MicroCorr 6
Manual

P R O D U C T S .

Products in the range include:-

- **MicroCorr** Leak Noise Correlators
- **MicroCALL** Computer Assisted Leak Locator
- **MAST** Step Testing System
- **Aqualog** Acoustic Leak Localiser
- **MK4** and **LK4** Ground Microphones
- **AP400** Portable Ultrasonic Flow Meter
- **Dataflo** and **Loflo** Flow Loggers
- **MAST** Pressure Monitor
- **PG10** Pressure Gauge
- **LS4** Electronic Listening Stick
- **Metrotech** Pipe and Cable Locators
- **Water Surveys**
- **Training**

```
                                MENU                    MICROCORR 6 V1.01UK
                                ======
01 LEAK POSITION          07 HELP                 13 CONFIGURATION
02 PRINT                  08 COMPUTE EDIT         14 DISTANCE MEASUREMENT
03 VELOCITY MEASUREMENT   09 SELF TEST            15 AUTOCORRELATION
04 SURVEY                 10 CUSTOM PIPE CHOICE   16 SET UP SCREEN
05 LISTENING              11 VELOCITY CALCULATION SELECT  OPTION  THEN
06 VELOCITY TABLES        12 MEMORY ERASE         PRESS  ENTER  TO  CONTINUE
```

Screen 1

```
BATTERY CHARGE REMAINING                LAST SCREEN RECAL, OFF ◄ TO CHANGE
[                                  ]

                                        ILLUMINATION TIME  15 SECS
                                        USE ▲ ▼ TO CHANGE
  0 PRINT FILES STORED
 SPACE FOR  61  MORE                    AUTO SHUTDOWN ON  USE SET TO CHANGE
 DATE  01:01:98    TIME  09:30:00
                                        PRESS ENTER TO CONTINUE
```

Screen 2

```
LEAK POSITION MODE
      RED               BLUE            SELECT SIGNAL SOURCE AND SENSOR TYPE
      ===               ====
 1 RADIO           6 RADIO               PRESS ZOOM FOR SIGNAL STRENGTH
 2 CABLE           7 CABLE               PRESS MENU FOR MENU  OR HELP FOR HELP
 3 DIRECT          8 DIRECT              DIRECT INPUT SET TO  PASSIVE
 4 ACCELEROMETER   9 ACCELEROMETER
 5 HYDROPHONE      0 HYDROPHONE          PRESS  ENTER  TO  CONTINUE
```

Screen 3

```
 LEAK POSITION MODE       SELECT MATERIAL

01 DUCTILE IRON       06 ASBESTOS CEMENT  11 CONCRETE
02 CAST IRON          07 PVC              12 CLAY
03 STEEL              08 H.D.P.E.         13 MIXED MATERIAL
04 COPPER             09 M.D.P.E.         14 UNKNOWN/OTHER
05 LEAD               10 GLASS FIBRE      15 CUSTOM PIPE MENU
                                          PRESS  ENTER  TO  CONTINUE
```

Screen 4

```
LEAK POSITION MODE     SELECT PIPE DIA.            PIPE MATERIAL = D.IRON
                         SIZE IN mm
    1 UNDER 100      6 600 - 800
    2 100 - 200      7 800 -1000
    3 200 - 300      8 OVER 1000
    4 300 - 400      9 UNKNOWN/MIXED
    5 400 - 600      0 MANUAL VELOCITY
                                  PRESS  ENTER  TO  CONTINUE
```

Screen 5

```
ENTER DISTANCE BETWEEN SENSORS
                                  NOTCH FILTER OFF
DISTANCE, D = 100.00 m

                                  PRESS 1 FOR AUTO FILTER SELECTION
                                        0 FOR MANUAL
```

Screen 6

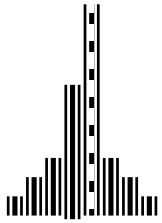
```
                                  0                    5000HZ
ENTER DISTANCE BETWEEN SENSORS
                                  NOTCH FILTER OFF
DISTANCE, D = 100.00 m
                                  PRESS SET TO CHANGE FILTERS,VIEW SIGNAL
                                  LEVELS AND DISPLAY LEAK NOISE
                                  PRESS ENTER TO CORRELATE
```

