MACHINED INSIDE CORNERS .02 R MAX	MATERIAL 0.062 THICK, 5052-H32 ALUMINUM	Acoustic Systems Incorporated
	FINISH Black Anodized	TITLE Data Broadcaster
SURFACE FINISH 125 ✓ — REMOVE BURRS AND SHARP EDGES	SCALE NONE — SHEET 1 OF 1	DATE 31 JULY 2007 — PART NUMBER 900.2076-00 — REV B



NOTES:

1. SENSOR CABLE IS #18 GAGE OR LARGE TWISTED SHIELD PAIR

NMR 602
4C TECHNOLOGIES PO #P7-1722-GCC
ARAMCO AREA CLASSIFICATION PHASE II
PIPELINE UPGRADE
BI-10-03096

UNLESS OTHERWISE SPECIFIED

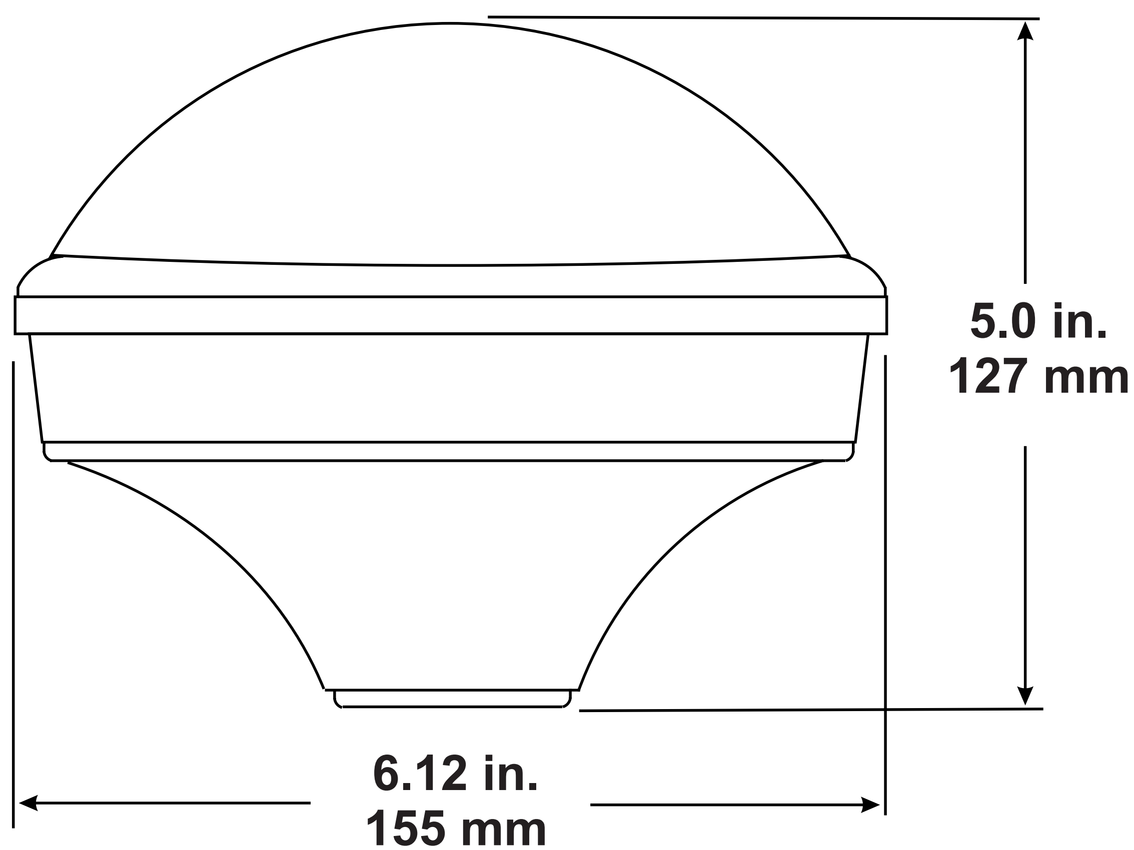
1. TOLERANCE INCHES MILLIMETERS
   .X = ±.03 .X = ±.8
   .XX = ±.015 .XX = ±.4
   .XXX = ±.005 .XXX = ±.15
2. ANGULAR ± 00 30'
3. ALL DIMENSIONS ARE IN INCHES OR INCHES (MILLIMETERS).
4. TOLERANCES ARE NON-ACCUMULATIVE.
5. CONCENTRICITY .015 TIR.
6. MACHINED INSIDE CORNERS .02 R MAX

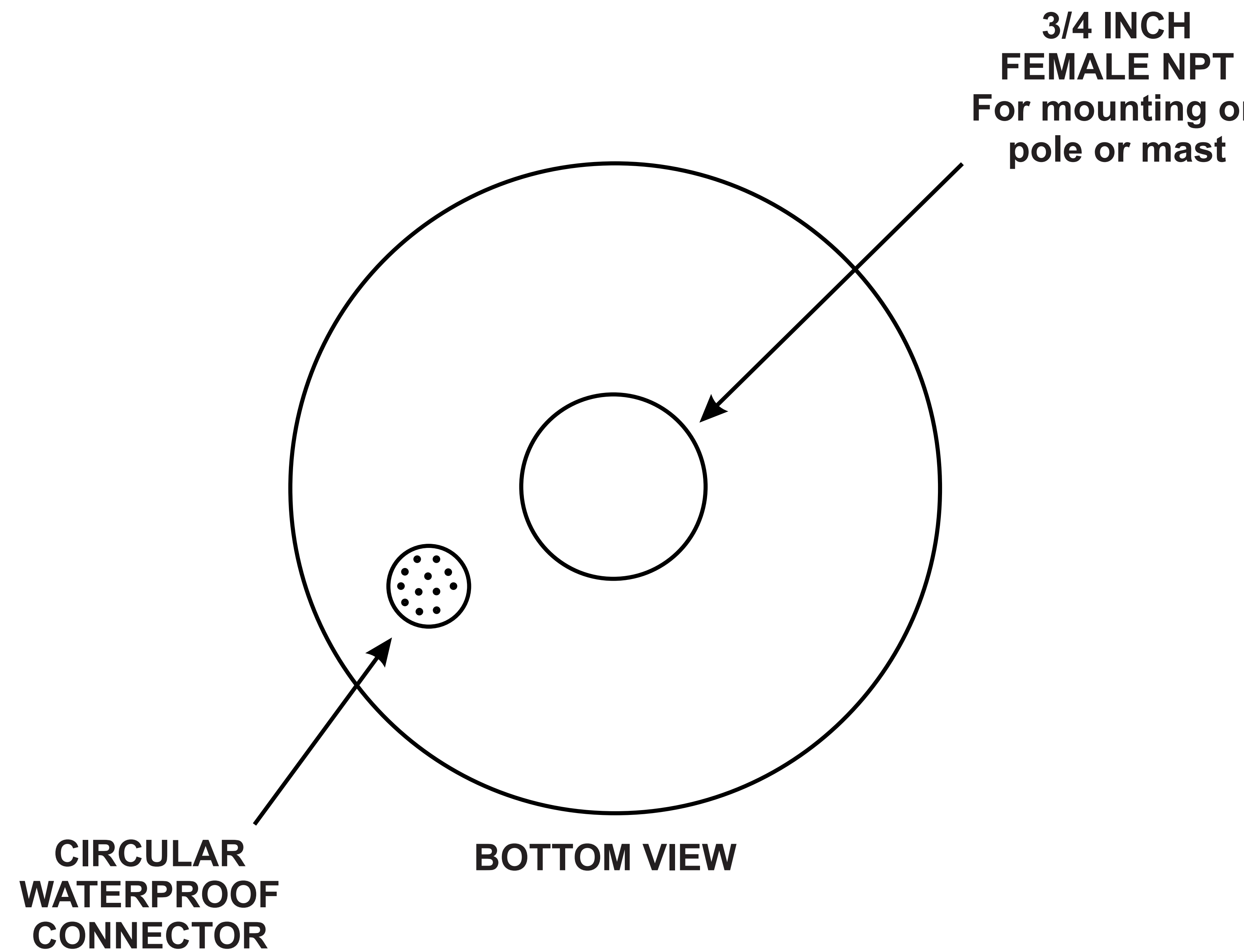
SURFACE FINISH 125 ✓ | REMOVE BURRS AND SHARP EDGES | SCALE NONE | SHEET 1 OF 1

Acoustic Systems Incorporated

TITLE
WAVEALERT SENSOR
WIRING DIAGRAM

DATE 31 JULY 2007 | PART NUMBER 900.2079-00 | REV A





NOTE:
1. Cable to be supplied by ASI (ASI Drawing # 9002290)
2. Mount antenna with a minimum 60 degree view of the sky

NMR 602

4C TECHNOLOGIES PO #P7-1722-GCC
ARAMCO AREA CLASSIFICATION PHASE II
PIPELINE UPGRADE
BI-10-03096

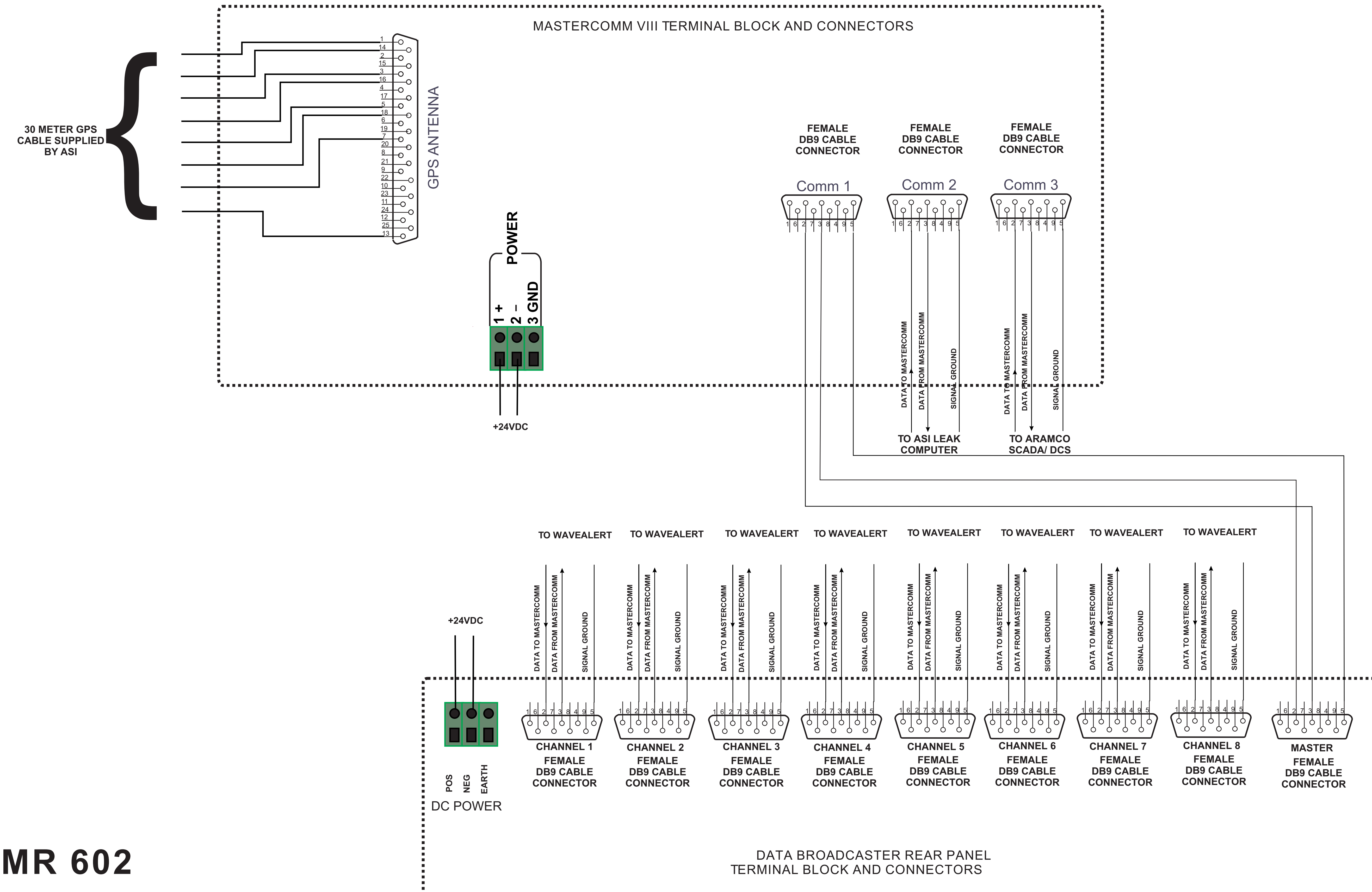
ANTENNA SPECIFICATION
POLE MOUNT GPS RECEIVER AND ANTENNA
ENVIRONMENTALLY SEALED, WATERPROOF AND ANTI-CORROSION HOUSING
OPERATING TEMPERATURE RANGE: -40 TO +85 C
WEIGHT: 363 GRAMS
CONNECTOR: 12-PIN ROUND, WATERPROOF
POWER: +8 TO +36 vdc, 110mA @ 12 VDC

UNLESS OTHERWISE SPECIFIED
1. TOLERANCE INCHES: .X = ±.03; .XX = ±.015; .XXX = ±.005 — MILLIMETERS: .X = ±.8; .XX = ±.4; .XXX = ±.15
2. ANGULAR ± 00 30'
3. ALL DIMENSIONS ARE IN INCHES OR INCHES (MILLIMETERS).
4. TOLERANCES ARE NON-ACCUMULATIVE.
5. CONCENTRICITY .015 TIR.
6. MACHINED INSIDE CORNERS .02 R MAX

SURFACE FINISH 125 ✓	REMOVE BURRS AND SHARP EDGES	SCALE NONE	SHEET 1 OF 1	

Acoustic Systems Incorporated

TITLE		
WAVEALERT VIII GPS Antenna		
DATE	PART NUMBER	REV
31 JULY 2007	900.2090-00	A



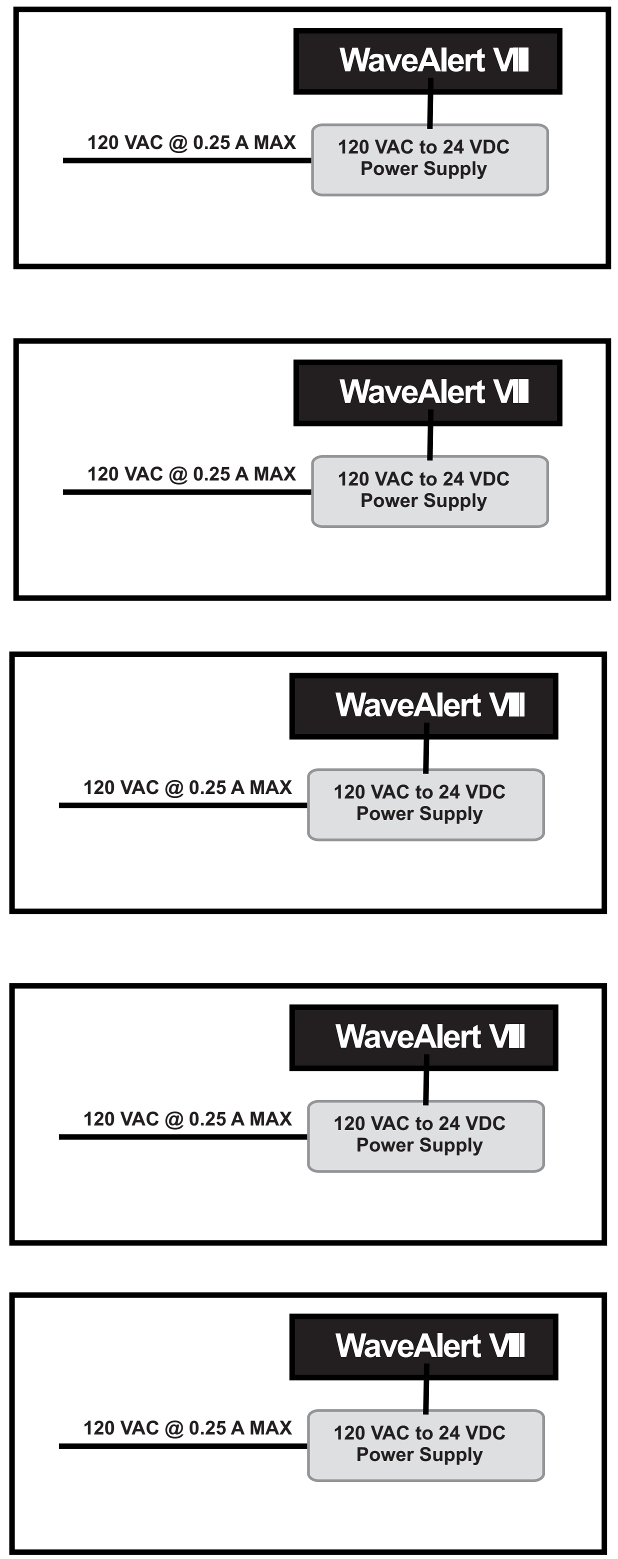
NMR 602

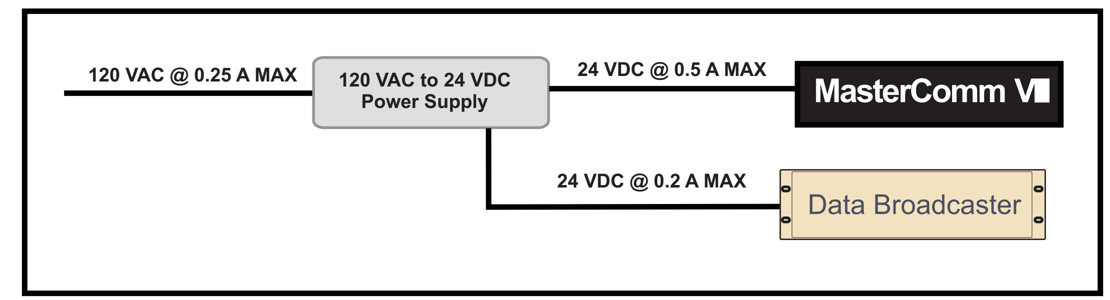
4C TECHNOLOGIES PO #P7-1722-GCC
ARAMCO AREA CLASSIFICATION PHASE II
PIPELINE UPGRADE
BI-10-03096

UNLESS OTHERWISE SPECIFIED
1. TOLERANCE INCHES MILLIMETERS
.X = ±.03 .X = ±.8
.XX = ±.015 .XX = ±.4
.XXX = ±.005 .XXX = ±.15
2. ANGULAR ± 00 30'
3. ALL DIMENSIONS ARE IN INCHES OR INCHES (MILLIMETERS).
4. TOLERANCES ARE NON-ACCUMULATIVE.
5. CONCENTRICITY .015 TIR.
6. MACHINED INSIDE CORNERS .02 R MAX
SURFACE FINISH 125 ✓ REMOVE BURRS AND SHARP EDGES

MATERIAL
FINISH
SCALE NONE SHEET 1 OF 1

Acoustic Systems Incorporated
TITLE MASTERCOMM / DATA BROADCASTER WIRING DIAGRAM
DATE 31 JULY 2007
PART NUMBER 900.2110-00
REV A