Screen 7

```
                        SET FILTERS     PRESS SET TO DISPLAY LEAK NOISE
                                        PRESS ZOOM FOR SPECTRUM/NOTCH FILTER
        DEFAULT FILTER SELECTION        SIGNAL LEVELS
0                                 5000  0          BLUE                100%
        MANUAL FILTER SELECTION
USE  ◀ ▶ TO CHANGE FILTER FREQUENCY     0          RED                 100%
USE  ▲ ▼ TO CHANGE FILTER WIDTH         PRESS ENTER TO CORRELATE / FIX FOR AFS
```

Screen 8

```
PIPE: D.IRON       V = 1.320m/Ms       CORRELATION RATE: MODERATE  1:30 MINS
DISTANCE, D = 100.00
0[][][][][][][]600[]                        5000HZ
TIME DELAY, TD =    11.6 Ms (BLUE)
|-----              |------
    RED■----------------■BLUE
 57.6 m              ↑       42.4 m
R 0.5 m    SCALE 1: 1.0   RANGE 2
```



Screen 9

```
 1 DISTANCE, D = 100.00 M              7 TYPE OF CORRELATION - ENHANCED
 2 VELOCITY, V =  1.320 M/MS           8 NOTCH FILTER OFF
 3 PIPE MATERIAL D.IRON                ◀4▶ VOLUME ----
 4 FILTERS :
0[][][][][][][]600[]                        5000HZ      SELECT ITEM TO CHANGE
 5 PIPE DIAMETER UNDER 100
 6 SELECT SOURCE AND SENSOR TYPE       PRESS ENTER TO CORRELATE
```

Screen 10

```
 LEAK POSITION MODE

  1 STORE RESULT
  2 RETURN TO CORRELATION
  3 STORE WITH SITE DETAILS
  4 RETURN TO START
  5 STORE FOR COMPUTE
  6 ALTER DISTANCE/VELOCITY            PRESS ENTER TO CONTINUE
```

Screen 11

```
SITE DETAILS  DATE 01:01:98 TIME 09:30
                                       ABCDEFGHIJKLMNOPQRSTUVWXYZ 0123456789END
SITE/MAP NUMBER          ■               ↑
                                       SELECT CHARACTER WITH  ◀ ▶ THEN ENTER


                                       PRESS SET TO SELECT SITE OR MAP NUMBER
MOVE CURSOR WITH ▲ ▼                    PRESS ENTER TO CONTINUE AFTER EACH ENTRY
```

Screen 12

```
 COMPUTE MODE      RESULT EDIT
RUN DIST     Td                                3+                  COMPUTED
 1  180.0  115.1R A)USE ▲▼ TO SELECT                                 RESULT
 2   92.0   36.6R              RESULT          1+
 3  283.0  206.3R B)ZOOM EXCLUDES OR                                 L=25.7m R
                       INCLUDES RESULT              2+              V=1.12 m/ms
                  C)CLEAR ERASES RESULT
                              FROM MEMORY PRESS ENTER TO STORE OR MENU TO QUIT
```

Screen 13

```
MIXED MATERIALS

HOW MANY SECTIONS OF PIPE BETWEEN

SENSORS? _  (MAXIMUM OF 6)

                                        WHEN CORRECT
                                        PRESS ENTER TO CONTINUE
```

Screen 14

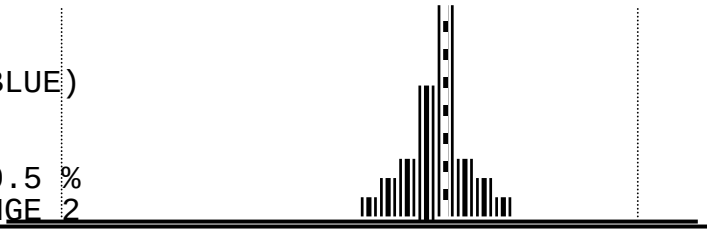
```
MIXED MATERIALS

 ENTER LENGTH THEN PIPE DETAILS
 FOR SECTION 1
    D1= 50.00 m
R ▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬ B

                                        PRESS ENTER TO CONTINUE
```

Screen 15

```
 MEASURE  VELOCITY
                                        ENTER DISTANCE OF NOISE FROM ANY SENSOR
NOISE SOURCE IN - BRACKET/OUT OF BRACKET
                                        DISTANCE, D =  100.00 m
PRESS SET TO CHANGE


                                        PRESS  ENTER  TO  CONTINUE
```

Screen 16

```
PIPE: D.IRON                          CORRELATION RATE: MODERATE  1:30 MINS
DISTANCE, D = 42.40 m

TIME DELAY, TD =  11.6 Ms (BLUE)
|------          |-------
ENTER – SAVE FOR PRINTOUT
VELOCITY = 1.320 m/Ms +/-  0.5 %
R 0.5 m   SCALE 1: 1.0   RANGE 2
```



Screen 17

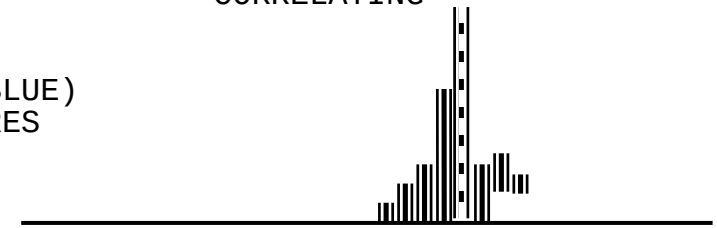
```
 PRINT     1   FILES IN MEMORY
 1 PRINT LIST                          SELECT OPTION THEN ENTER
 2 PRINT FILE NUMBER ___
 3 PRINT SITE NUMBER ___
 4 PRINT ALL OF DATE __:__:__
 5 PRINT ALL FILES                     PRESS MENU TO ESCAPE
 6 DOWNLOAD TO COMPUTER
 7 EXAMINE ALL FILES                   PRESS ENTER TO CONTINUE
```

Screen 18

```
 SURVEY MODE                                  PIPE MATERIAL = D.IRON

SELECT MAXIMUM LENGTH OF SURVEY SECTION

 1   36 M
 2  294 M
 3 1181 M
 4 2055 M                              PRESS ENTER TO CONTINUE
```

Screen 19

```
 SURVEY MODE                           CORRELATING

PIPE MATERIAL = D.IRON
TIME DELAY, TD =  11.6 Ms (BLUE)
 SURVEY DISTANCE =  294 METRES

PRESS ENTER TO STORE/PAUSE
```



Screen 20

```
SURVEY MODE

 1 STORE RESULT
 2 RETURN TO CORRELATION
 3 STORE WITH SITE DETAILS
 4 RETURN TO START
 5 NEXT SURVEY
 6 CHANGE TO LEAK POSITION             PRESS ENTER TO CONTINUE
```

Screen 21

```
                                        85H
          LISTENING
          FILTERS                      SIGNAL LEVELS
  0                               5000  0          BLUE                 100%

                                       PRESS ZOOM FOR DISPLAY OF SPECTRUM
 USE  ◀ ▶ TO CHANGE FILTER FREQUENCY   PRESS ENTER TO STORE CURRENT LEVEL
 USE ▲  ▼ TO CHANGE FILTER WIDTH       PRESS SET FOR MANUAL OR MENU TO QUIT
```

Screen 22

```
CUSTOM PIPE CHOICE
                  V= 0.000 m/Ms        USE CURSOR,▲▼ TO SELECT CHARACTER THEN
0                          5000HZ      PRESS ENTER. SELECT END WHEN ENTRY
                                       CORRECT (MAXIMUM 12 CHARACTERS)
ABCDEFGHIJKLMNOPQRSTUVWXYZm0123456789._

     DELETE END
            ↑                          PRESS ENTER TO CONTINUE OR MENU TO QUIT
```

Screen 23

```
  0                               5000 SELECT BEST FILTERS FOR PIPE

 USE  ◀ ▶ TO CHANGE FILTER FREQUENCY
 USE ▲  ▼ TO CHANGE FILTER WIDTH       PRESS ENTER TO CONTINUE OR MENU TO QUIT
```