NMR 602

4C TECHNOLOGIES PO #P7-1722-GCC
ARAMCO AREA CLASSIFICATION PHASE II
PIPELINE UPGRADE
BI-10-03096

UNLESS OTHERWISE SPECIFIED

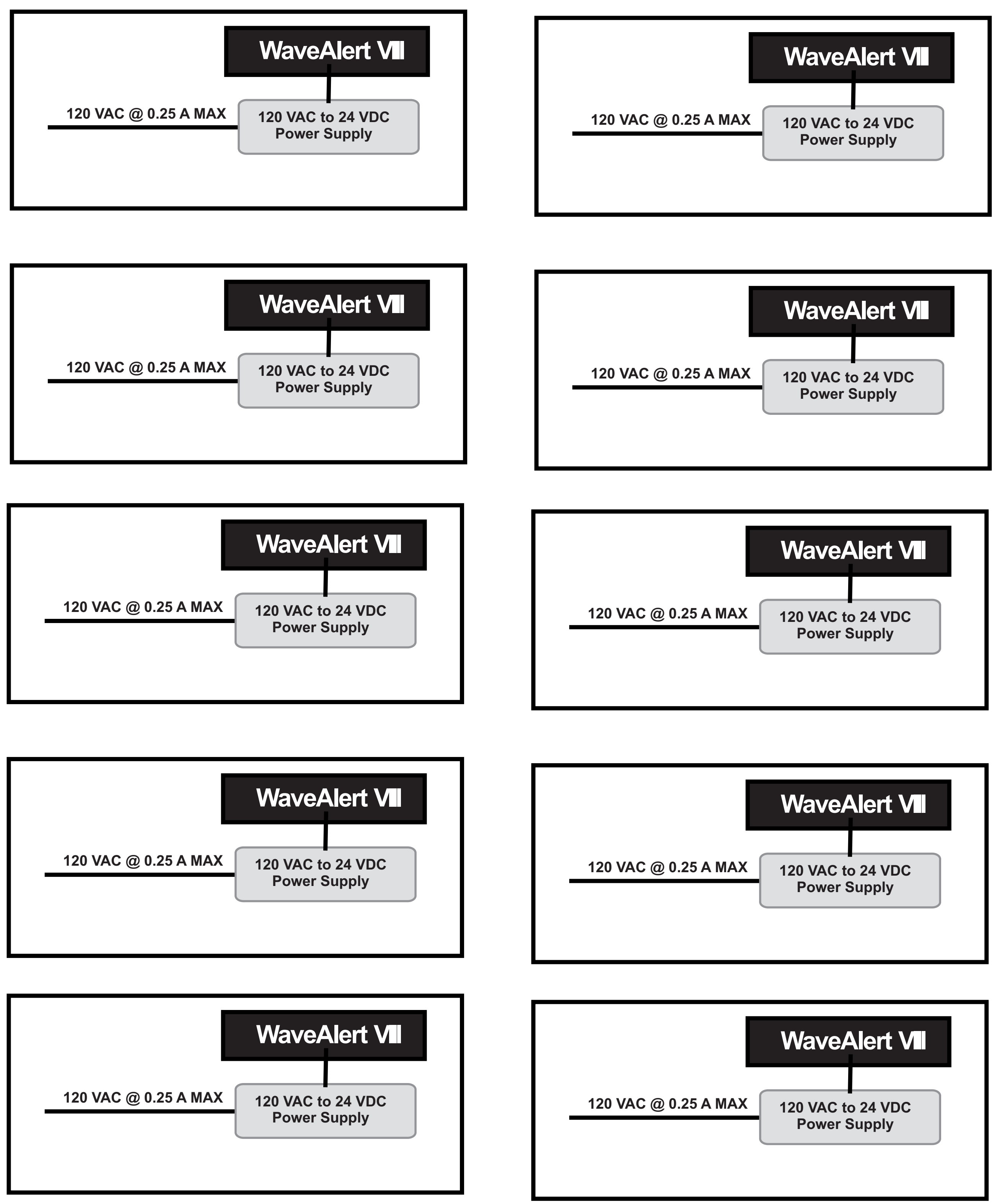
1. TOLERANCE INCHES .X = ±.03 .XX = ±.015 .XXX = ±.005 — MILLIMETERS .X = ±.8 .XX = ±.4 .XXX = ±.15
2. ANGULAR ± 00 30'
3. ALL DIMENSIONS ARE IN INCHES OR INCHES (MILLIMETERS).
4. TOLERANCES ARE NON-ACCUMULATIVE.
5. CONCENTRICITY .015 TIR.
6. MACHINED INSIDE CORNERS .02 R MAX

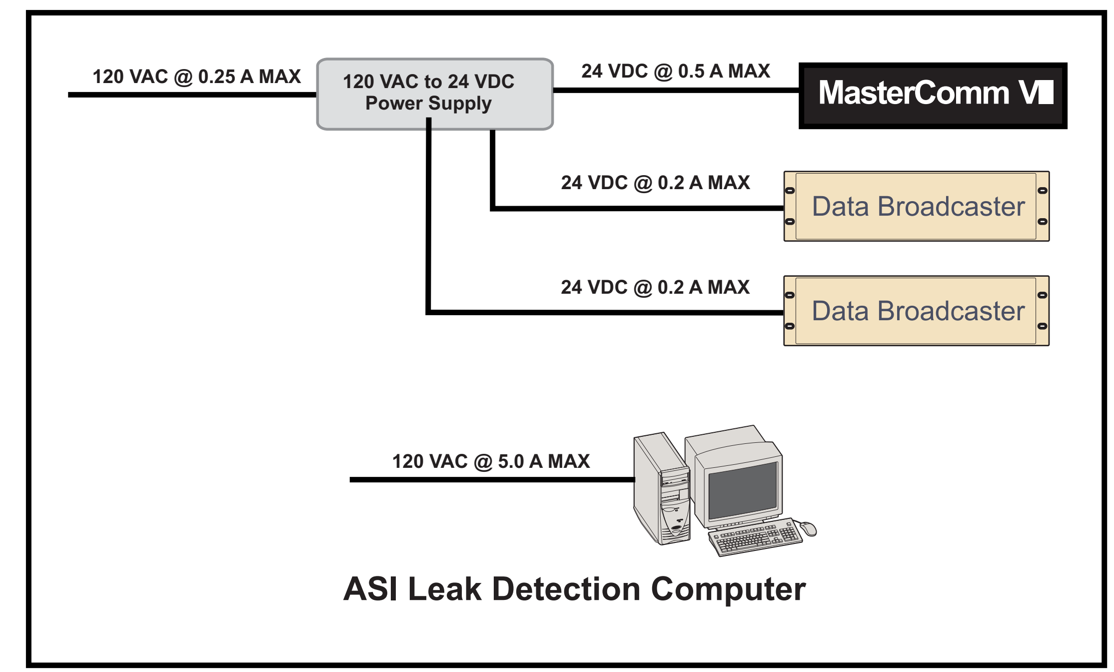
SURFACE FINISH 125 ✓ | REMOVE BURRS AND SHARP EDGES | SCALE NONE | SHEET 1 OF 1

Acoustic Systems Incorporated

TITLE WaveAlert ALDS AA Electrical Power Distribution

DATE	PART NUMBER	REV
6 August 07	900.2111-00	A





NMR 602

4C TECHNOLOGIES PO #P7-1722-GCC
ARAMCO AREA CLASSIFICATION PHASE II
PIPELINE UPGRADE
BI-10-03096

UNLESS OTHERWISE SPECIFIED

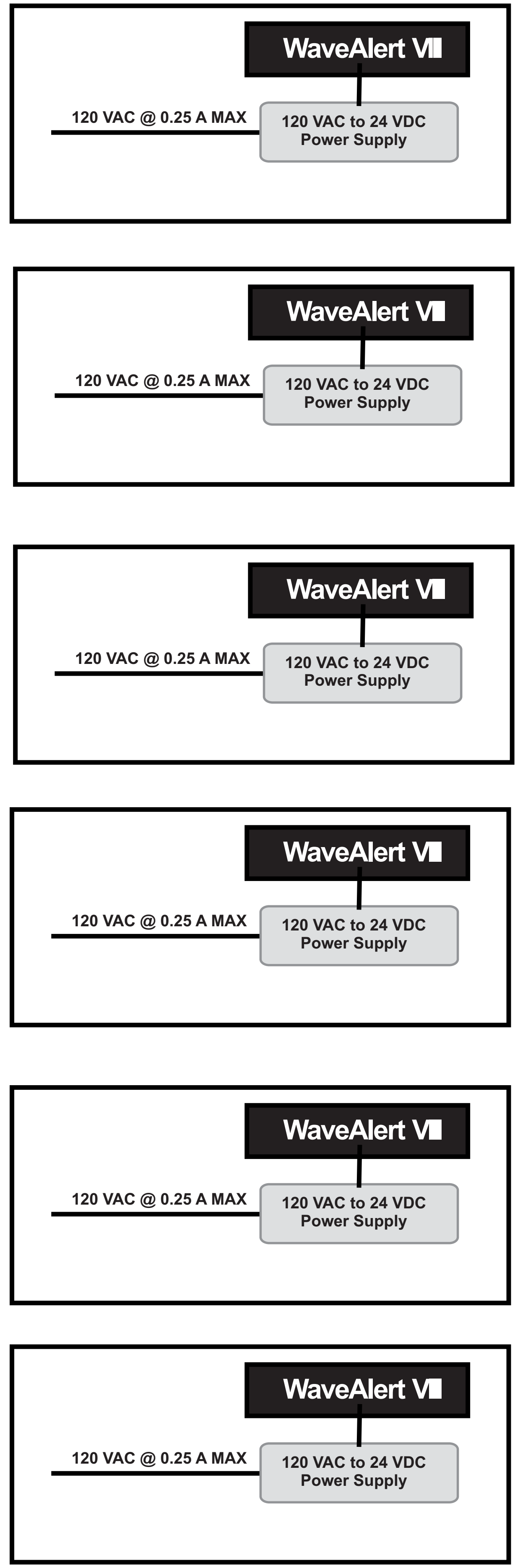
1. TOLERANCE INCHES .X = ±.03 .XX = ±.015 .XXX = ±.005 MILLIMETERS .X = ±.8 .XX = ±.4 .XXX = ±.15
2. ANGULAR ± 00 30'
3. ALL DIMENSIONS ARE IN INCHES OR INCHES (MILLIMETERS).
4. TOLERANCES ARE NON-ACCUMULATIVE.
5. CONCENTRICITY .015 TIR.
6. MACHINED INSIDE CORNERS .02 R MAX

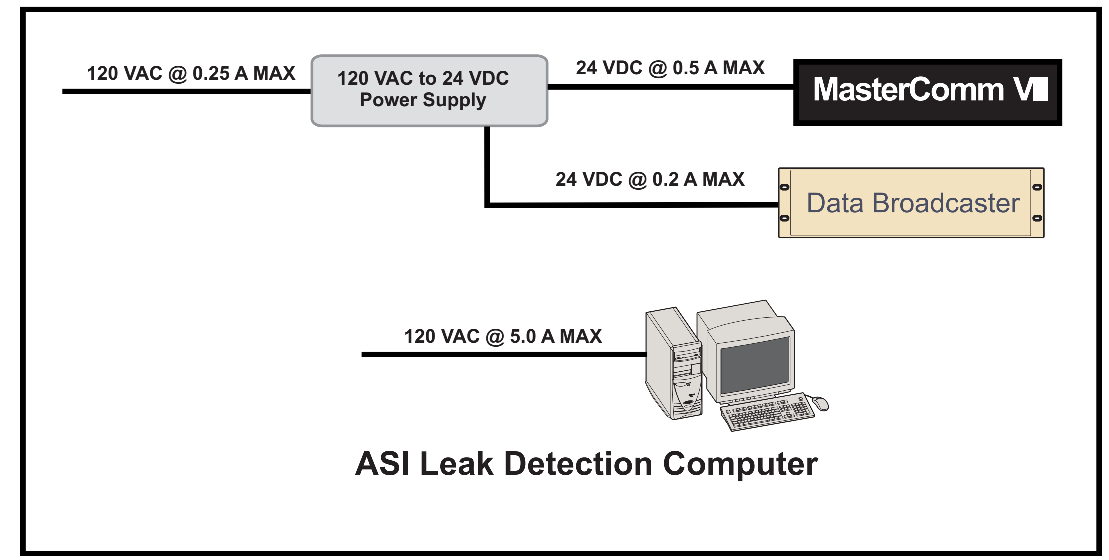
SURFACE FINISH 125 ✓ | REMOVE BURRS AND SHARP EDGES | SCALE NONE | SHEET 1 OF 1

Acoustic Systems Incorporated

TITLE WaveAlert ALDS QA,AY,ABGG Electrical Power Distribution

DATE	PART NUMBER	REV
6 August 07	900.2112-00	A

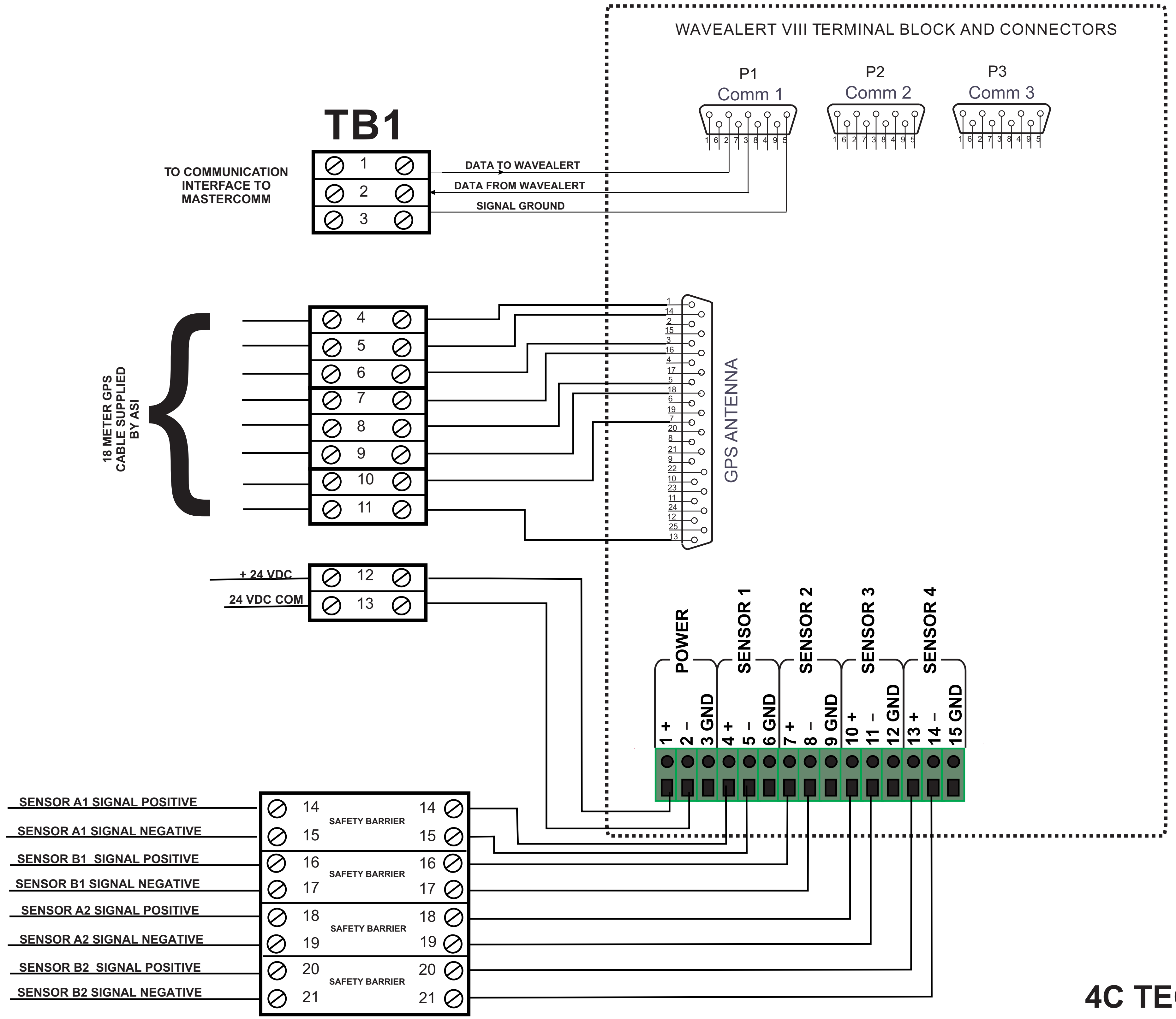




NMR 602

4C TECHNOLOGIES PO #P7-1722-GCC
ARAMCO AREA CLASSIFICATION PHASE II
PIPELINE UPGRADE
BI-10-03096

UNLESS OTHERWISE SPECIFIED 1. TOLERANCE INCHES .X = ±.03 .XX = ±.015 .XXX = ±.005; MILLIMETERS .X = ±.8 .XX = ±.4 .XXX = ±.15 2. ANGULAR ± 00 30' 3. ALL DIMENSIONS ARE IN INCHES OR INCHES (MILLIMETERS). 4. TOLERANCES ARE NON-ACCUMULATIVE. 5. CONCENTRICITY .015 TIR. 6. MACHINED INSIDE CORNERS .02 R MAX		Acoustic Systems Incorporated
		TITLE WaveAlert ALDS UA Electrical Power Distribution
SURFACE FINISH 125 ✓ / REMOVE BURRS AND SHARP EDGES	SCALE NONE / SHEET 1 OF 1	DATE 6 August 07 / PART NUMBER 900.2113-00 / REV A

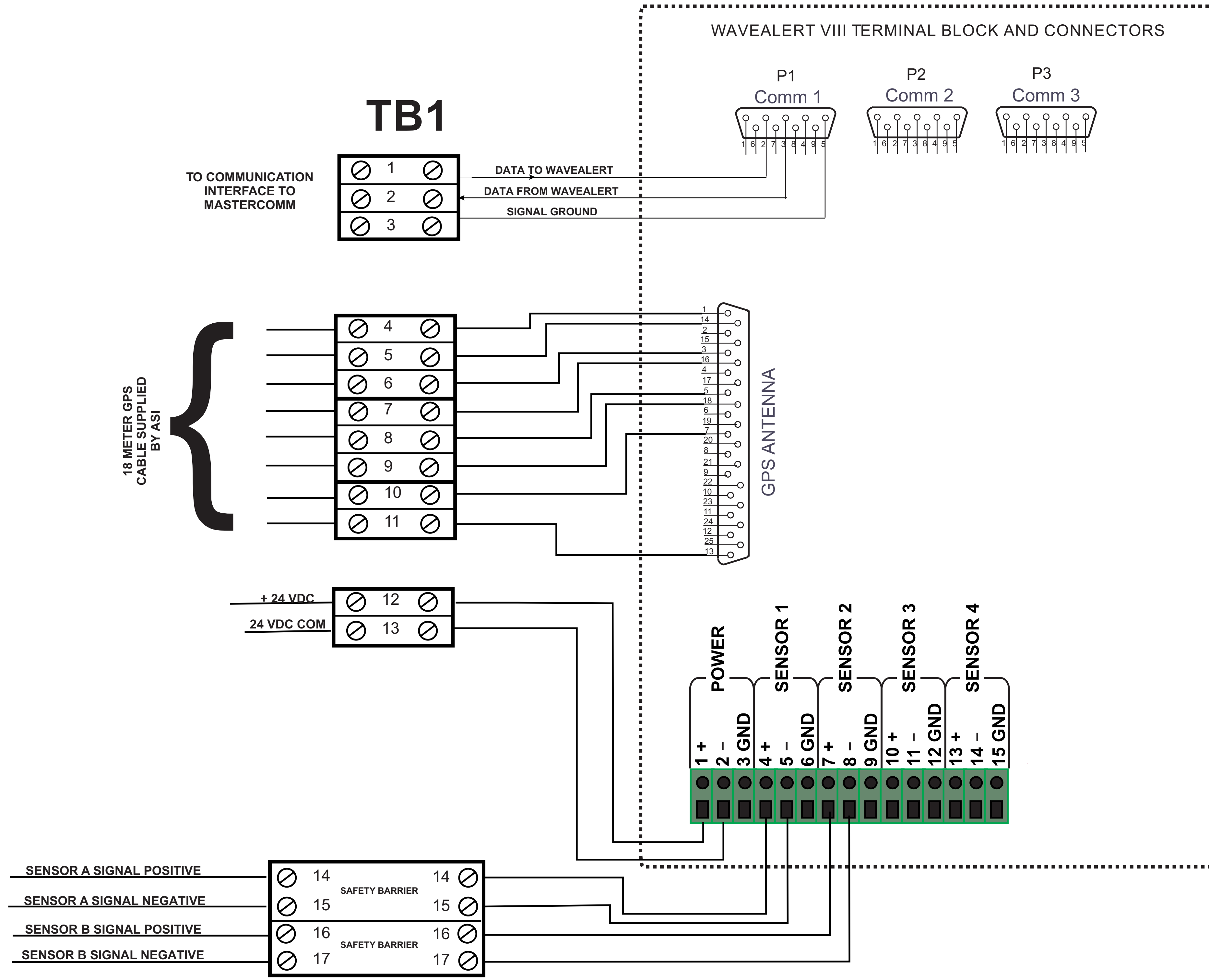


PN: 030.2009-04

NMR 602

4C TECHNOLOGIES PO #P7-1722-GCC
ARAMCO AREA CLASSIFICATION PHASE II
PIPELINE UPGRADE
BI-10-03096

UNLESS OTHERWISE SPECIFIED		Acoustic Systems Incorporated
1. TOLERANCE INCHES .X = ±.03 .XX = ±.015 .XXX = ±.005; MILLIMETERS .X = ±.8 .XX = ±.4 .XXX = ±.15 2. ANGULAR ± 00 30' 3. ALL DIMENSIONS ARE IN INCHES OR INCHES (MILLIMETERS). 4. TOLERANCES ARE NON-ACCUMULATIVE. 5. CONCENTRICITY .015 TIR. 6. MACHINED INSIDE CORNERS .02 R MAX		TITLE: WAVEALERT D4 WIRING DIAGRAM
SURFACE FINISH 125 ✓ / REMOVE BURRS AND SHARP EDGES	SCALE NONE / SHEET 1 OF 1	DATE 31 JULY 2007 / PART NUMBER 900.2203-01 / REV A