Screen 24

```
CONFIGURATION SCREEN

1 AUTO SHUTDOWN      -  ON              7 DIRECT ENTRY   -  OFF
2 ILLUMINATION TIME  -  15              ◀4▶ VOLUME ----
3 LAST SCREEN RECAL  -  OFF
4 TYPE OF CORRELATION-  ENHANCED        PRESS HELP FOR HELP
5 SET DATE / TIME    -
6 LCD BLINK ENABLE   -  ON              PRESS MENU TO RETURN TO MENU
```

Screen 25

```
AUTOCORRELATION
                    BLUE                SELECT SIGNAL SOURCE AND SENSOR TYPE
                    ====
                6 RADIO                 PRESS ZOOM FOR SIGNAL STRENGTH
                7 CABLE                 PRESS MENU FOR MENU OR HELP FOR HELP
                8 DIRECT                DIRECT INPUT SET TO  PASSIVE
                9 ACCELEROMETER
                0 HYDROPHONE            PRESS ENTER TO CONTINUE
```

Screen 26

```
VELOCITY CALCULATION

 SELECT LIQUID

 1 FRESH WATER       5 PETROL
 2 SALT WATER        6 DIESEL FUEL OIL
 3 KEROSENE          7 METHANOL
 4 GLYCOL            8 OTHER LIQUID     PRESS ENTER TO CONTINUE OR MENU TO QUIT
```

Screen 27

```
VELOCITY CALCULATION

ENTER PIPE OUTSIDE DIAMETER IN mm    100

ENTER PIPE WALL THICKNESS IN mm  20.00

                                        PRESS ENTER AFTER EACH ENTRY
```

Screen 28

```
VELOCITY CALCULATION
                                        1 STORE UNDER PROGRAM PIPE MENU
VELOCITY OF SOUND     1.349METRES/Ms
LIQUID TYPE          FRESH WATER        2 STORE FOR PRINTOUT
PIPE MATERIAL        D.IRON
PIPE DIAMETER         100 mm            3 RETURN TO MENU
PIPE WALL THICKNESS  10.00 mm
```

Screen 29

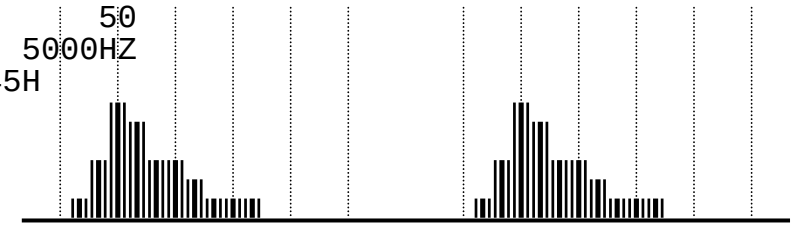
```
MEMORY ERASE

WARNING. THIS WILL ERASE ALL MEMORY
FILES.

DO YO WISH TO CONTINUE?     YES = 1
                            NO  = 0
```

Screen 30

```
MEMORY TEST PASSED
TO ERASE CUSTOM PIPE MENU AND USER SETUP
PRESS 1 2 3 4 FOR RAM CLEAR
PRESS FIX TO TEST DSP CARD
OTHERWISE PRESS ENTER

                                    PRESS ENTER TO CONTINUE
```

Screen 31

```
FREQUENCY SPECTRUM                50
0                              5000HZ
BLUE GAIN=45H   RED GAIN=45H
 1 RESTART
 2 CHANGE SCALE   : LOG
 3 CHANGE CHANNEL : B+R
 4 TURN NOTCH ON / OFF
 0 EXIT      CHANNEL : B+R       BLUE  1   2   3  4   5      RED  1  2  3  4  5
```



Screen 32

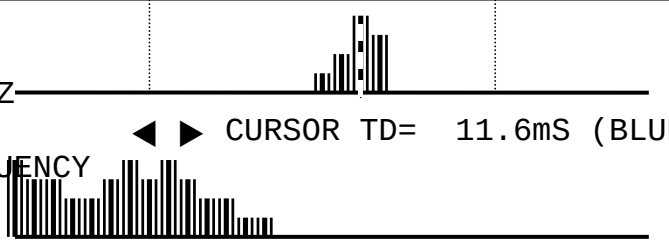
```
PIPE: D.IRON       V = 1.320m/mS       CORRELATION RATE: MODERATE  1:30 MINS
ESTIMATED DISTANCE =   14.4 m
0                600          5000HZ
TIME DELAY, TD =  11.6 Ms (BLUE)

ENTER – SAVE FOR PRINTOUT

R 1.1 m  SCALE 1: 2.4   RANGE 2
```