PN: 030.2009-10

NMR 602

4C TECHNOLOGIES PO #P7-1722-GCC
ARAMCO AREA CLASSIFICATION PHASE II
PIPELINE UPGRADE
BI-10-03096

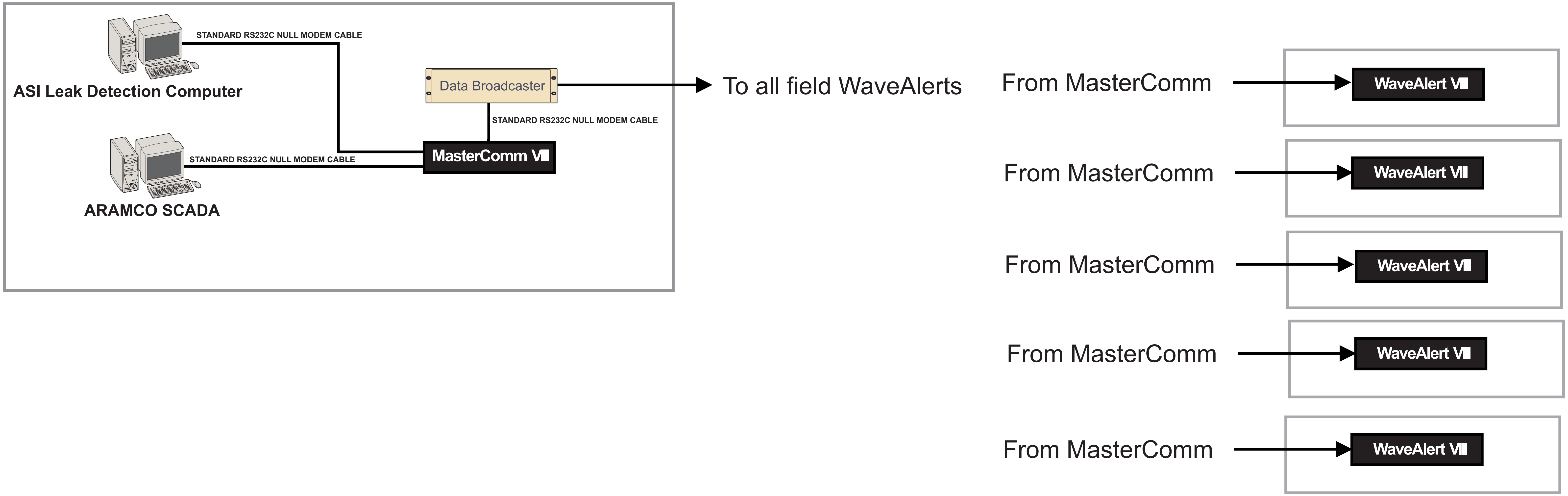
UNLESS OTHERWISE SPECIFIED
1. TOLERANCE INCHES MILLIMETERS
.X = ±.03 .X = ±.8
.XX = ±.015 .XX = ±.4
.XXX = ±.005 .XXX = ±.15
2. ANGULAR ± 00 30'
3. ALL DIMENSIONS ARE IN INCHES OR INCHES (MILLIMETERS).
4. TOLERANCES ARE NON-ACCUMULATIVE.
5. CONCENTRICITY .015 TIR.
6. MACHINED INSIDE CORNERS .02 R MAX

SURFACE FINISH 125 ✓ | REMOVE BURRS AND SHARP EDGES | SCALE NONE | SHEET 1 OF 1

Acoustic Systems Incorporated

TITLE: WAVEALERT D2 WIRING DIAGRAM

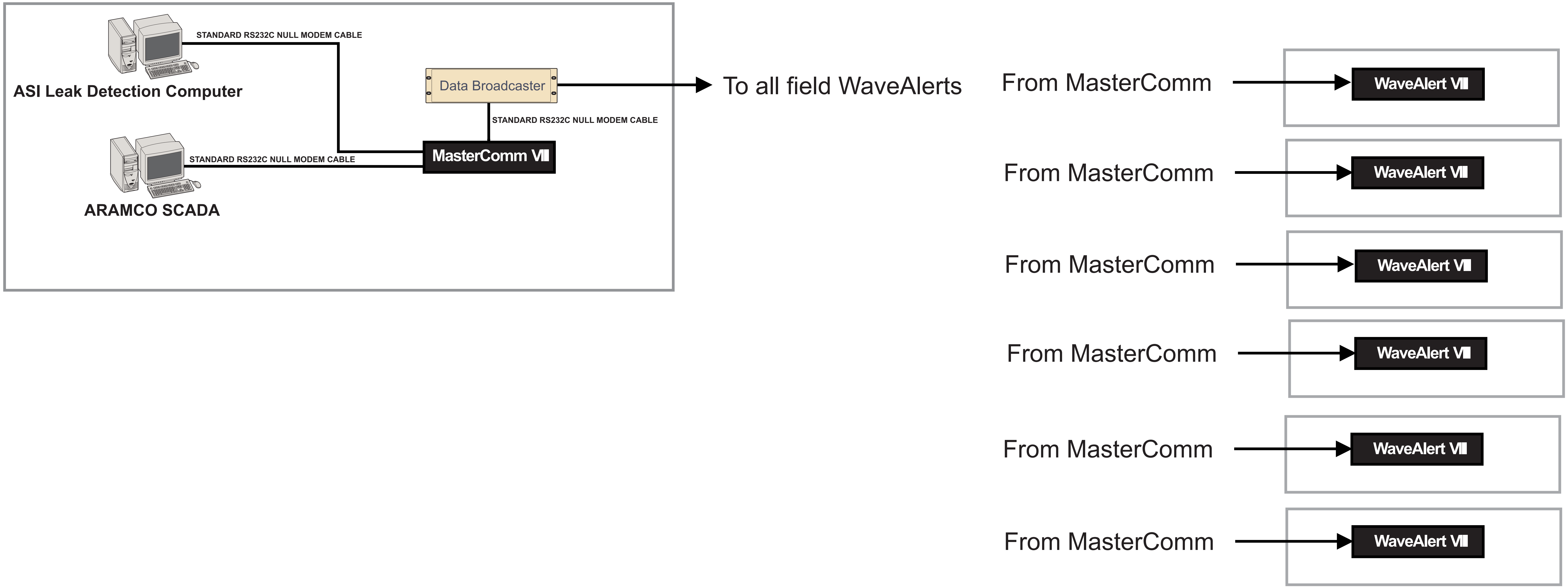
DATE: 31 JULY 2007 | PART NUMBER: 900.2204-04 | REV: A



NMR 602

4C TECHNOLOGIES PO #P7-1722-GCC
ARAMCO AREA CLASSIFICATION PHASE II
PIPELINE UPGRADE
BI-10-03096

UNLESS OTHERWISE SPECIFIED 1. TOLERANCE INCHES .X = ±.03, .XX = ±.015, .XXX = ±.005; MILLIMETERS .X = ±.8, .XX = ±.4, .XXX = ±.15 2. ANGULAR ± 00 30' 3. ALL DIMENSIONS ARE IN INCHES OR INCHES (MILLIMETERS). 4. TOLERANCES ARE NON-ACCUMULATIVE. 5. CONCENTRICITY .015 TIR. 6. MACHINED INSIDE CORNERS .02 R MAX		Acoustic Systems Incorporated TITLE AA-1, AA-2 and AA-3 WaveAlert Interconnections
SURFACE FINISH 125 ✓ / REMOVE BURRS AND SHARP EDGES	SCALE NONE / SHEET 1 OF 1	DATE 6 August 2007 / PART NUMBER 900.2208-00 / REV A



NMR 602

4C TECHNOLOGIES PO #P7-1722-GCC
ARAMCO AREA CLASSIFICATION PHASE II
PIPELINE UPGRADE
BI-10-03096

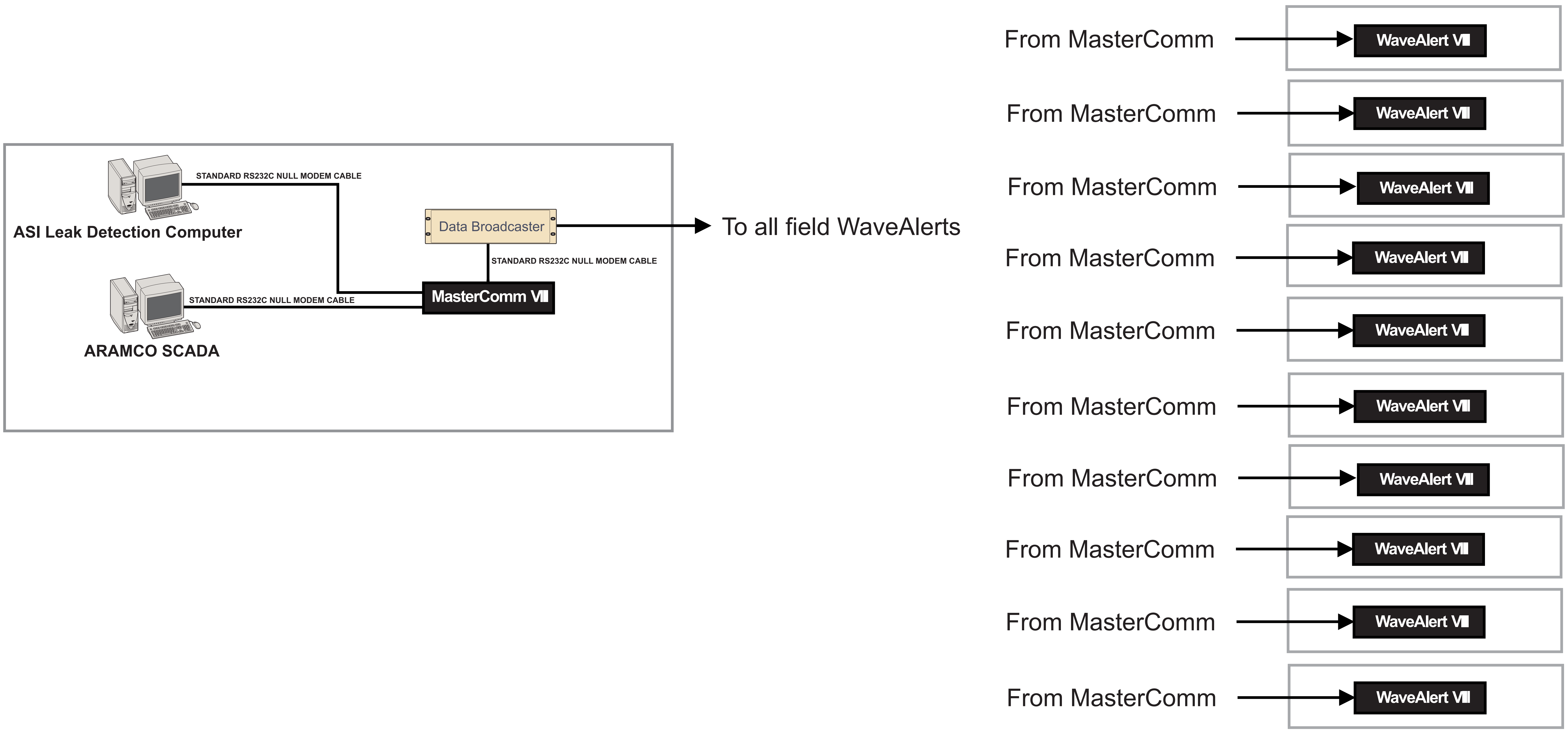
UNLESS OTHERWISE SPECIFIED
1. TOLERANCE INCHES .X = ±.03 .XX = ±.015 .XXX = ±.005 MILLIMETERS .X = ±.8 .XX = ±.4 .XXX = ±.15
2. ANGULAR ± 00 30'
3. ALL DIMENSIONS ARE IN INCHES OR INCHES (MILLIMETERS).
4. TOLERANCES ARE NON-ACCUMULATIVE.
5. CONCENTRICITY .015 TIR.
6. MACHINED INSIDE CORNERS .02 R MAX

SURFACE FINISH 125 ✓ | REMOVE BURRS AND SHARP EDGES | SCALE NONE | SHEET 1 OF 1

Acoustic Systems Incorporated

TITLE UA-1, UA-2, UA-3, UA-4, UA-6 WaveAlert Interconnections

DATE	PART NUMBER	REV
6 August 2007	900.2209-00	A



NMR 602

4C TECHNOLOGIES PO #P7-1722-GCC
ARAMCO AREA CLASSIFICATION PHASE II
PIPELINE UPGRADE
BI-10-03096

UNLESS OTHERWISE SPECIFIED

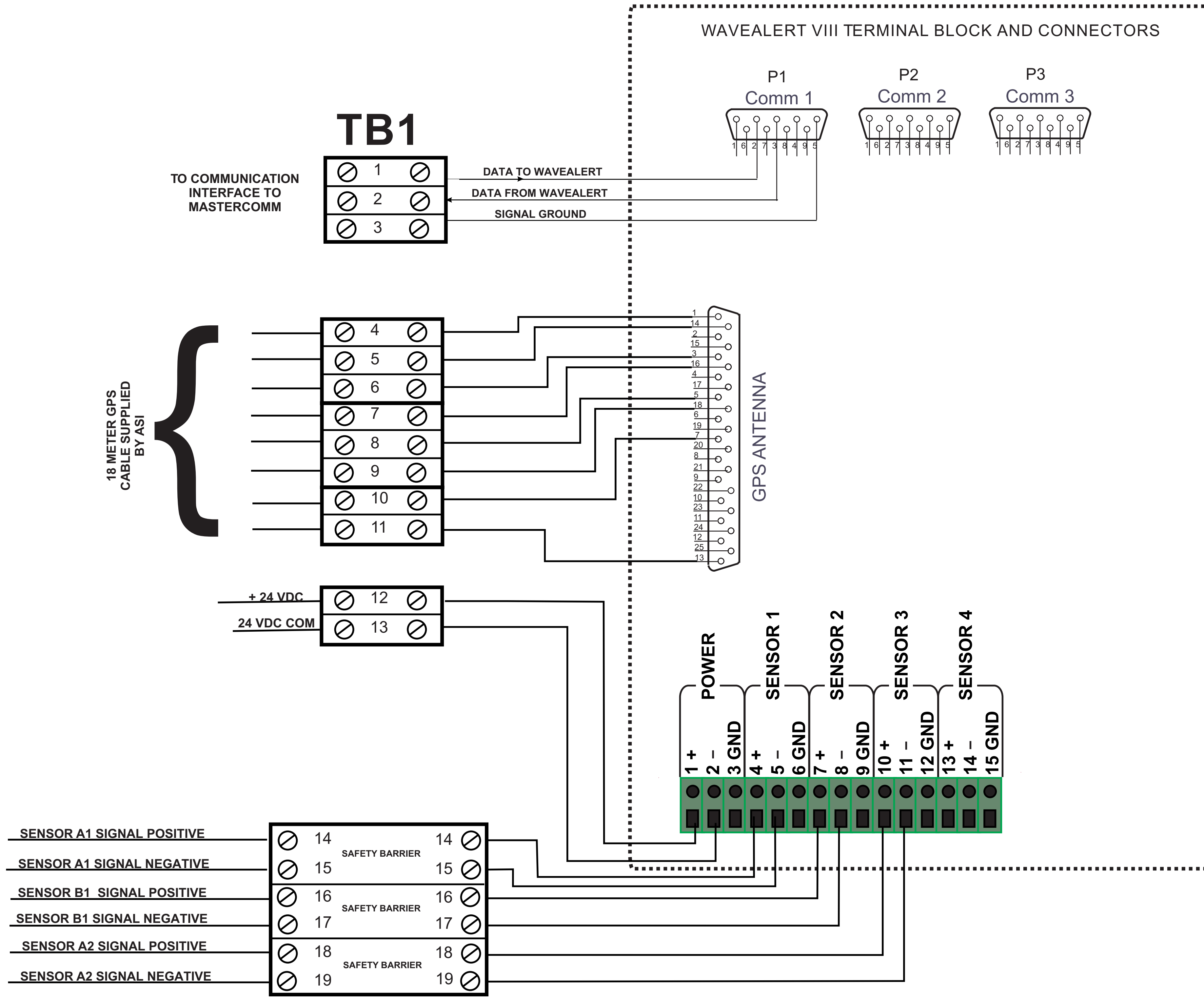
1. TOLERANCE INCHES .X = ±.03, .XX = ±.015, .XXX = ±.005; MILLIMETERS .X = ±.8, .XX = ±.4, .XXX = ±.15
2. ANGULAR ± 00 30'
3. ALL DIMENSIONS ARE IN INCHES OR INCHES (MILLIMETERS).
4. TOLERANCES ARE NON-ACCUMULATIVE.
5. CONCENTRICITY .015 TIR.
6. MACHINED INSIDE CORNERS .02 R MAX

SURFACE FINISH 125 ✓ | REMOVE BURRS AND SHARP EDGES | SCALE NONE | SHEET 1 OF 1

Acoustic Systems Incorporated

TITLE QA, AT, ABGG WaveAlert Interconnections

DATE	PART NUMBER	REV
6 August 2007	900.2210-00	A



PN: 030.2009-03

NMR 602

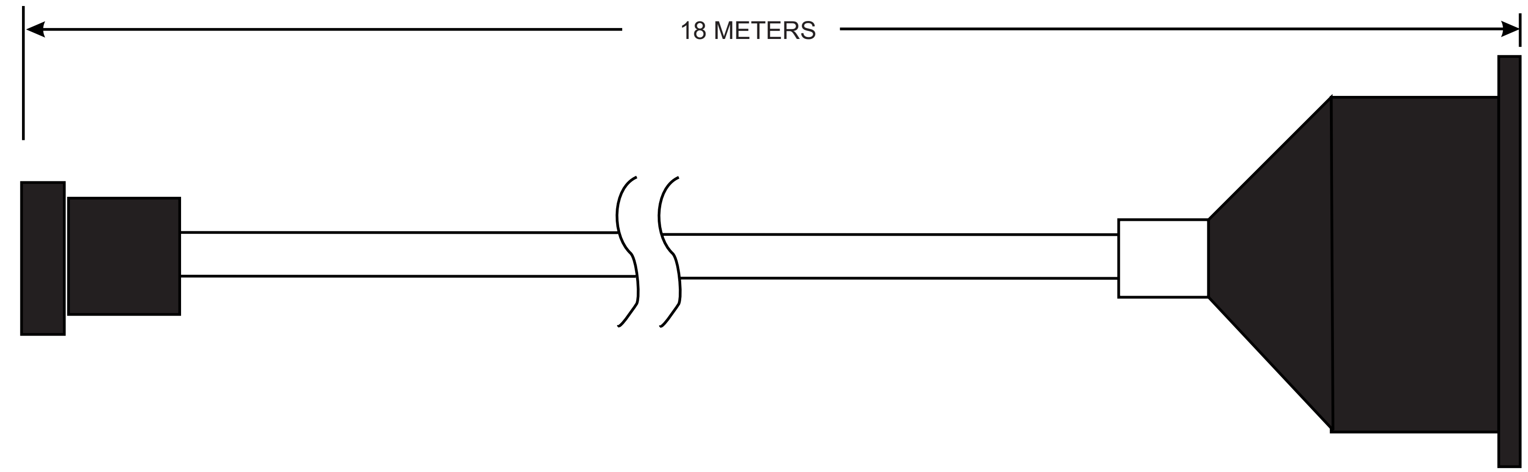
4C TECHNOLOGIES PO #P7-1722-GCC
ARAMCO AREA CLASSIFICATION PHASE II
PIPELINE UPGRADE
BI-10-03096

UNLESS OTHERWISE SPECIFIED
1. TOLERANCE INCHES .X = ±.03 .XX = ±.015 .XXX = ±.005; MILLIMETERS .X = ±.8 .XX = ±.4 .XXX = ±.15
2. ANGULAR ± 00 30'
3. ALL DIMENSIONS ARE IN INCHES OR INCHES (MILLIMETERS).
4. TOLERANCES ARE NON-ACCUMULATIVE.
5. CONCENTRICITY .015 TIR.
6. MACHINED INSIDE CORNERS .02 R MAX

SURFACE FINISH 125 ✓ REMOVE BURRS AND SHARP EDGES

Acoustic Systems Incorporated

TITLE	WAVEALERT D3 WIRING DIAGRAM		
SCALE NONE	SHEET 1 OF 1	DATE 31 JULY 2007	PART NUMBER 900.2220-01	REV A



12 PIN CIRCULAR WATERPROOF GPS ANTENNA CONNECTOR

25 PIN RS-232 MALE CONNECTOR

Signal	Wire Color	Protocol	GPS Antenna Connector	DB-25 Connector
DC Power (+8 to +36V DC)	Red/Blue	+8 to 36 V	Pin 1	Pin 13
Port B: RS-422 / Receive	White/Orange	TSIP RS422	Pin 2	Pin 14
Port B: RS-422 / Receive +	Orange/White	TSIP RS422	Pin 3	Pin 1
Port B: RS-422 / Transmit -	Brown/White	TSIP RS422	Pin 4	Pin 3
Port B: RS-422 / Transmit +	White/Brown	TSIP RS422	Pin 5	Pin 16
DC Ground	Blue/Red	Ground	Pin 9	Pin 7
One PPS: Transmit +	White/Blue	RS422	Pin 11	Pin 18
One PPS: Transmit -	Blue/White	RS422	Pin 12	Pin 5

GPS ANTENNA CABLE SPECIFICATION:
Low Capacitance Computer Cable, 4 pair, 24 AWG stranded (7x32) , twisted, shielded.