Screen 33

```
PIPE: D.IRON       V = 1.320m/mS
DISTANCE, D = 100.00 m
0                600          5000HZ
1. NEW CORRELATION                  ◄ ► CURSOR TD=  11.6mS (BLUE) D=  42.7
2. RE-CORRELATION
3. RECALL FFT DATA
4. STORE FFT DATA
5. PRINT RESULTS                    0HZ     1KHZ     2KHZ     3KHZ     4KHZ
```

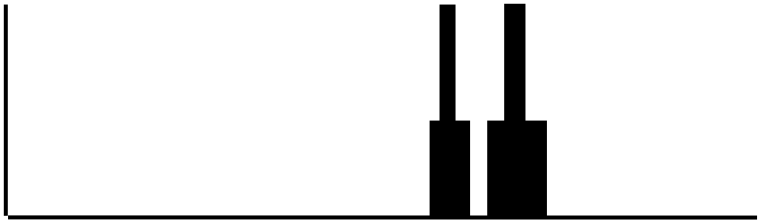
Screen 34

```
PIPE: D.IRON       V = 1.320m/mS
DISTANCE, D = 100.00m
0                600          5000HZ
                                    ◄ ► CURSOR TD=  11.6mS (BLUE) D=  42.7
 USE  ◄ ►  TO CHANGE FILTER FREQUENCY
 USE  ▲▼  TO CHANGE FILTER WIDTH

PRESS ENTER TO CONTINUE             0HZ     1KHZ     2KHZ     3KHZ     4KHZ
```



Screen 35

```
CORRELATOR BOARD TEST


BLOCK 1
```



Screen 36

FIG 1

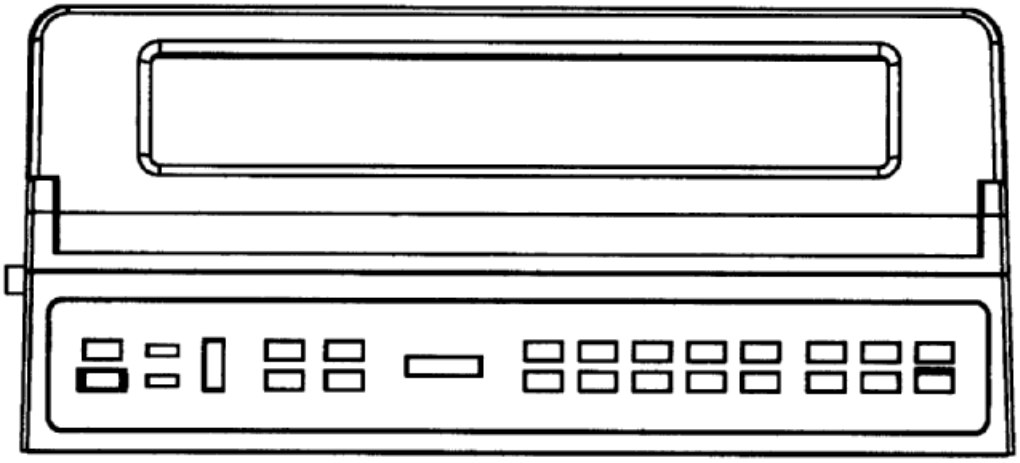


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FIG 2

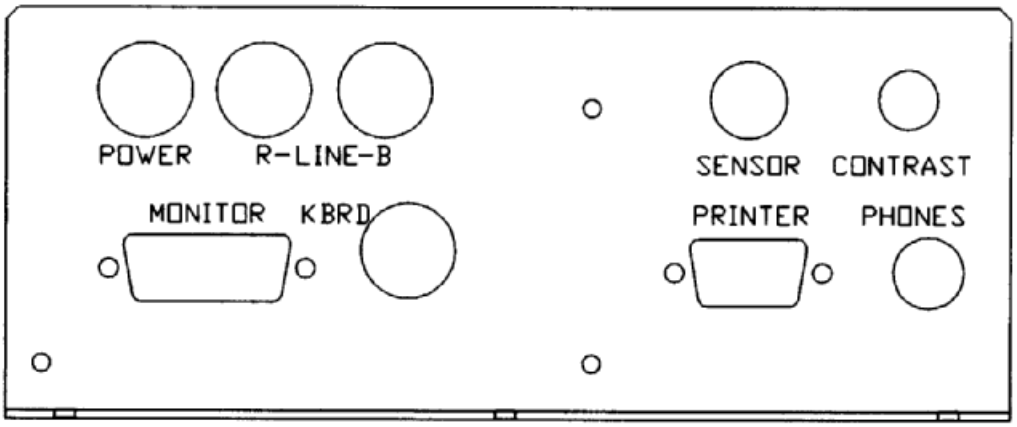


TABLE OF CONTENTS

SAFETY PROCEDURES

I M P O R T A N T

Working with water and other fluids under pressure can be hazardous. Recommended safety procedures for the working conditions must be followed at all times, and operational procedures described in this manual should not take precedence over current safe working practice or company procedure. If in doubt, ask your safety officer.

Use of MicroCorr® equipment with the water supply must be subject to the hygiene procedures applicable to any objects coming into contact with drinking water supplies. Hydrophone sensors and adapters should be appropriately sterilised prior to use and applicable procedures should be followed during their installation.

Use of MicroCorr® with other liquids or gases should follow national and company safety procedures for operation in proximity with these substances.

DO NOT use your hands for installing the sensors in valve/hydrant chambers or meter boxes without checking for foreign objects. Sharp objects such as disused syringes can easily pierce gloves. If any excavation is required, use suitable tools.

ELECTRICAL SAFETY

Water pipes are frequently used as the connection for electrical earth. Danger of electric shock exist with metal pipes when disconnecting meters, etc. An earthing strap should be fitted between the two ends of the pipe before disconnection.

SECTION 1.0

INTRODUCTION

The MicroCorr® 6 is a computerised high speed leak location system which employs highly efficient electronic methods to produce accurate survey data using cross correlation techniques.

This latest model retains all the key features of earlier MicroCorr® systems and provides many new benefits which ensure greater operating flexibility and faster operating speed.

The MicroCorr® 6 system is fully menu driven and a large number of HELP SCREENS are provided to assist the operator at all stages of data input and correlation analysis.

USING THE SYSTEM

Operators who are experienced with earlier MicroCorr® systems, and are fully conversant with leak noise correlation techniques, may wish to refer straight to Section 4.0 which provides start-up and operating procedures for the MicroCorr® 6.

Other users are recommended to read Appendix One - THE BASIC PRINCIPLES - and then to read Sections 2.0 and 3.0 of this Manual before operating MicroCorr®. These sections provide an overview of the MicroCorr® system and detail optional equipment which increases operating flexibility.

MicroCorr's Main Menu and the section numbers in this Manual are cross referenced in Section 5.0.

SYSTEM OVERVIEW AND OPTIONAL EQUIPMENT

MicroCorr® 6 is generally supplied in the following basic kit form which is the minimum system configuration specified for effective leak location operations:

1 - MicroCorr® 6 correlator unit

2 - Active sensors with protective shrouds and leads

1 - Pair stereo headphones

1 - Power - charger unit

1 - Radio transmitter (red channel)

1 - Set interconnecting leads

1 - Cassette test tape and lead

SIGNALS AND SENSORS

Operators should note that all sensors can be damaged by sudden shock impact and should be handled with care. Do not drop sensors onto the ground and ensure they do not bang against the pipeline during fitting or removal.

The two active sensors supplied with the MicroCorr® 6 system are coupled to ferrous pipelines or fitting by magnet assemblies which must be screwed firmly to the sensor units.

The accelerometer to magnet mating surfaces must be kept clean and the magnet 'keeper' should be replaced after use. A range of clamps are available for connecting sensors to non-ferrous pipes and fittings.

The two sensors detect the noise signals travelling along the pipe from the leak point. These signals are then fed into the correlator unit for measurement and analysis.