NMR 602

4C TECHNOLOGIES PO #P7-1722-GCC
ARAMCO AREA CLASSIFICATION PHASE II
PIPELINE UPGRADE
BI-10-03096

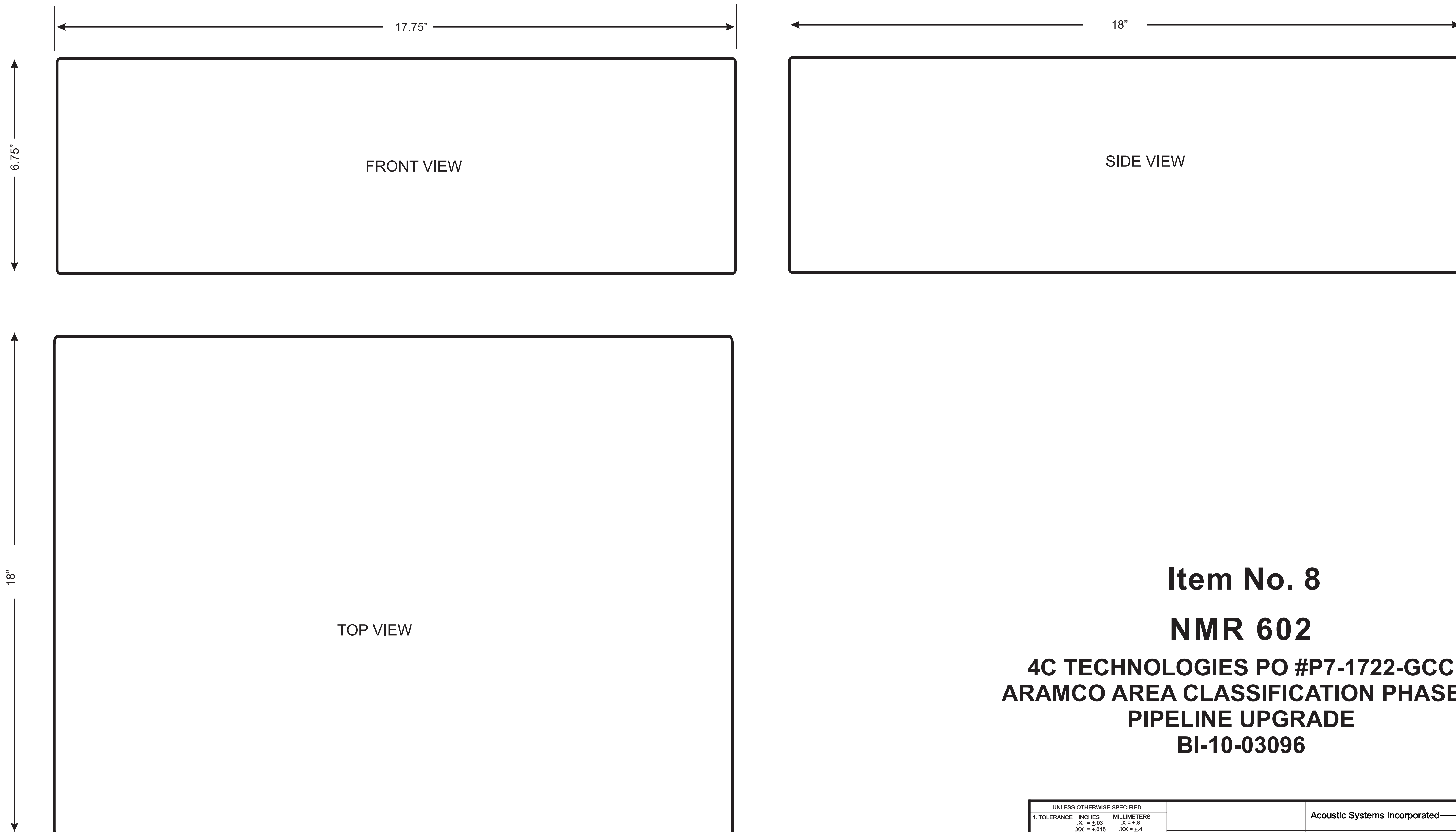
UNLESS OTHERWISE SPECIFIED
1. TOLERANCE INCHES .X = ±.03, .XX = ±.015, .XXX = ±.005; MILLIMETERS .X = ±.8, .XX = ±.4, .XXX = ±.15
2. ANGULAR ± 00 30'
3. ALL DIMENSIONS ARE IN INCHES OR INCHES (MILLIMETERS).
4. TOLERANCES ARE NON-ACCUMULATIVE.
5. CONCENTRICITY .015 TIR.
6. MACHINED INSIDE CORNERS .02 R MAX

SURFACE FINISH 125 ✓ | REMOVE BURRS AND SHARP EDGES | SCALE NONE | SHEET 1 OF 1

Acoustic Systems Incorporated

TITLE: WAVEALERT VIII GPS Antenna Cable

DATE: 31 JULY 2007 | PART NUMBER: 900.2290-00 | REV: A



Item No. 8

NMR 602

4C TECHNOLOGIES PO #P7-1722-GCC
ARAMCO AREA CLASSIFICATION PHASE II
PIPELINE UPGRADE
BI-10-03096

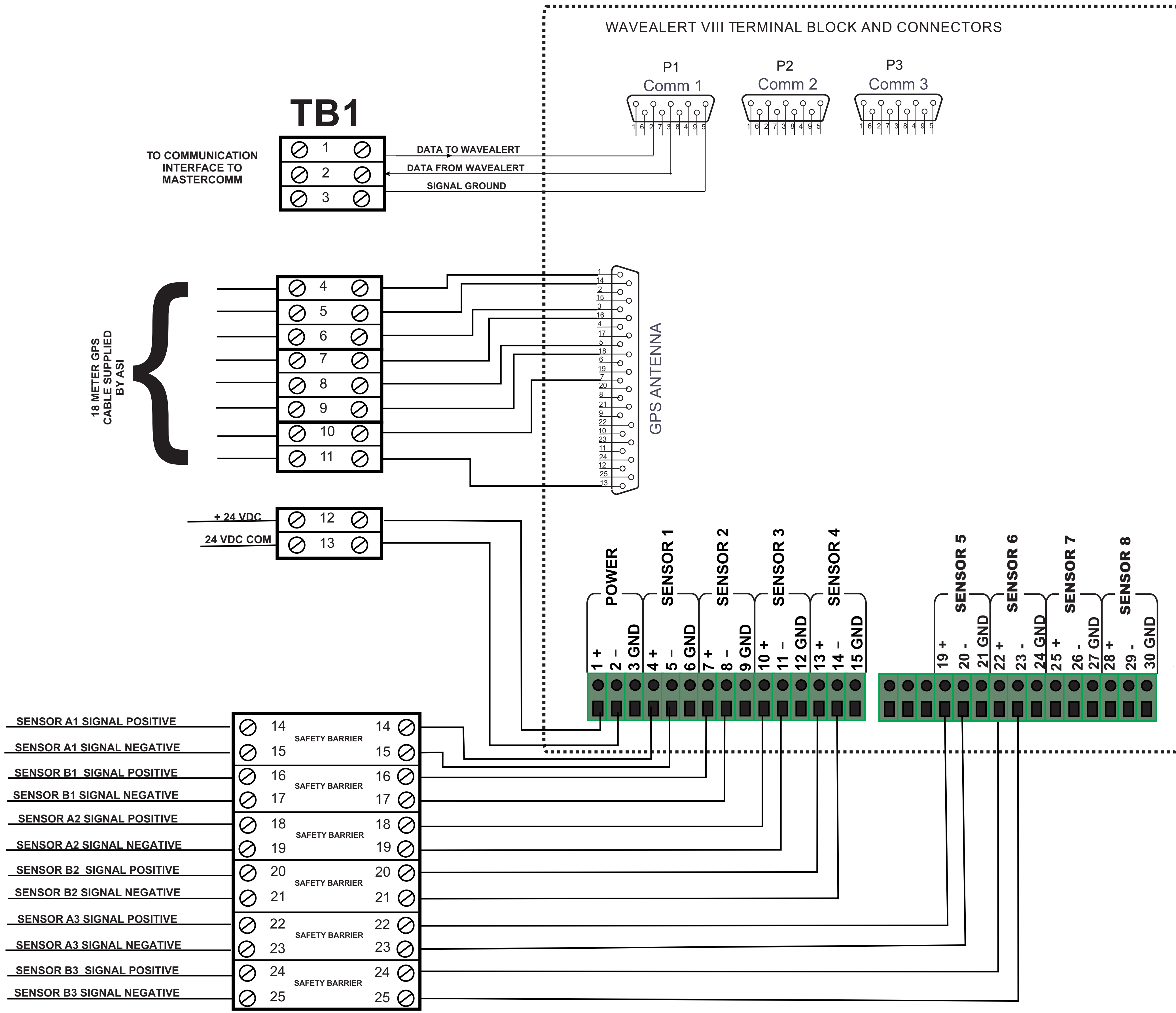
UNLESS OTHERWISE SPECIFIED

1. TOLERANCE INCHES: .X = ±.03; .XX = ±.015; .XXX = ±.005 — MILLIMETERS: .X = ±.8; .XX = ±.4; .XXX = ±.15
2. ANGULAR ± 00 30'
3. ALL DIMENSIONS ARE IN INCHES OR INCHES (MILLIMETERS).
4. TOLERANCES ARE NON-ACCUMULATIVE.
5. CONCENTRICITY .015 TIR.
6. MACHINED INSIDE CORNERS .02 R MAX

SURFACE FINISH 125 ✓ | REMOVE BURRS AND SHARP EDGES

Acoustic Systems Incorporated

TITLE	ASI Leak Computer Dimensions			
SCALE NONE	SHEET 1 OF 1	DATE 12 APRIL 2007	PART NUMBER 900.2344-00	REV A



PN: 030.2009-06

NMR 602

4C TECHNOLOGIES PO #P7-1722-GCC
ARAMCO AREA CLASSIFICATION PHASE II
PIPELINE UPGRADE
BI-10-03096

UNLESS OTHERWISE SPECIFIED
1. TOLERANCE INCHES .X = ±.03 .XX = ±.015 .XXX = ±.005 MILLIMETERS .X = ±.8 .XX = ±.4 .XXX = ±.15
2. ANGULAR ± 00 30'
3. ALL DIMENSIONS ARE IN INCHES OR INCHES (MILLIMETERS).
4. TOLERANCES ARE NON-ACCUMULATIVE.
5. CONCENTRICITY .015 TIR.
6. MACHINED INSIDE CORNERS .02 R MAX
SURFACE FINISH 125
REMOVE BURRS AND SHARP EDGES

Acoustic Systems Incorporated

TITLE: WAVEALERT D6 WIRING DIAGRAM

SCALE	SHEET	DATE	PART NUMBER	REV
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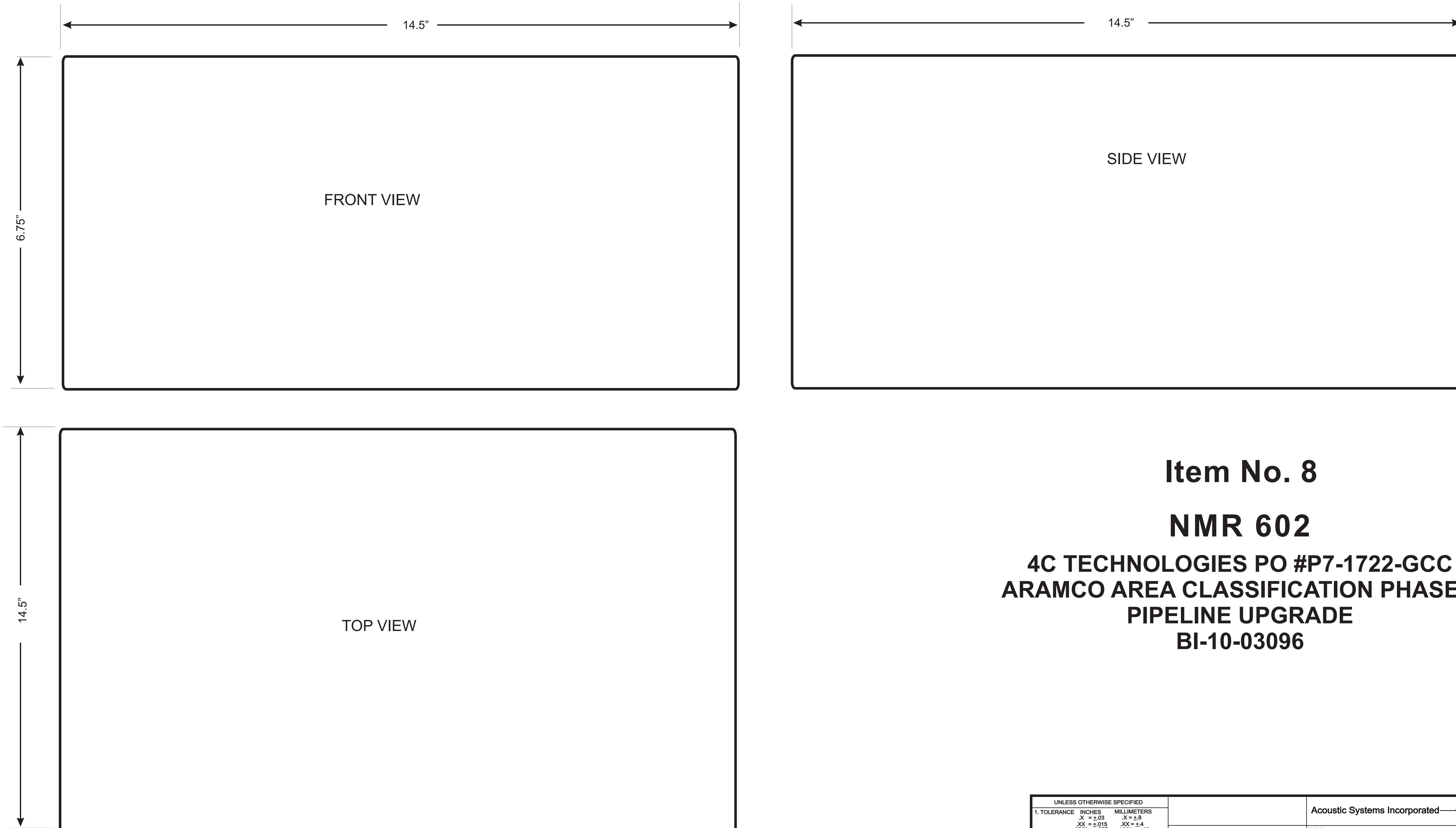


Item No. 8

NMR 602

4C TECHNOLOGIES PO #P7-1722-GCC
ARAMCO AREA CLASSIFICATION PHASE II
PIPELINE UPGRADE
BI-10-03096

UNLESS OTHERWISE SPECIFIED

1. TOLERANCE

	INCHES	MILLIMETERS
.X	= ±.03	.X = ±.8
.XX	= ±.015	.XX = ±.4
.XXX	= ±.005	.XXX = ±.15

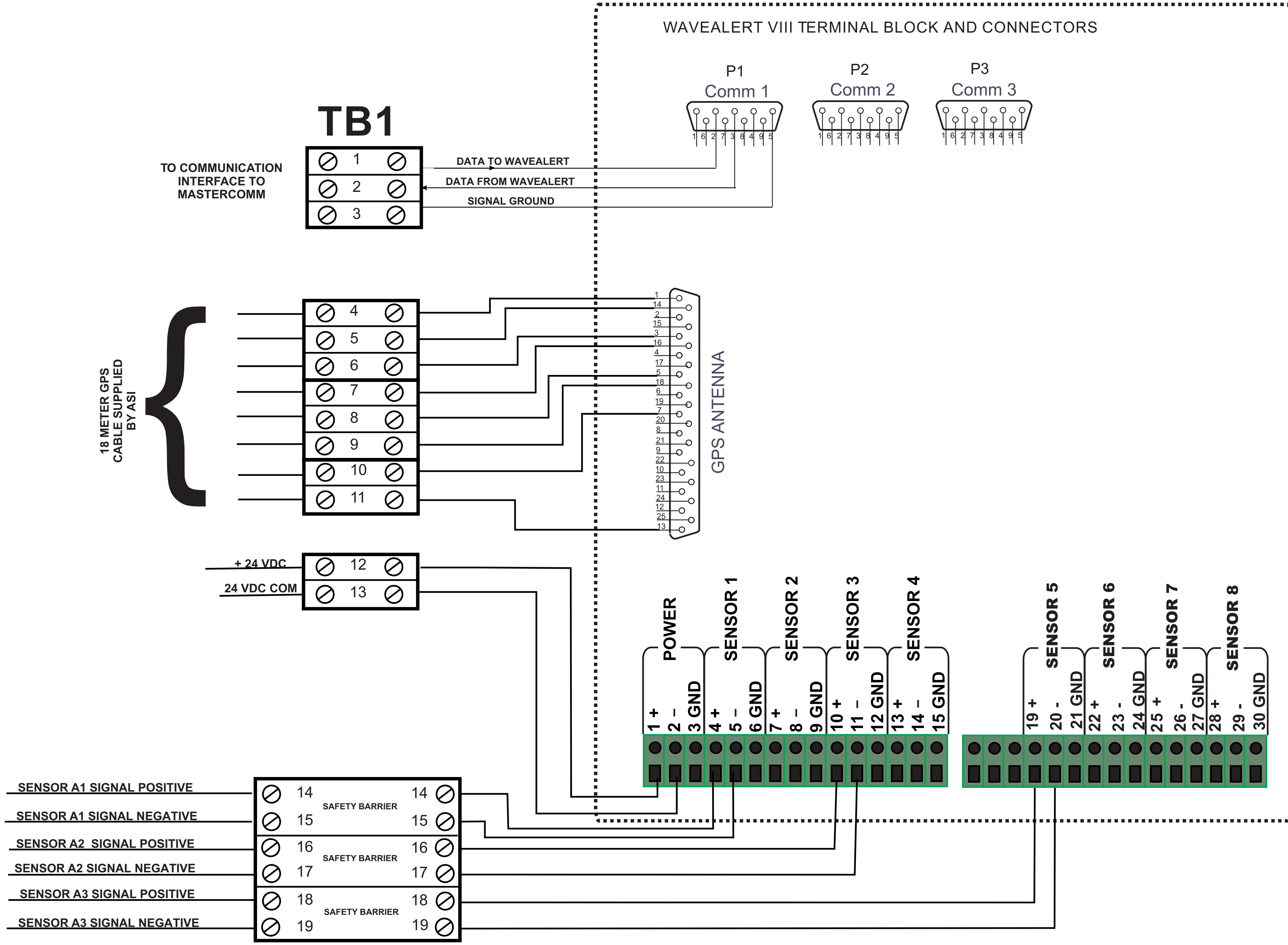
2. ANGULAR ± 00 30'
3. ALL DIMENSIONS ARE IN INCHES OR INCHES (MILLIMETERS).
4. TOLERANCES ARE NON-ACCUMULATIVE.
5. CONCENTRICITY .015 TIR.
6. MACHINED INSIDE CORNERS .02 R MAX

SURFACE FINISH 125 ✓ | REMOVE BURRS AND SHARP EDGES | SCALE NONE | SHEET 1 OF 1

Acoustic Systems Incorporated

TITLE: Printer Dimensions

DATE	PART NUMBER	REV
12 APRIL 2007	900.2346-00	A



PN: 030.2009-10

NMR 602

4C TECHNOLOGIES PO #P7-1722-GCC
ARAMCO AREA CLASSIFICATION PHASE II
PIPELINE UPGRADE
BI-10-03096

UNLESS OTHERWISE SPECIFIED
1. TOLERANCE INCHES .X = ±.03 .XX = ±.015 .XXX = ±.005; MILLIMETERS .X = ±.8 .XX = ±.4 .XXX = ±.15
2. ANGULAR ± 00 30'
3. ALL DIMENSIONS ARE IN INCHES OR INCHES (MILLIMETERS).
4. TOLERANCES ARE NON-ACCUMULATIVE.
5. CONCENTRICITY .015 TIR.
6. MACHINED INSIDE CORNERS .02 R MAX

SURFACE FINISH 125 ✓ REMOVE BURRS AND SHARP EDGES

Acoustic Systems Incorporated

TITLE: WAVEALERT S3 WIRING DIAGRAM

SCALE: NONE | SHEET 1 OF 1 | DATE: 31 JULY 2007 | PART NUMBER: 900.2346-01 | REV: A

Acoustic Systems Incorporated

Detect Pipeline Leaks at the Speed of Sound

Data Broadcaster Specifications

The Data Broadcaster allows the MasterComm to poll WaveAlerts on up to 8 separate RS232 serial ports without losing signal strength. No baud rate or serial port configuration is required, data input at the MASTER port is regenerated and transmitted out of each of the 8 serial SLAVE ports simultaneously at the same baud rate (transparent to speed and data). All serial ports (1 MASTER and 8 SLAVE) use DB-9 connectors and are configured as DTE with transmit output at pin 3, receive input at pin 2 and signal ground at pin 5. Pin 1 (CD), pin 6 (DSR), pin 8 (CTS) and pin 4 (DTR) are connected together on all ports internally inside the Data Broadcaster.