One sensor is generally connected directly to MicroCorr® with a short cable and the second, remote, sensor is plugged into the RED channel radio transmitter. The radio unit amplifies the leak noise and transmits the signals to the built- in receiver in the correlator unit.

The MicroCorr® operator monitors these two signals with stereo headphones which confirms instantly that the sensor pick up and signal transmission part of the system is functioning correctly. This important procedure also enables experienced operators to determine if the leak signals are suitable for effective correlation and to check for the presence of background interference in the pipework under test.

THE CORRELATOR FUNCTION

The prime function of the sophisticated correlator built into MicroCorr® 6 is to measure the time difference between the leak noise signals arriving at each sensor. MicroCorr® determines the leak position by relating this difference in propagation (travel) time to the velocity of sound along the pipe and to the measured distance between the sensors.

THE MICROCORR UNIT

MicroCorr® 6 is a totally self-contained electronic unit which performs the leak noise correlation calculations accurately and very quickly. The system features a software driven operator interface with a large number of built-in help screens, which guide and prompt the operator throughout all data input and processing phases.

The system is designed primarily for rapid Leak Position and Velocity Measurement operations but it also incorporates excellent Listening mode and Surveying mode facilities. A key feature of MicroCorr® 6 is its ability to transfer all stored results to a hard-copy printer or computer system.

The operator calls up the various screens and enters the data using a keypad. All input data are shown on MicroCorr's liquid crystal display screen and the information can also be viewed simultaneously on a monochrome or colour TV monitor available as optional equipment.

ACTIVE SENSORS

Two active sensors are supplied with the MicroCorr® 6 system and these units are suitable for a very wide range of leak detection operations on pipes or fittings. Previous MicroCorr® systems have been supplied with passive sensors and although these old style sensors can be used with MicroCorr® 6 the new active sensors represent the next step in sensor technology.

However, as accelerometers are attached to the external surfaces of pipe systems, weak noise signals may sometimes be degraded by mechanical filtering or high background interference effects.

In these instances, and if suitable pipe fittings are available, Hydrophone sensors can be used instead of accelerometers. Hydrophones, which are available as optional equipment, generally provide better leak noise signals in difficult operating conditions. The specific benefits of using hydrophones are discussed more fully in Section 3.0

POWER - CHARGER UNIT

The MicroCorr® Power - charger unit has three functions:

(1) It provides a 12 volt stabilised supply for operating from a domestic 120 or 240 volt AC mains source.

(2) It charges MicroCorr's internal battery pack for portable on-site operations, either from the AC mains supply, or from a DC 12 volt vehicle supply.

(3) It provides two power outlets for charging the transmitter battery packs.

MicroCorr's internal battery will run the system continuously for approximately Eight hours without re-charging or slightly less if the AMS function is used. The system draws very little current and can also be operated from a vehicle's 12 volt battery for long-term site operations. The sealed lead-acid batteries employed are interchangeable with those of the transmitter units.

HEADPHONES

The studio quality stereo headphones supplied have earpieces labeled 'Right' and 'Left' and should be worn accordingly for effective operations. The Red channel signals are fed to the Right earpiece and the Blue channel signals to the Left earpiece although front panel switching on MicroCorr® 6 enables the operator to select monaural signals from either channel. In Listening mode the headphones are automatically switched to feed equal monaural signals to both earpieces.

The headphones can also be plugged directly into the "Phones" socket of a MicroCorr® radio transmitter connected to a remote sensor on the pipe to monitor a monaural signal. This technique aids sensor installation and set up by allowing the operator to confirm leak noise and interference levels quickly at each sensor position before completing the correlation.

Use only the headphones supplied with MicroCorr® as other types may cause centre correlations and/or badly distorted signals.

RADIO TRANSMITTERS

MicroCorr's two channels are colour coded 'Red' and 'Blue' for ease of identification.

The basic MicroCorr® kit includes a Red transmitter and this is connected to the remote sensor with a short cable. The transmitter amplifies the leak noise from the sensor and radiates the signals at U.H.F. to the Red channel receiver in the correlator unit.

The transmitters, which are described fully in Appendix 4, are powered by an interchangeable lead-Acid battery which is re-charged with the MicroCorr® Power - charger unit.