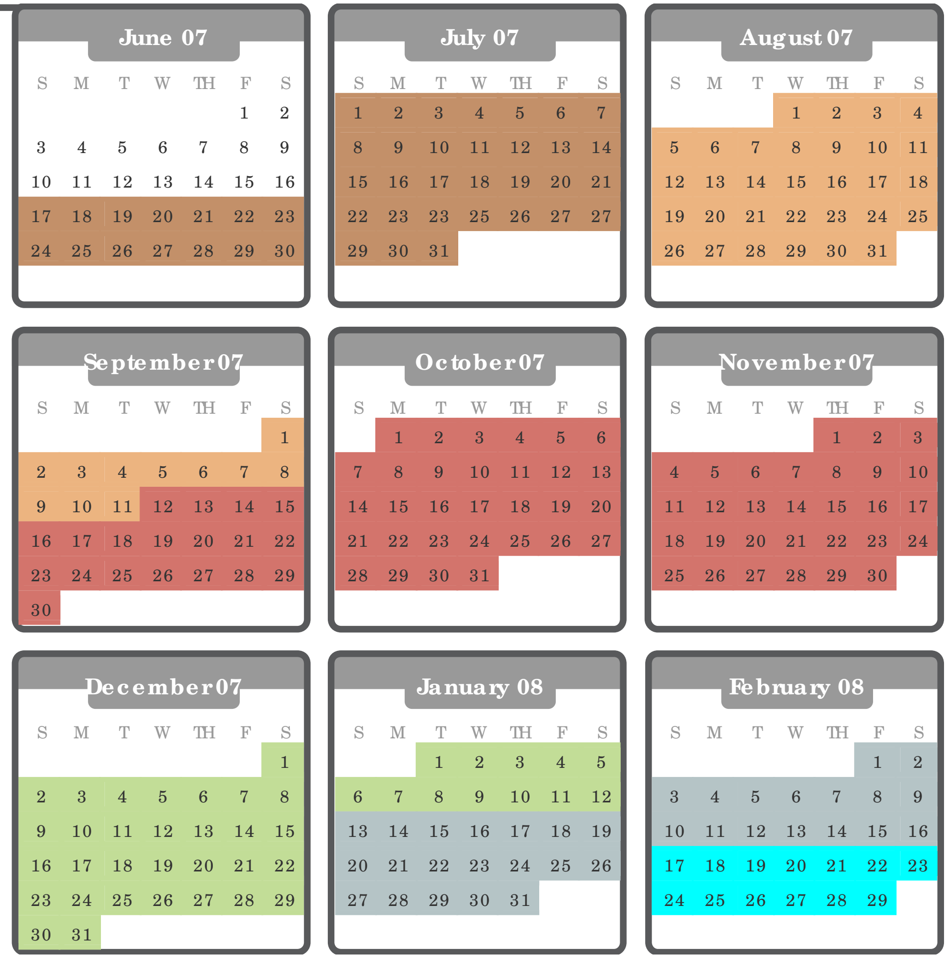
The Data Broadcaster can be mounted in a standard 19 inch electronics rack. If installing outdoors these units must be mounted in weather tight enclosures. Climate control is not required, based on the following specification:

Operating Temperature	-30 to 85 degrees Celsius (-22 to 185 degrees Fahrenheit)
Storage Temperature	-50 to 85 degrees Celsius (-58 to 185 degrees Fahrenheit)
Relative Humidity	0 to 95 percent, Noncondensing
Input Voltage	9 to 24 Vdc
Input Current (Nominal)	200 mA @ 9- 24 VDC
Flow Control	Software only, transparent to speed and data
Protocol	Async
Speed	Transparent
User Channels	8
Interface	RS-232

9803 Whithorn Drive • Houston, Texas 77095-5026 • Phone: 281-345-9995 • Fax: 281-345-9998
E-mail: sales@wavealert.com • www.wavealert.com

BI-3096 PROJECT SCHEDULE

PROJECT PHASE	START DATE	END DATE
NMR 601 Drawings & Documentation	17 JUNE 07	31 JULY 07
NMR 602 Drawings and Documentation – Procurement	1 AUG 07	11 SEPT 07
Component Assembly	12 SEPT 07	30 NOV 07
Component Level Testing – System Assembly	1 DEC 07	12 JAN 08
Engineering and Full System Test	13 JAN 08	16 FEB 08
FAT – System Shipment	17 FEB 08	29 FEB 08



1. INTRODUCTION

Acoustic Systems Incorporated (ASI), a Houston, Texas based company, is an established leader in leak detection, with over twenty years experience in the development of quality hardware and software products.

ASI specializes in on-line real-time pipeline monitoring using acoustic techniques which provide unique advantages for pipeline leak detection, including:

- Minimal time to detect and locate leaks, typically within one minute of leak occurrence
- Very accurate leak location calculation, typically to within +/- 30 meters
- Extremely low false alarm rate (typically less than one per year)
- Used for most pressurized pipelines, including single phase liquid, single phase gas and multi-phase flow pipelines
- Very sensitive, detect and locate very small leaks
- Detect leaks with or without (shut-in) flow, steady state as well as various transient operations (valve open/close, pump shut down/startup, flow increase/decrease, etc.)
- Very easy to install and operate
- Continuous leak detection with loss of communications
- Minimum maintenance, no calibration required
- Used for automatic valve shut off upon detection of leak
- Decreased risk to people and environment
- Reduced financial loss for product and for clean-up in case of accidents

ASI's Acoustic Leak Detection Systems (ALDS) employs proprietary hardware for on-line real-time leak detection and associated hardware and software for supervising communications, structuring databases, data analysis, decision-making, report and display generation and issuing alarms. Systems employ combinations of radio, fiber optic and hardwire communications with either personal or mainframe computers for operator interface. Applications include liquid, gas and multi-phase flow pipelines, and consist of single transmission lines, networks, gathering lines, subsea lines, single and multiple product transfer lines.

The WaveAlert® system is the only leak detection system with an establish record of not only detecting leaks but automatically shutting in pipeline valves to limit environmental damage and possible casualties. This can only be accomplished with a minimum number of false alarms. (See section 6.1 for a detailed example).

1.1. Acoustic Systems Incorporated

Taft Communications Systems Incorporated, pioneered acoustic leak detection monitoring technology for pipeline application; the direct forerunner of the ASI ALDS system. The first client was Tennessee Gas Pipeline Company.

Taft Communications was renamed Bethany International in 1973. In September 1978, Crutcher Resources Corporation purchased Bethany under a pooling of interests and Bethany became CRC Bethany International, Inc. Scientific Software Intercomp, a software company, purchased CRC Bethany in 1983. ASI was incorporated in the State of Texas in December 1983 and purchased the CRC Bethany Hardware Division (including patents, license agreements and inventory) on February 1, 1984.

Since 1984, ASI has worked continuously to keep hardware based monitoring techniques at the forefront of leak detection technology. ASI's ALDS has been installed worldwide (Figure 1-1) on pipelines including gas, liquid and multi-phase flow.

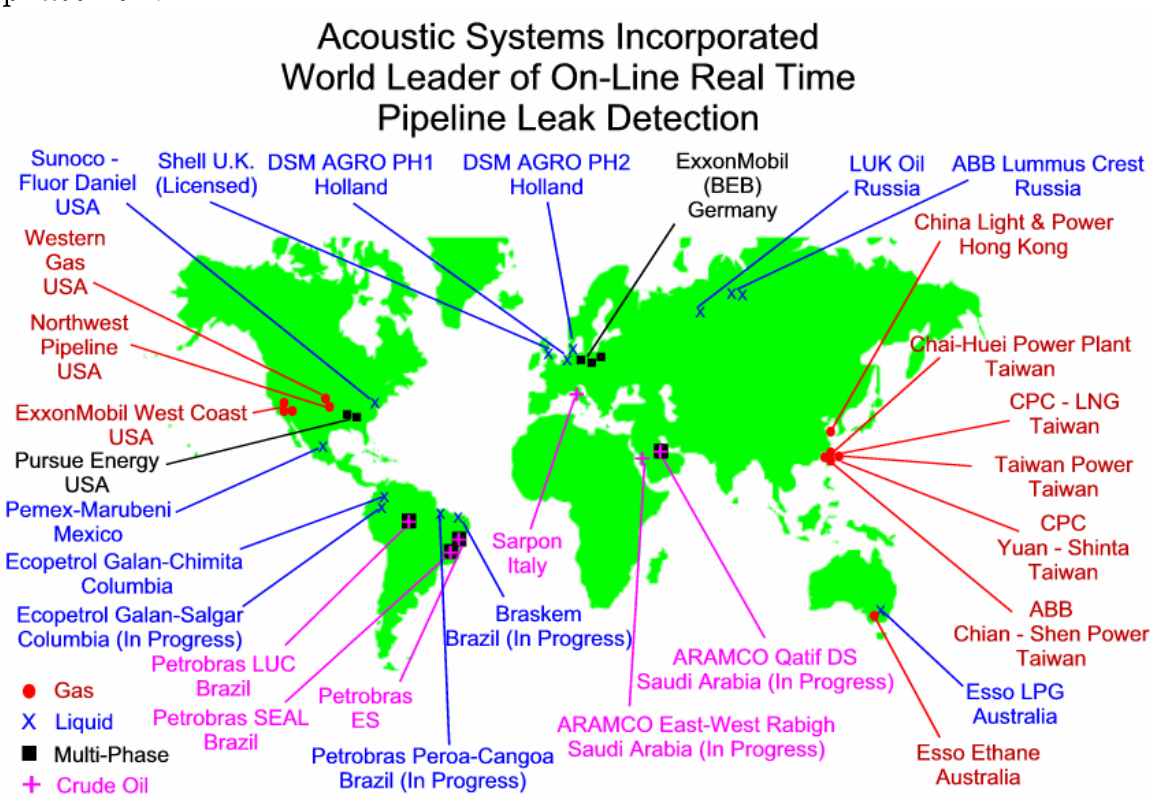


Figure 1-1: Installations around the World with Various Pipelines

1.2. Facilities

ASI headquarters are located in Houston, Texas, USA, with a branch office in New Jersey and a network of marketing representatives covering the globe.

Mailing Address: Acoustic Systems Incorporated
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Houston, Texas 77095-5026, USA

Telephone: (281) 345-9995

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Website: www.wavealert.com

2. REAL TIME LEAK DETECTION

2.1. Pipeline Monitoring

Moving fluids by pipeline is an energy-efficient means of transportation, proven safe and effective over years of industry experience. In recent years, total mileage of installed pipelines has increased dramatically. This trend is expected to continue. A wide variety of fluids are transported by pipeline, including crude oil, natural gas, water and refined petroleum products. Many other liquid and gaseous industrial products, such as carbon monoxide, ammonia, phenol, cumene, acetone and copper slurry, are moved by pipeline.

Responsibility for a pipeline and its operations lies with the operator. Pipeline leaks are rare, but present serious problems when they occur. The most serious problem is the release of hazardous substance. Even if the release is not life threatening, there is concern over the effect of emissions on the environment and upon public image.

An unchecked leak represents loss of valuable product; clean up costs; increased hazard to life and environment; and cost to public image. The amount of product loss in a monitored pipeline depends upon:

- Minimum detectable hole size
- Elapsed time from leak to action

Additional costs include loss of service and repair expenses. The time required, to return a pipeline to service after a leak occurrence, can be greatly reduced by timely leak location information. The WaveAlert® Leak Detection System provides leak occurrence and location information quickly and accurately based upon direct measurements.

2.2. Leak Statistics

The following statistics show causes of known worldwide pipeline failures for recent years.

Cause	Percentage
External Damage	58 %
Material Failure	18 %
Corrosion	15 %
Construction Faults	6 %
Others	3 %

Table I: Causes of Known Pipeline Failures

The majority of leaks are caused by third-party intervention, such as bulldozers, backhoes or theft. Additional causes include ground movement, earthquakes, corrosion and washouts under riverbeds. Material failures and improper operating procedures that cause damaging transient pressures or pressure surges have also been reported as causing leaks.

3. ACOUSTIC LEAK DETECTION

Acoustic Leak Detection Systems (ALDS) are used on both liquid and gas pipelines as well as multi-phase flow pipelines to detect leaks quickly and provide a means of limiting product loss.

With over 20 years of worldwide applications, Acoustic Systems Incorporated (ASI) ALDS has proven to be the most effective, true real-time, on-line leak detection method. Acoustic Systems Incorporated has improved leak detection technology from many years of field proven applications providing the quickest leak detection, high sensitivity, precise leak location accuracy and low false alarm rate with minimum maintenance requirement. These improvements were made by developing and applying advanced data processing techniques such as differential filtering, moving average filtering, proprietary 'SMART DRIVE' for adaptive dynamic threshold adjustment, as well as various repetitive filters. One of these developments, the patented Signature Signal Matching Filter, is especially effective. The real-time signal is continuously compared against signature leak profiles for the particular operating and geometric conditions. These profiles were developed from a database established from over 20 years of experimental and field leak tests. This technique not only drastically reduces the false alarm rate (one alarm a year or less), but also significantly improves the sensitivity and leak location accuracy. This system will also detect leaks with shut-in flow (zero flow rate in the pipeline). With the use of GPS (Global Positioning System) it not only improves leak location accuracy, but also allows for continuous leak detection during the loss of communications.

3.1. System Configuration

The WaveAlert® VIII ALDS is shown in Figure 3-1.

The ALDS includes three major assemblies and associated communications links:

- WaveAlert® VIII Site Processor (including Acoustic Sensor Assembly)
- MasterComm™ VIII Node Processor
- ASI Leak Computer with SCADA Software

System operations are summarized in Figure 3-2.

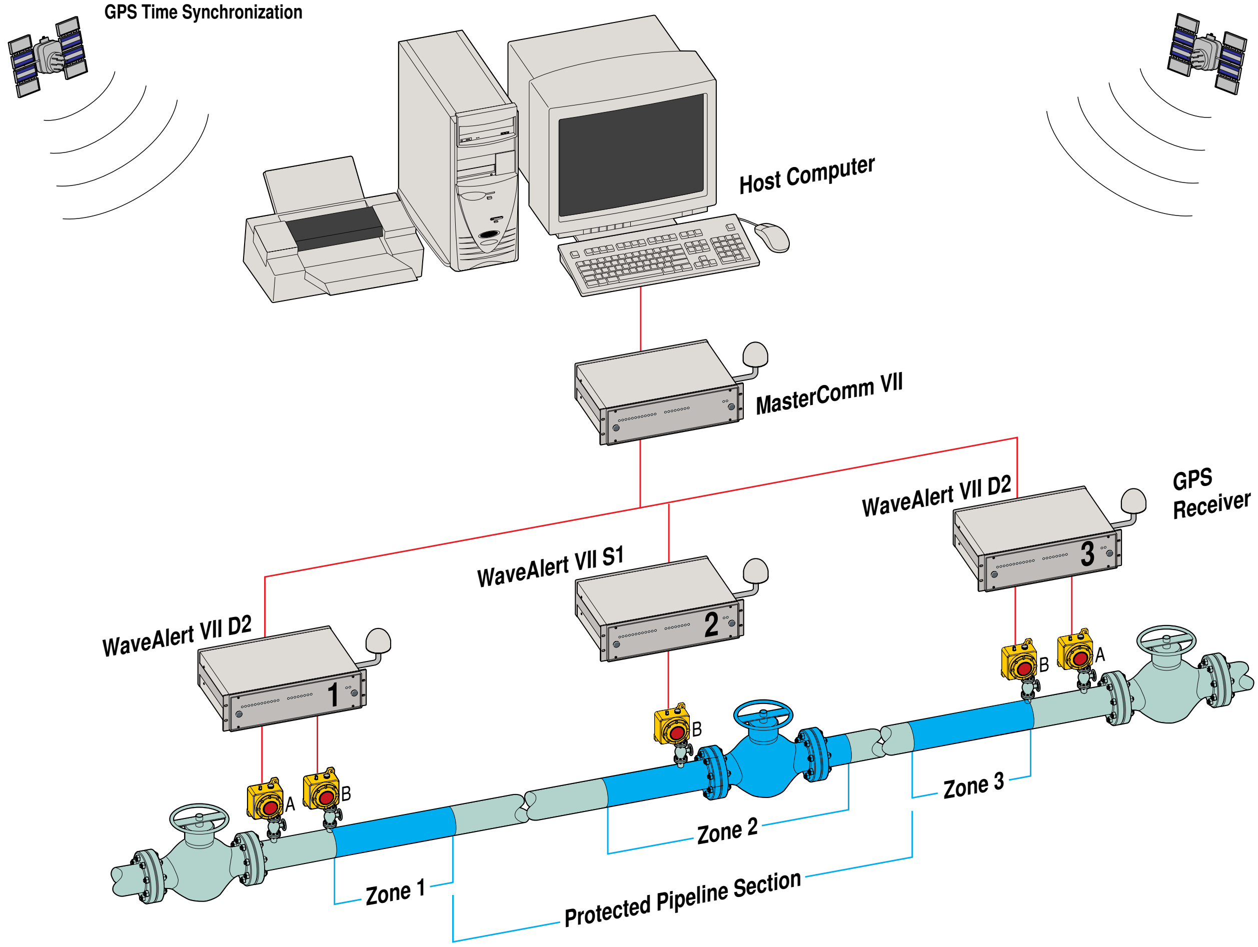


Figure 3-1: Schematic Diagram of the Acoustic Leak Detection System.

3.1.1. WaveAlert® VIII Site Processor and Acoustic Sensor Assembly

The WaveAlert® VIII Site Processor and Acoustic Sensor Assembly are located along the pipeline (usually at valve sites or other designated locations) and comprise two separate assemblies.

The WaveAlert® VIII Site Processor monitors inputs from one or more acoustic sensors and distinguishes a leak signal from other pipeline noises.

The WaveAlert® VIII Site Processor can be located within a standard 19-inch rack mount electronics cabinet and can be sited either in an equipment shelter, in a NEMA-3R (rain tight) enclosure or waterproof enclosure for underground installation.

3.1.2. MasterComm VIII Node Processor

The MasterComm™ VIII Node Processor serves as the central processing unit for the ALDS. It polls WaveAlert® VIII Site Processors in turn. During each poll cycle, it stores digital and analog values including the time of any acoustic event registered. By comparing times of arrival of an acoustic event at two WaveAlert® VIII Site Processors, it determines if a leak has occurred, locates the leak, categorizes its size and issues appropriate messages to the ASI Leak Computer.

The MasterComm™ VIII enclosure is physically identical to the WaveAlert® VIII enclosure.

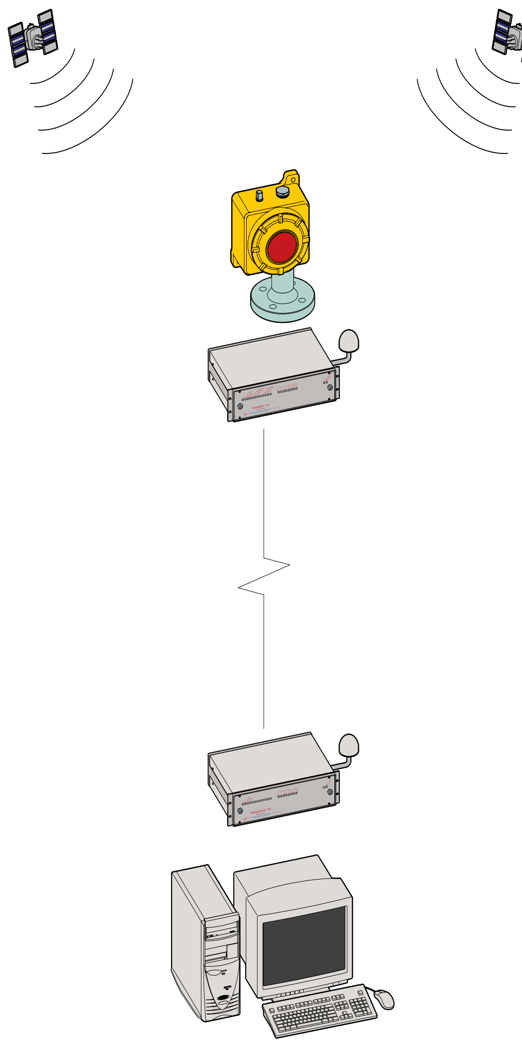


Figure 3-2:Summary of System Operations

Acoustic Sensor Assembly

- Produce 4-20 mA dynamic acoustic signal

WaveAlert® VIII Site Processor Assembly

- Convert acoustic signals from analog to digital
- Compute correlation of dynamic pressure with mask leak profile
- Compare correlation with threshold
- Perform system tests
- Set flags indicating acoustic event
- Uses GPS receiver to synchronize data sampling between WaveAlert® VIII sites
- Report to MasterComm™ VIII Node Processor when polled

Communications Link

- Provide two way communications between WaveAlert® VIII Site Processor and MasterComm™ VIII Node Processor

MasterComm™ VIII Node Processor

- Integrate information from WaveAlert® VIII Site Processors
- Analyze physical data (Leak/No Leak)
- Originate updated polling requests for monitor stations.

ASI Leak Computer or Host Computer

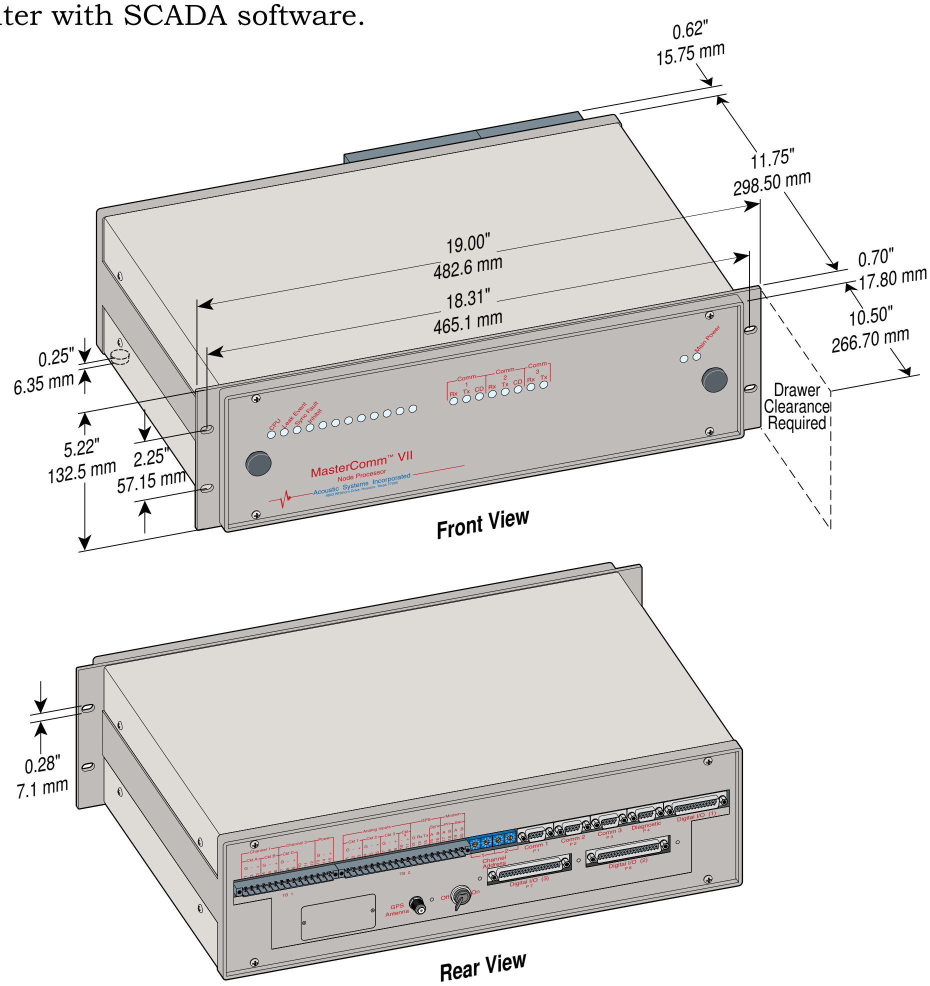
- Maintain system database
- Provide operator interface
- Produce appropriate displays, alarms and messages
- Generate leak signal for valve control

3.1.3. Communication Link

The communication link between WaveAlert® VIII Site Processors and the MasterComm™ VIII Node Processor is a dedicated two-way half-duplex link. It may include radio, hardwire landline, fiber optic sections or any other dedicated communication links.

3.1.4. ASI Leak Computer and SCADA Software

The ASI Leak Computer with SCADA Software provides user interface with the ALDS via Video Screens, Keyboard, Audio Alarms and Printer. ASI can provide either a turnkey system featuring a Personal Computer with SCADA software or provide a detailed interface specification to permit interface to a mainframe computer with SCADA software.



Notes:

1. Access to rear panel is required for wiring connections, power switch and DB connectors.
2. Approximate total weight (with all circuit boards included) is 20lbs. (9kg).

Figure 3-3: Outline Drawing of the WaveAlert® VIII Site Processor and MasterComm™ VIII Node Processor Enclosures.

3.1.5. WaveAlert® VIII and MasterComm™ VIII Hardware

The WaveAlert® VIII Site Processor and the MasterComm™ VIII Node Processor incorporate advanced signal processing hardware.

The WaveAlert® VIII Site Processor uses the following circuits:

- Power Supply Circuit
- Signal Processor Circuit
- Signal Conditioner Circuit
- Interface Status I/O Circuit

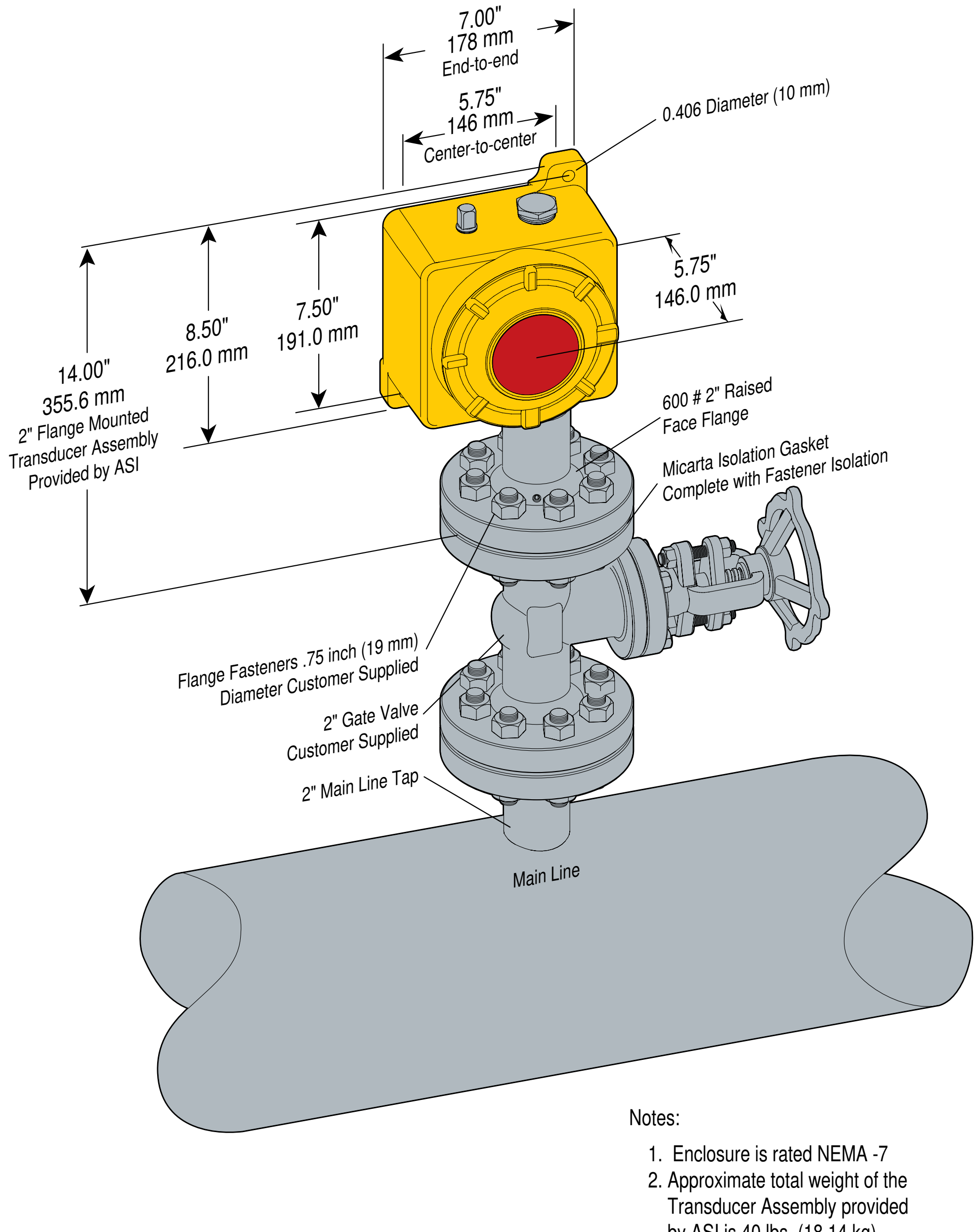


Figure 3-4: Outline Drawing of the Acoustic Sensor Assembly

The MasterComm™ VIII Node Processor uses the following circuits:

- Power Supply
- Signal Processor Circuit
- Interface Status I/O Circuit

3.1.5.1. Power Supply Circuit

The Power Supply consists of an advanced switch-mode DC/DC converter, which accepts raw DC input and generates required system voltages. Input to output isolation of 500 VDC is provided, as well as output current limiting, automatic restart, and input transient suppression.

3.1.5.2. Signal Processor Circuit

The Signal Processor Circuit is the central control subsystem of the Site and Node Processors. It consists of a signal processor with associated clock, interface and memory circuits. It generates control and timing signals, provides communication oversight, provides digital filtering to discriminate against noise caused by pumps, opening or closing of valves, or other normal pipe operations and performs internal self tests to assure proper system operation. This also consists of various ASI patented proprietary data processing algorithm

3.1.5.3. Signal Conditioner Circuit

The primary functions of the Signal Conditioner Circuit are galvanic isolation and filtering of signals from the Acoustic Sensor Assembly.

3.1.5.4. Interface Status I/O Circuit

The Interface Status I/O Circuit allows the WaveAlert® VIII to perform application specific tasks. Inputs include four optically isolated status inputs. Output include four, 2 ampere, dry, NO/NC contacts.

3.1.6. ASI Leak Computer

The ASI Leak Computer may be either a dedicated personal computer for smaller systems or a mini-computer (which may timeshare). The ASI Leak Computer communicates with one or more MasterComm™ VIII Node Processors. Usually this is via direct connection conforming to the RS-232C standard.

3.2. Measuring Techniques

3.2.1. Directional Dual Element Acoustic Sensor Arrays

In a typical installation, it is often necessary to locate acoustic sensors near pumping stations and active flow control valves; usually sites of high noise levels. To discriminate against this off line noise, directional acoustic sensor arrays consisting of two acoustic-sensing elements separated by a distance of 50 to 100 meters (165 to 328 ft) are used at the ends of protected pipeline sections.

This dual element sensor array forms a directional filter, rejecting noise from one direction, but detecting a signal from the other.

The WaveAlert® VIII S1 Site Processor employs a single acoustic sensor, sensitive to acoustic signals originating from either direction. This configuration is used at intermediate locations along the pipeline, away from compressor stations, control valves, etc.

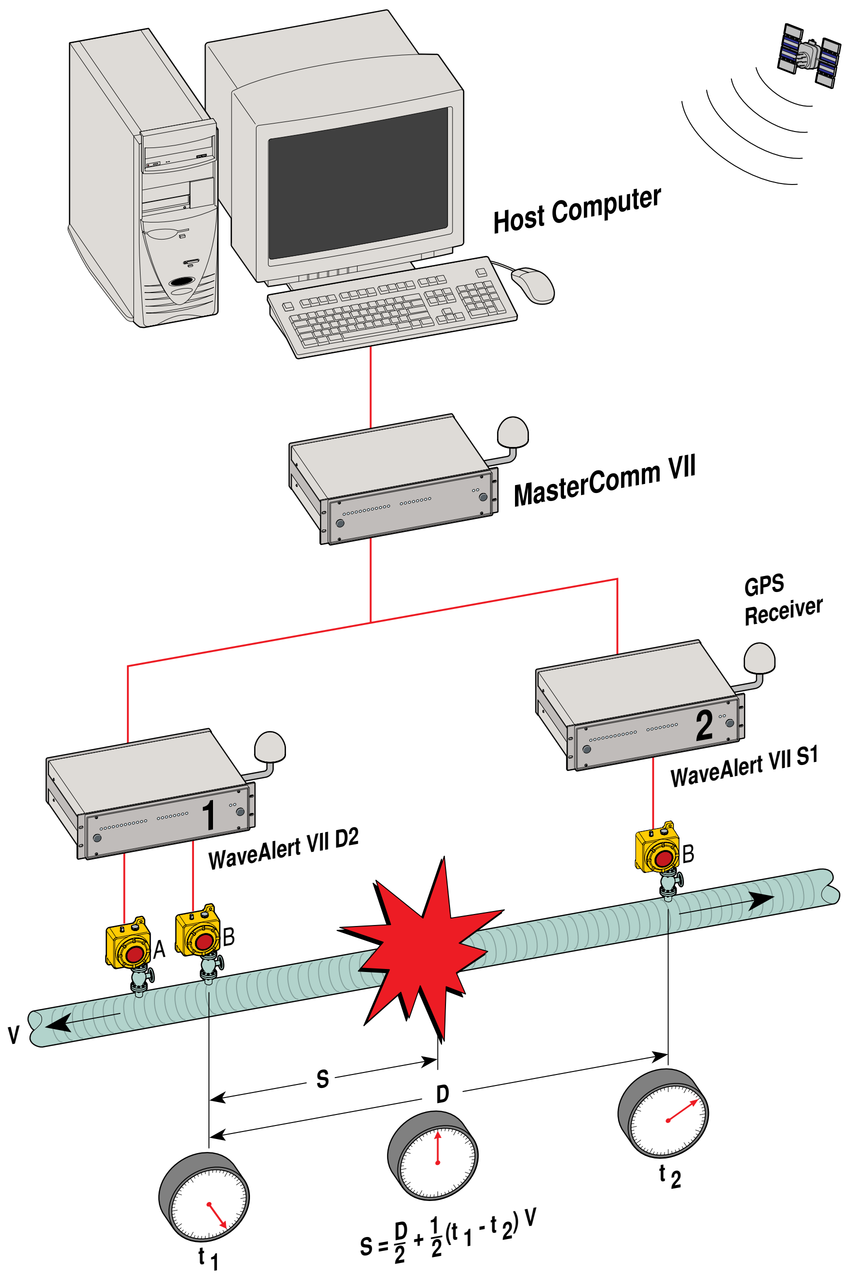


Figure 3-5: Algorithm for Determining Leak Location

3.2.2. Leak Location

Leak Location is determined from times of arrival of the acoustic signal at two adjacent WaveAlert® VIII acoustic sensors. Figure 3-5 shows the algorithm for the case of a single product in the pipeline between sites. The rupture occurs at time t = 0 shown by the middle clock. The signal travels away from the leak in both directions and arrives at the acoustic sensors at later times. If the rupture is farther from site 1 than site 2, clock 1 runs longer than clock 2.

The leak location, S, is measured from site 1. D is the distance between sites.

Notice that if $t_1 = t_2$, according to the location algorithm, the leak is located at the midpoint of the pipeline segment. If $t_1 < t_2$, the leak is located left of the midpoint.

3.2.3. Leak Declaration

Leak declaration decisions, are made by the MasterComm™ VIII Node Processor from information, supplied by WaveAlert® VIII Site Processors. Decisions are based upon requirements that:

- More than one WaveAlert® VIII Site Processor recorded an acoustic event
- The acoustic signal source is found to originate at a location on the protected segment of the pipeline
- The potential leak event signals received from two or more local Wavealert® Processors are verified by proprietary data processing and identification algorithm at the MasterComm™.

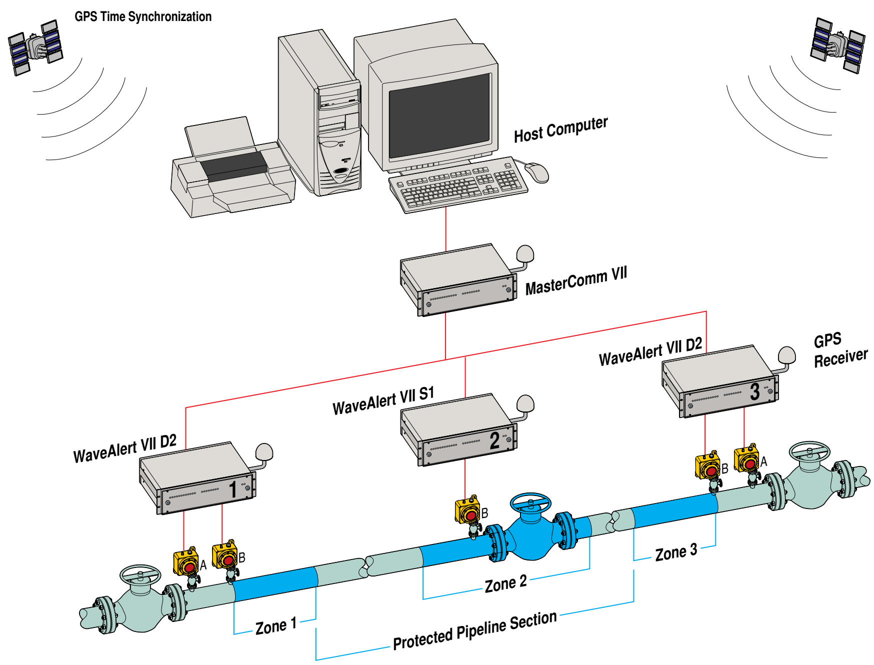


Figure 3-6: Muting Zones Adjacent to Wavealert® VIII Sites

3.2.4. Muting Zones

Noise from sources located beyond the ends of the protected section of the pipeline which result in acoustic event declarations by more than one WaveAlert® VIII Site Processor will be determined to be within the leak location accuracy from the near acoustic sensor. Since the majority of false event declarations are produced by off line acoustic sources, the false leak alarm rate is greatly reduced, if acoustic signals observed outside of the protected zone can be excluded. However, due to the uncertainty associated with location calculation, a muting zone is declared on either side of each acoustic sensor within which that WaveAlert® VIII is not allowed to contribute data leading to a leak declaration (See Figure 3-6.) Thus, at the ends of the pipeline, protection is not afforded for a short distance (determined by the leak location accuracy) from the B transducer. At intermediate WaveAlert® VIII sites, even though the local WaveAlert® VIII cannot contribute to a leak decision for leak signals originating within its muting zone, one active WaveAlert® VIII located on either side can contribute data for a decision. Thus, protection is provided at intermediate sites.

3.2.5. Detection Time

The maximum time required to detect a leak is the sum of:

- Travel time for an acoustic signal from the leak site to the farthest monitor site, equal to the distance between adjacent monitor sites divided by acoustic velocity in the pipeline medium.
- Time for the Node Processor to poll all Site Processors twice and compute leak location. Scan time includes communications delays such as radio keying time.

Typical time of detecting and locating leak ranges from 10 seconds to 1 minute.

3.2.6. System Performance

Minimum detectable leak size depends upon several factors, which include:

- Static pressure in the pipeline
- Distance of the WaveAlert® VIII from the leak
- Pipe diameter and wall thickness
- Background noise levels of the pipeline
- Fluid properties

The leak threshold setting of a WaveAlert® VIII Site Processor depends upon the typical noise level in the pipeline during normal operation and the signal-to-noise ratio required to achieve a satisfactory false alarm rate. These factors depend upon the design and operation of the pipeline. ASI performs a sensitivity analysis of the line to determine the minimum detectable theoretical leak size, location accuracy, maximum detecting time and optimum placement of WaveAlert® VIII Site Processors on the pipeline. A data sheet for data used to perform this sensitivity analysis is enclosed in the Appendix of this document.

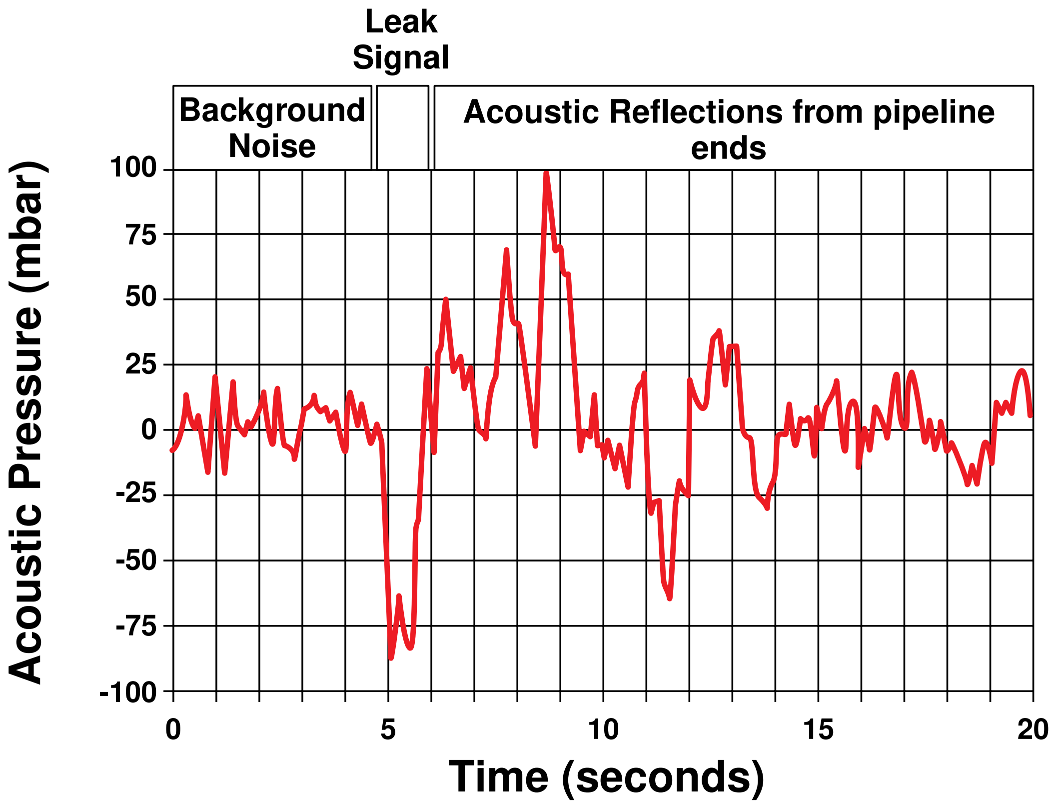


Figure 3-7: Leak Signal Produced by a 0.62-Inch Diameter Leak on a 12-Inch Diameter Pipe

3.2.7. Signal Profile

A signal produced by a simulator field leak test on a liquid line is shown in Figure 3-7. The acoustic signal was created by rapidly opening a ball valve through a flow controlling orifice plate. The signal has been filtered through a band pass filter. The signal amplitude is 78 mbar. The orifice was 15.7 mm (0.62 inch) diameter with a static pressure of 57 psig and was located 6.4 km (4 miles) from the acoustic monitor. This profile is typical of liquid bearing pipelines. Signal amplitude increases with hole area and pressure and decreases with pipeline cross section. The signal profiles changes with products and with different degrees of dispersion and attenuation during propagation. The unique feature of the signal profile and its change while propagating along the pipeline is the basis of the ASI proprietary mask filter for pattern recognition.

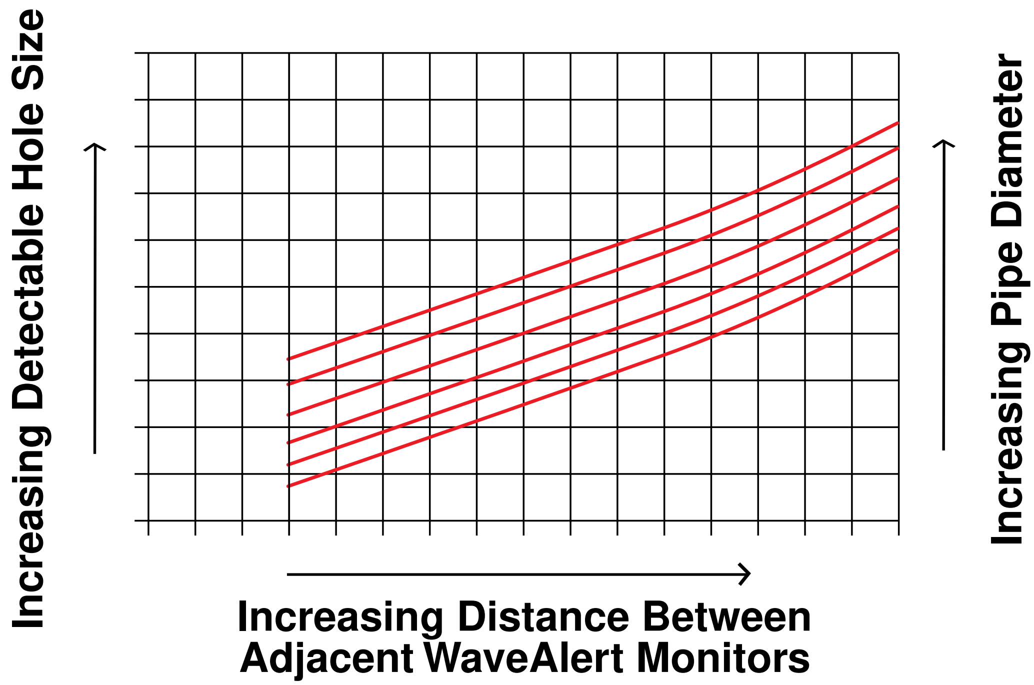


Figure 3-8: Minimum Detectable Hole Diameter vs Distance

3.2.8. Sensitivity

Figure 3-8 shows how minimum detectable hole size versus distance between acoustic monitors varies for different pipe diameters. Actual sensitivities depend upon the fluid in the pipeline, static pressure and background noise conditions.

In order to minimize false alarms, all acoustic leak events must pass the multi-layer proprietary verification algorithm at the MasterComm. Due to the positive pattern recognition technique used in this system, a true leak can be identified even in noisy environments (low signal to noise ratio). A leak is not declared unless an acoustic event is detected by two monitors, one upstream and one downstream. Since a leak can occur randomly at any point between these two monitors, a key determinant of detection sensitivity is the leak distance from the farther of two adjacent monitors.

The system is most sensitive for a leak, which is located at the mid-point of the pipeline segment. Worst case occurs when the leak is farthest from one of the monitors and close to another monitor.

3.2.9. False Alarm Rejection

Wavealert® VIII Site Processors employ multiple techniques for reducing false alarm rates:

- Dual element directional array acoustic sensors at ends of the pipeline. The recommended pipeline distance between transmitters is 50-100 meters (165 to 328 ft).
- ASI's matched filters use the signature of a leak from ASI proprietary database as a mask against which real-time acoustic

signals data compared. The ASI proprietary database was built over twenty years of efforts compiling from both field leak data as well as experimental leak test data for various pipeline operating conditions and different transporting fluids. This allows a fingerprint matching type of positive identification on the true leak signal and drastically reduces the possibility of false alarm and increases the detection sensitivity.

- Digital high pass and low pass filters with adjustable roll-off frequencies.
- Moving average filter to suppress higher frequency noise.
- Dynamic threshold logic utilizes the ASI proprietary "SMART DRIVE' auto-adjust mechanism in distinguishing abnormal noise from true leak signals. The ASI 'SMART DRIVE' program continuously scans, computes, and verifies all incoming data and automatically adjusts the dynamic thresholds based on the ASI proprietary expert logic developed over years of experiences. This will further reduce the false alarm rate.
- Repetitive Filters to suppress cyclic pipeline noise and other various unusual noise sources.

False alarm rate is also a function of frequency of activity (sudden pressure changes on the pipeline associated with operating changes and background noise.) By use of the above filters false alarms have been reduced significantly. The false alarm frequency is expected to be less than three per year (typically less than one per year) for a commissioned system.

3.3. Available Configurations

The WaveAlert® VIII D Site Processor is configured to monitor one or two dual element, directional sensor arrays at the end of a protected pipeline segment. The WaveAlert® VIII S Site Processor monitors one or two single element sensors.

Site Processor configurations are summarized in Table II. The last number in the designation is the total number of sensor elements supported.

Designation	Sensor Configuration	Total Number of Sensor Elements
WaveAlert® VIII S1	Single sensor	1
WaveAlert® VIII D2	Directional sensor array	2
WaveAlert® VIII S2	Two single sensors *	2
WaveAlert® VIII D4	Two directional sensor arrays	4
WaveAlert® VIII D3	One single sensor One directional sensor array*	3
WaveAlert® VIII SR1	Single sensor, remote Wavealert® processor	
	** For monitoring parallel lines*	

Table II: Available Configurations for WaveAlert® VIII Site Processors.

4. SOFTWARE

The WaveAlert® VIII Leak Detection System employs three basic software/firmware systems. Software/firmware tasks within these systems are shown in Figure 4.1.

4.1. WaveAlert® VIII Site Processor Firmware

Site Processor instructions are supplied in ROM and contain local operating instructions for the WaveAlert® VIII including data gathering, housekeeping, first line data processing and analysis, decision making, communications and self-test instructions.

4.2. MasterComm™ VIII Node Processor Firmware

MasterComm™ VIII Node Processor Firmware provides instructions for communications with Site Processors, data storage, data processing and analysis decision-making (leak vs no leak, leak location and size), self-tests and communications with the ASI Leak Computer. Node Processor firmware is configured specifically to each installation.

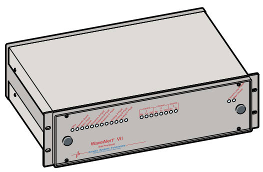
4.3. SCADA

SCADA software residing in the ASI Leak Computer includes: information and communications management instructions for transfer of data between the ASI Leak Computer and MasterComm™ VIII Node Processor(s), database management information and instructions for the organization, maintenance and security of the system, historical (operating) information, instructions concerning organization and content of printed reports; and format and contents of graphic displays.

The system database maintained under SCADA contains scaling constants to convert binary numbers to engineering values (psig, mbar, etc.), system operating parameters (alarm threshold values, digital filter parameters, etc., which are downloaded to the MasterComm™ VIII Node Processor and hence to individual WaveAlert® VIII Site Processors and historical information (times, pressure values, flag settings, flag clearings, events declared, etc.)

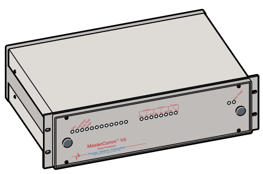
Leak Event reports are displayed on the ASI Leak Computer terminal and printed, whenever, an event flag is set by any WaveAlert® VIII Site Processor. A representative display is shown in Figure 4-2. Other printed system reports can be provided daily, displaying system parameters, performance summaries, etc.

WaveAlert® VIII Site Processor Firmware (ROM)



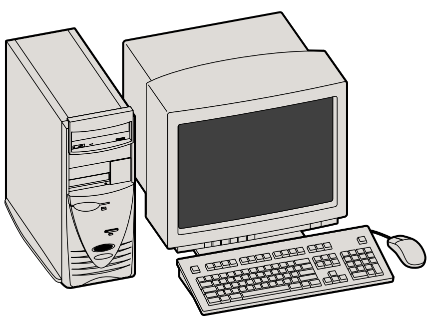
1. Data acquisition
2. Local data analysis
3. Built in tests
4. Report preparation
5. Communications
6. Local valve control

MasterComm™ VIII Node Processor Firmware (ROM)



1. Data analysis (Leak/No Leak?)
2. Leak Location
3. Leak Size
4. Built in tests
5. Communications
6. Automatic valve control on leak decision

ASI Leak Computer or Host Computer with SCADA Software



1. Communications
2. Database organization and management
3. System reports
4. Graphics format
5. Remote valve control

Database Contents

1. Scaling constants
2. System parameters
3. Alarm parameters
4. Historic Data

Figure 4-1: System Software/Firmware Structure

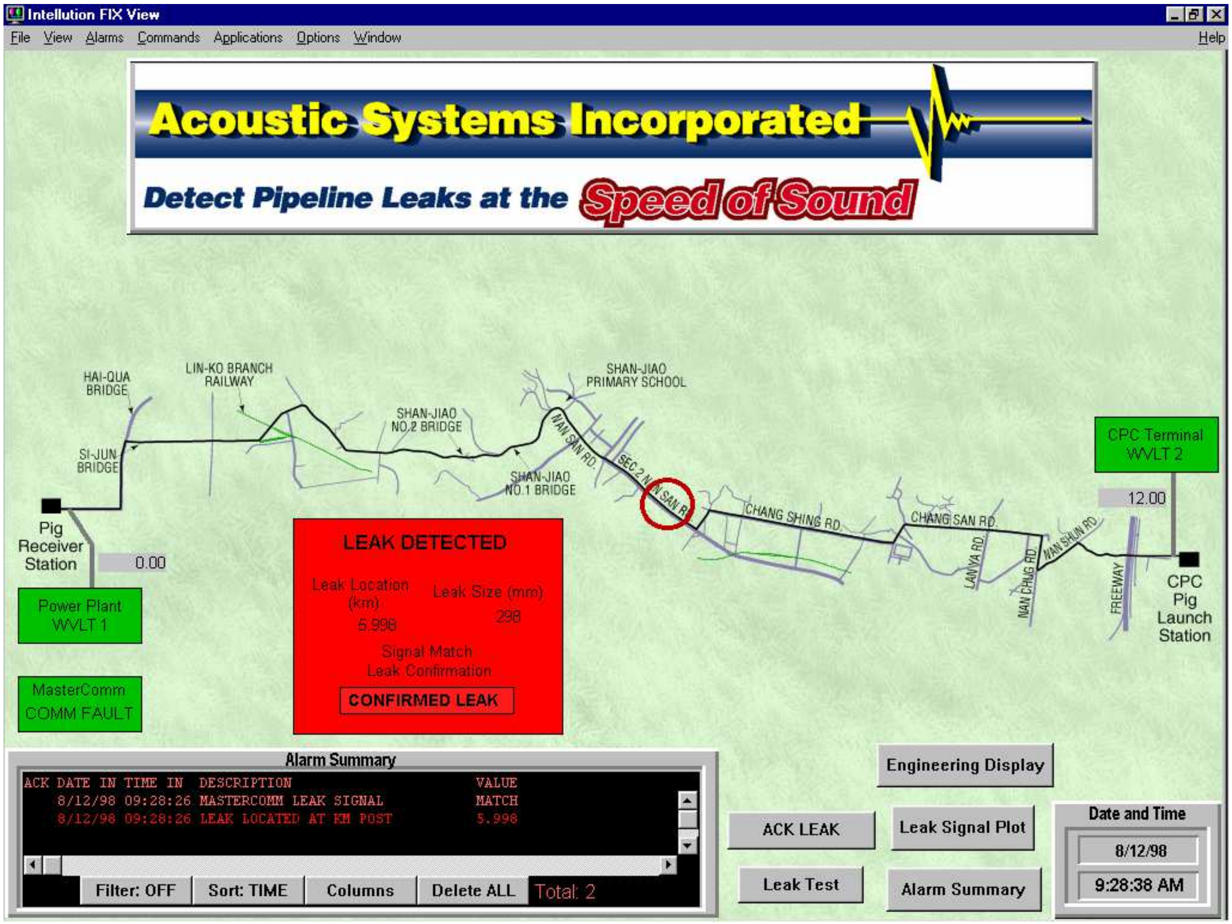


Figure 4-2: Representative Leak Display at ASI Leak Computer

5. SYSTEMS

Typical ALDS installations are shown on the following pages.

Figure 5-1 shows an installation consisting of two WaveAlert® VIII D2 (dual element sensor array) Site Processors on a single pipeline segment. Dual sensor directional arrays are used to attenuate noise entering the pipeline at the ends of the protected segment. The WaveAlert® VIII D2 Site Processors communicate with the MasterComm™ VIII Node Processor either via dedicated landlines or by half duplex radio link. One MasterComm™ VIII Node Processor can monitor up to twenty Site Processors, collecting and analyzing system data and communicating with the ASI Leak Computer. Multiple MasterComm™ VIII Node Processors can be used for larger systems.

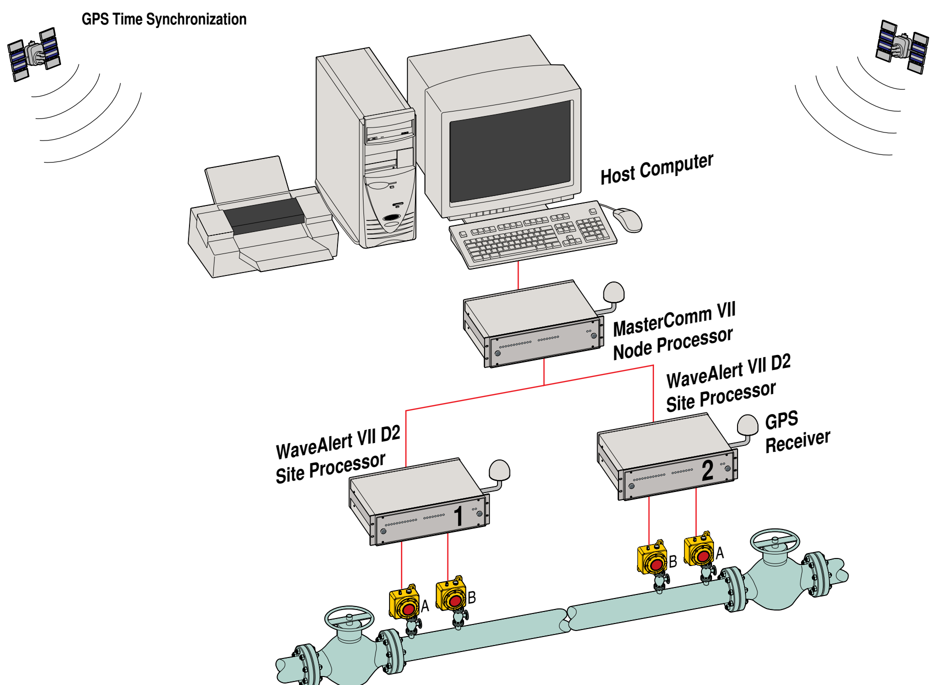


Figure 5-1: Two WaveAlert® VIII D2 Site Processors Monitoring a Simple Pipeline

Figure 5-2 shows a similar system in which the personal computer communicates with a central mainframe computer via a secondary communication link, permitting centralized monitoring of multiple Leak Detection Systems and providing data for a permanent record as part of an integrated risk management program.

Figure 5-3 shows a long transmission line. WaveAlert® VIII D2 Site Processors with directional sensor arrays are located at ends of the monitored pipeline segment near compressor stations or other sources of acoustic noise. WaveAlert® VIII S1 Site Processors with sensors at intermediate block valve sites provide fail-safe shut-in valve control in case of need. The system uses a combination of radio links and landlines for communication between WaveAlert® VIII Site Processors and MasterComm™ VIII Node Processor.

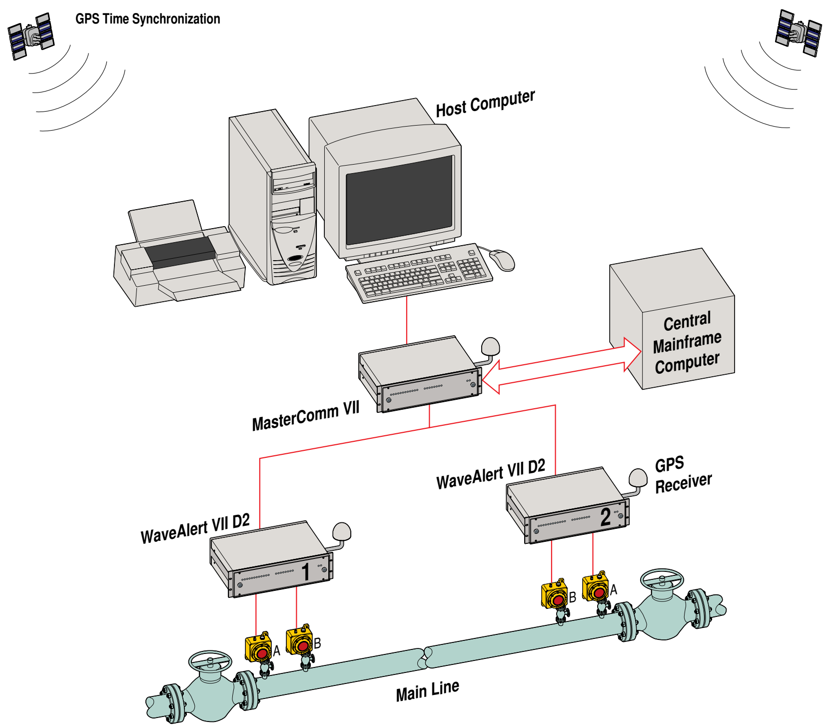


Figure 5-2: ASI Leak Computer Communicating With A Central Main Frame Computer

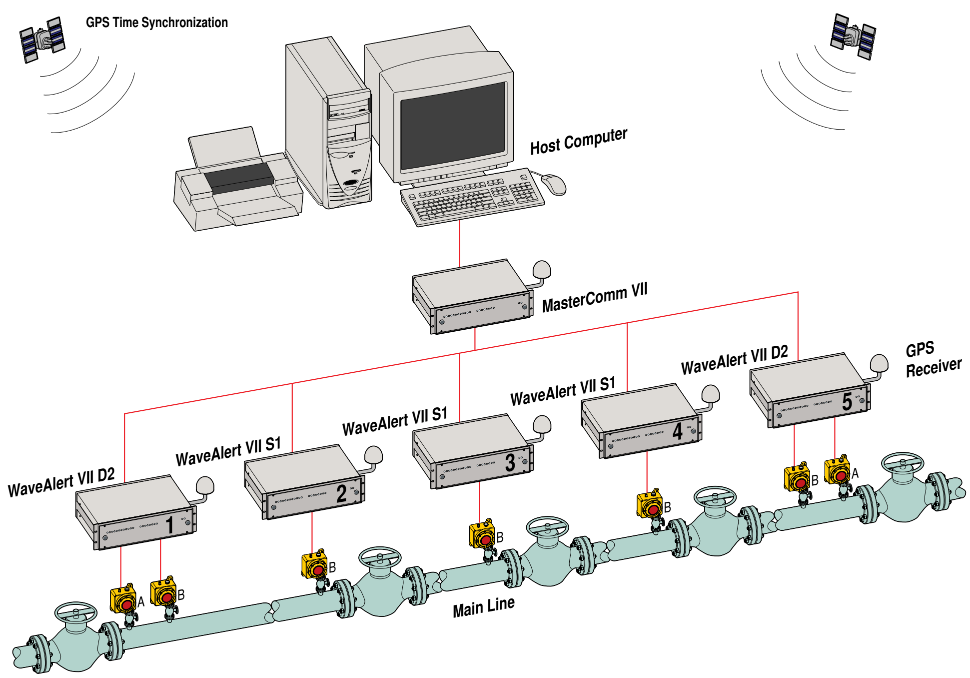


Figure 5-3: WaveAlert® VIII Monitoring a Transmission Line

Figure 5-4 shows a similar system used to monitor parallel transmission lines.

Figure 5-5 shows a more complex installation monitoring a network.

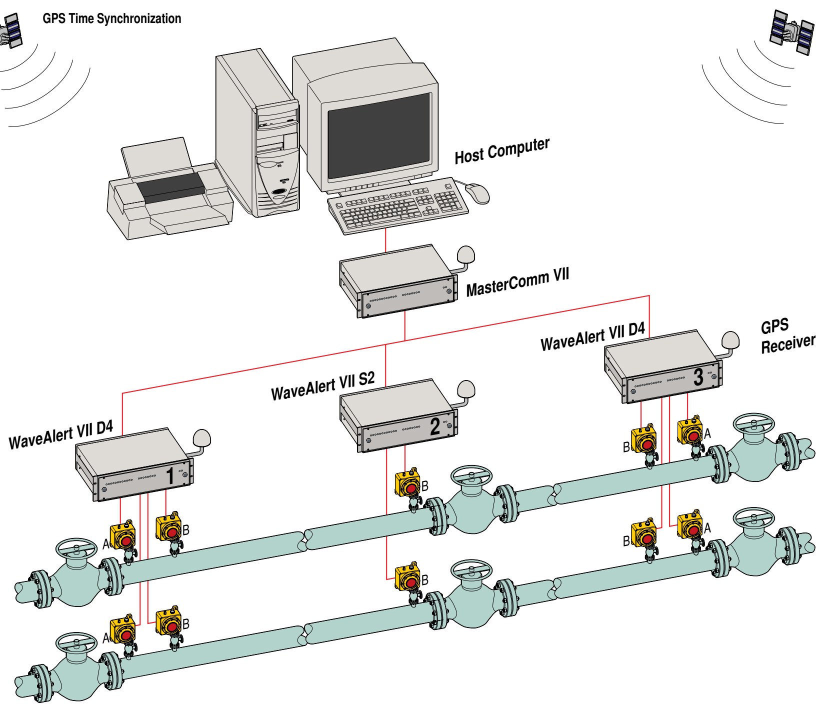


Figure 5-4: WaveAlert® VIII Site Processors Monitoring Parallel Lines

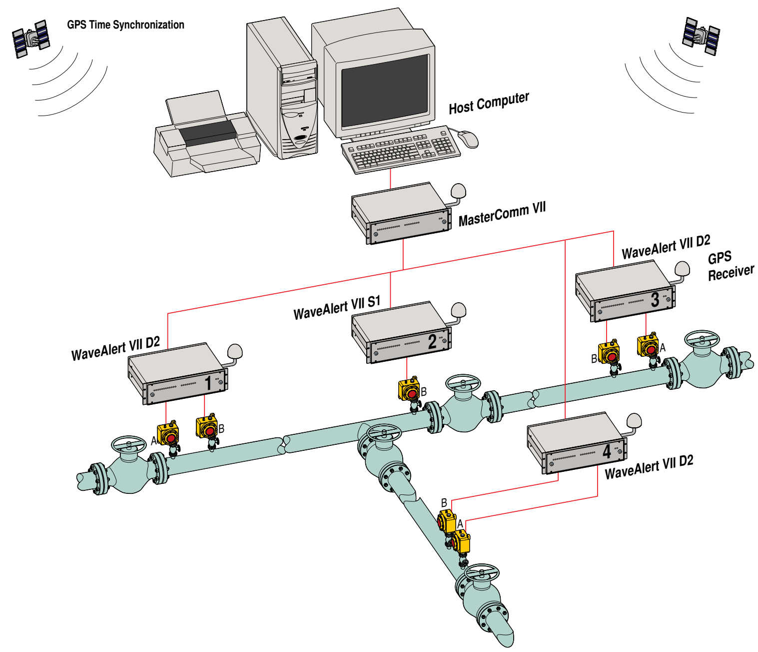


Figure 5-5: WaveAlert® VIII Site Processors Monitoring a Network

6. TYPICAL INSTALLATIONS AND APPLICATIONS

Since 1979, WaveAlert® ALDS have been installed and used worldwide for various applications (liquid, gas, as well as multi-phase flow pipelines). ASI's customer list includes companies such as ABB (Russia), BEB (Germany, a Shell/Esso subsidiary), Chian-Shen Power Plant (Taiwan), Chinese Machinery Corporation, China Light & Power, CPC (Taiwan), ESSO (Australia), Fluor-Daniel, HPCL (India), Mobil, Northwest Pipeline, Sarpon (Italy), Shell, Taiwan Power Company, Sunoco, Western Gas, etc. ASI's customer list is available upon request.

6.1. ESSO AUSTRALIA LPG Pipeline

A WaveAlert® IV system was installed in 1982 to monitor a 10-inch ESSO LPG pipeline in Australia. The system was upgraded to a WaveAlert® VIII system in 1998. The ESSO LPG Pipeline provides an excellent example of the reliability of Acoustic Leak Detection.

ESSO required a fully autonomous leak detection system requiring no operator intervention so that when a leak is detected, the leak detection system must quickly shut-in the pipeline with no further input from personnel. Therefore, the leak detection system must not only detect and locate small leaks, but also do so with a very low number of false alarms. Throughout these years of service, the WaveAlert® ALDS has achieved this difficult task with only two false alarms while detecting two actual leaks.

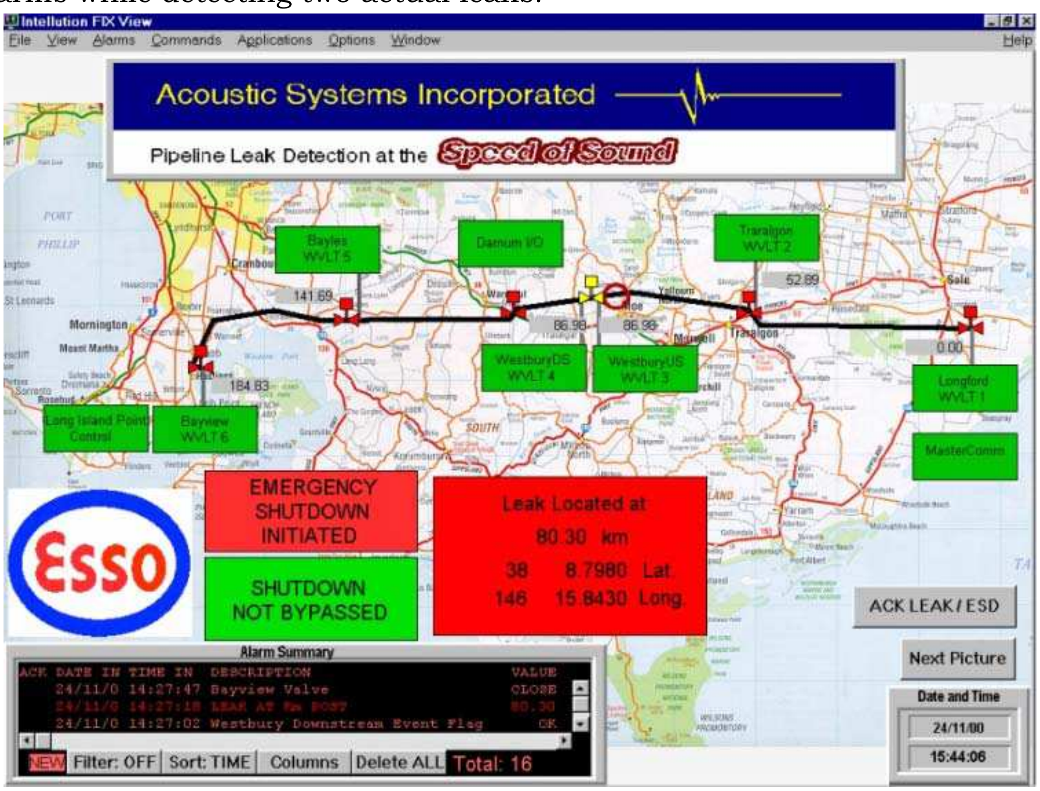


Figure 6-1: Diagram of the ESSO LPG ALDS with leak detected on November 24, 2000

6.1.1. System Configuration

Six WaveAlert® VIII site processors are used to monitor the 188 km pipeline. The system is configured to monitor valve status and provide independent pressure measurements from each WaveAlert® site. Each WaveAlert® Site Processor controls an isolation valve. With control of isolation valves the WaveAlert® system will automatically shut-in the pipeline when a leak is detected without any human intervention.

6.1.2. System Operation

This type of installation allows for the fastest possible response to a leak and clearly demonstrates the level of false alarm rejection the WaveAlert® System has achieved. **On July 19, 1999, a leak occurred midway on the LPG pipeline and was detected by the WaveAlert® system, which automatically shut in the pipeline preventing a potentially disastrous accident and possible casualties. This is the only known occurrence of any type of leak detection system automatically shutting in a pipeline on the occurrence of a leak. Again, on November 24, 2000, a leak caused by a work crew burying fiber optic cable was detected and located within 100 meters (see Figure 6-1). The block valves were automatically shut off within one minute preventing another potential disaster.**

6.2. Mobil West Coast Methane Gas Pipeline

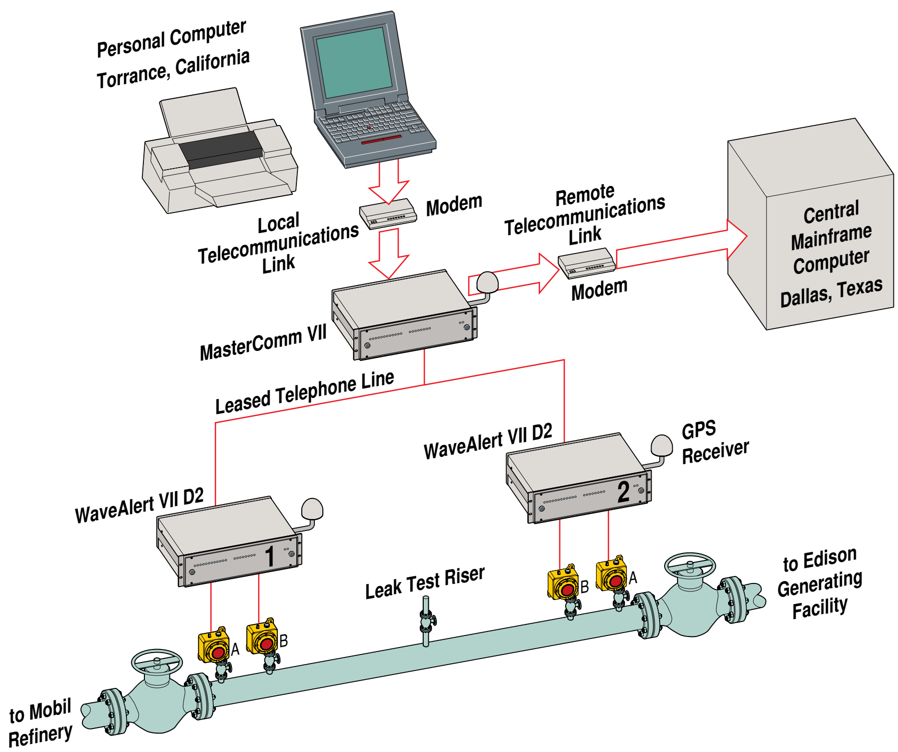


Figure 6-2: Diagram of the Mobil West Coast Methane Gas ALDS

6.2.1. System Configuration

ASI Acoustic Leak Detection monitors are installed on a Mobil West Coast 14 inch methane gas pipeline. The line is 2.85 miles long and protected by WaveAlert® VIII Site Processors at each end. The pressure of the gas in the line is about 75 psi, with a flow rate of 3800 Mscf/hour. The confirmation of a leak event is performed by proprietary firmware residing on the MasterComm ™ VIII and displayed on the central mainframe computer video terminal located at Dallas, Texas. It is critical that any occurrence of a leak on this segment be detected and located within seconds, due to the hazardous nature of the product.

6.2.2. System Performance

Tests, using standard leak test procedures, were conducted to establish threshold settings, verify the sensitivity of the system, confirm the acoustic velocity in this particular pipeline and the time required to detect and locate the leak.

Leaks were simulated in the line at a leak site located 1.43 miles from the refinery end of the line (see Figure 6-2). A two-inch ball valve in series with an orifice plate was used in the tests. Several tests with different orifice sizes were conducted. The sensitivity of the system under average flow conditions was determined to be well within specified performance. The system displayed accurate leak locations within 53 feet of each leak test.

Detection-time, also was determined. All leaks were detected within 7 seconds at the refinery end. A leak occurring at one end of the segment is detectable at the other end within 13 seconds. (Detection time and leak location accuracy improves as the leak occurs closer to the midpoint of the line).

6.3. Sunoco Frankford Plant Chemical Pipelines

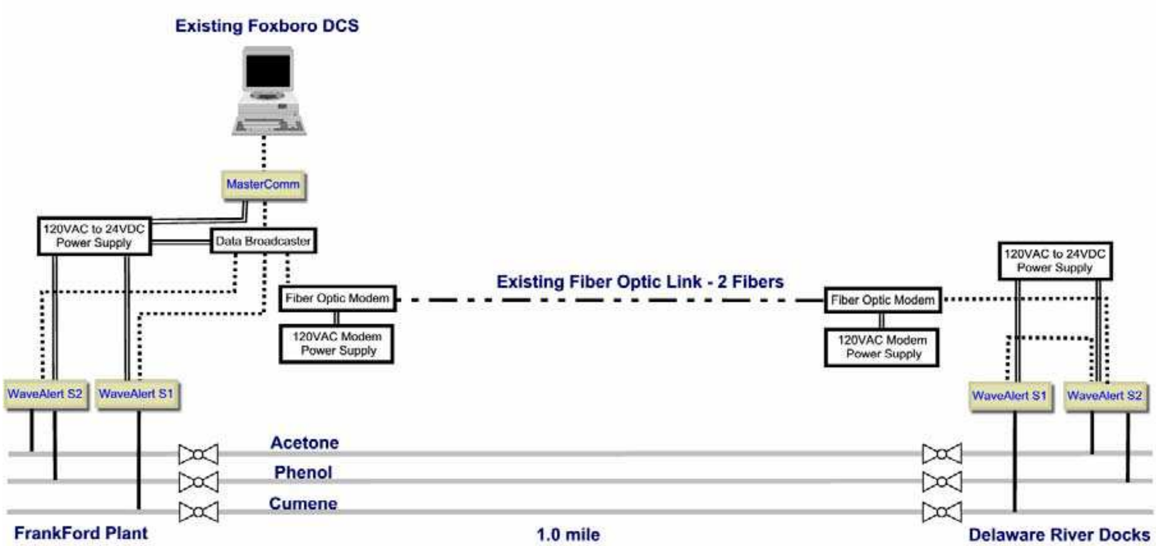


Figure 6-3: Diagram of the Sunoco ALDS

In 1999 Sunoco selected the WaveAlert® ALDS to meet local requirements for leak detection on three chemical pipelines. The WaveAlert® VIII system was installed on each of the phenol, acetone and cumene pipelines (Figure 6-3). These pipelines ran from the plant to loading docks on the Delaware River.

6.3.1. System Configuration

The system is configured to monitor all three pipelines while ships are being loaded at the dock and also while the pipelines are shut-in. Since the pipelines load ships infrequently (as little as once per week) Sunoco was required to have a leak detection system, which would operate at high sensitivity during zero flow conditions. Since the WaveAlert® ALDS is not based on flow measurement it will maintain high sensitivity without flow in the pipeline.

7. ANALYSIS FORM

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email: sales@wavealert.com web: www.wavealert.com

Requested By

Name	Title	Date
Company		Department
Street / P.O. Box		City
State	Country	Postal Code
Phone Number	Fax Number	E-Mail

Pipeline Data

Name of Fluid(s)	Pipeline Diameter (inches)	Length(s) of Line(s) (miles or km)
Downstream Pressure (psi)	Upstream Pressure (psi)	Pressure Gradient (psi/mile)

Gas Data

Specific Gravity of the Gas		Ratio of Specific Heats of the Gas
Average Compressibility	Viscosity (poise)	Flow (MMSCF/D)

Liquid Data

Bulk Modulus of the Liquid (psi)	Density of the Liquid (lb/cu. ft.)
Viscosity (poise)	Flow (barrels per day)

Other Data

Does SCADA system already exist? If yes, describe what type.

Does a communication system already exist? If yes, describe what type: Radio Microwave Hardwire Dedicated Phone Line

Draw a diagram of pipeline to be studied. Provide: location of branches, location of block valves, instrumentation hardware, control room, populated area and environmentally sensitive areas

Desired Sensitivity

Hole size (inches or mm)	Accuracy of Location (feet or meters)	Speed of detection (seconds)

TABLE OF CONTENTS

TECHNOLOGY
And
QUALIFICATIONS

Revised:
August 2007

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Website: www.wavealert.com

Acoustic Systems Incorporated

Detect Pipeline Leaks at the Speed of Sound

WaveAlert Site Processor / MasterComm Node Processor Specifications PN: 030.2009-10, 030.2009-03, 030.2009-04, 030.2009-06, 030.2008-00

WaveAlert® VIII and MasterComm VIII Specifications

WaveAlert VIII and MasterComm VIII processors provide a robust hardware platform, which can be mounted in a standard weather tight electronics enclosure. Climate control is not required, based on the following specification:

Operating Temperature	-30 to 85 degrees Celsius (-22 to 185 degrees Fahrenheit)
Storage Temperature	-50 to 85 degrees Celsius (-58 to 185 degrees Fahrenheit)
Relative Humidity	0 to 95 percent, Noncondensing
Input Voltage	20 to 36 VDC
Input Current (Nominal)	250 mA @ 24 VDC

WaveAlert® VIII and MasterComm VIII CPU and Memory

WaveAlert VIII Site Processor and MasterComm VIII Node Processor employ a high-speed signal processor for all pipeline leak evaluation, computation and processing. Leak detection programs are ran from high speed flash memory allowing for easy program updates. Sensor, GPS and communications status are provided by front panel LEDs.

WaveAlert® VIII and MasterComm VIII Acoustic Leak Detection I/O

WaveAlert VIII Site Processor and MasterComm VIII Node Processor each include 4 RS232 serial communications ports. For the MasterComm VIII Node Processor two of these communications ports can be used for sending Acoustic Leak Data to two SCADA systems simultaneously. Both units also include GPS synchronization. The WaveAlert VIII Site Processor can be configured with up to 8 isolated Acoustic Sensor Inputs.

WaveAlert® VIII and MasterComm VIII Configurable RTU I/O Features

WaveAlert VIII and MasterComm VIII each include 4 dry contact form 'C' relay outputs. Each unit also includes 4 optically isolated digital inputs. These I/O can be configured for any use including valve control, valve status, alarm control, etc. The WaveAlert VIII Site Processor also can include isolated 4-20 ma inputs from any of the 8 unused Acoustic Sensor Inputs. These inputs can be used for any process measurements including temperature, flow rate, pressure, etc and are powered by the internal WaveAlert sensor power supply. A 16 bit A/D is used for conversion of the inputs.

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