The audio pre-amplifiers in the transmitters may also be directly connected to MicroCorr®'s Line Input sockets via the system's cable- drums which are optional equipment. The cable-drums are employed at sites where U.H.F. transmitters are not allowed or where radio signals could be screened and degraded by buildings or geographical terrain. For full details of line operation and limitations refer to Appendix 4.

MICROCORR OPTIONAL EQUIPMENT

Palmer Environmental Services Limited can provide the following optional equipment which expands the overall capability of MicroCorr® even further and improves operating flexibility in difficult situations.

BLUE CHANNEL TRANSMITTER / RECEIVER UNIT

The addition of the Blue Channel secondary radio link provides greater operational flexibility and speeds up many aspects of on-site work. Radio links also increase operator safety by allowing the sensors to be deployed remotely in busy streets or other work areas with heavy traffic flows.

With both sensors plugged into transmitters the MicroCorr® unit itself can be located anywhere within radio signal range or mounted in a vehicle for fully mobile operations.

VEHICLE MOUNTED AERIALS

Two extension aerials are required for effective receiver operation when MicroCorr® is mounted in a vehicle and operating over extended ranges.

The standard MicroCorr® receiver aerials are simply unscrewed and the coaxial cables of the extension aerials are connected instead. The extension aerials themselves have a magnetic base for fixing to the vehicle's roof. Alternatively mounts for non-ferrous roofs are available.

HYDROPHONE SENSOR

Replacing MicroCorr's active sensors with hydrophones enables the operator to locate leaks over greater distances. These sensors also provide better leak noise signals under difficult background noise conditions.

If two suitable pipe fittings are not available operators may use one hydrophone and one accelerometer. It should be noted, however, that this technique is not generally recommended because the hydrophone sensitivity and working range is restricted by the accelerometer sensor performance.

Hydrophone sensors are mounted for direct contact with the water at hydrant, air valve or flowmeter points. A selection of pipe fitting adapters are supplied in the hydrophone kit which is described in Appendix 5. It is important that the connection instructions given in Appendix 5 are followed. These should be referred to before using the hydrophones.

Leak noise propagates very efficiently along the water core which gives hydrophones a greater working range than accelerometers. Hydrophones are also far more sensitive to low pressure waves (signals) and they are particularly effective in locating leaks in large diameter trunk lines.

Hydrophones give good results in all types of plastic pipe systems and the signal information from hydrophones increases operator confidence where any soft or non-metallic pipe materials are encountered.

CABLE DRUMS

Each drum contains 200 metres of low noise cable which provides a direct high quality connection between the audio amplifiers of the radio transmitters and MicroCorr®. The twin balanced cable has a durable conducting plastic screen (instead of conventional wire braid) and this feature provides excellent protection against damage from on-site traffic, and immunity to electrical interference.

Cables are used where U.H.F. transmissions are prohibited or when radio signals may be degraded by interference or screening effects. The free-end of the cable is plugged into the radio transmitter line input socket and a flexible lead is provided to connect between the cable drum and MicroCorr's "line" input socket.

HARD-COPY PRINTER

A lightweight, fully portable thermal printer is available as optional equipment and this plugs into the RS 232 port on the side of MicroCorr®. Full operating details for MicroCorr® printers are listed in Appendix 3.

The printer provides the operator with an on site hard-copy record of all correlation input and processed information including graphics, pipe diagram and site reference data.

Alternatively, data collected on site and stored in MicroCorr's memory can be transferred to the printer later. A complete listing of all correlation runs are available before printing each report in full detail. The printer operates from internal nickel-cadmium batteries and is supplied with its own charger unit.

A serial to parallel converter cable is available to connect the MicroCorr® 6 to a standard Epson compliant parallel printer.

GROUND MICROPHONE FOOT

The ground microphone foot is a valuable leak detection tool which is offered as an optional plug-in accessory to MicroCorr®. We can also supply a complete ground microphone package which includes the microphone, a separate amplifier and headphones.

The leak noise signals detected by the microphone can be amplified and filtered by MicroCorr® to provide audio confirmation of the correlation results. The microphone may also be operated by connection to one of the transmitter units.

The acoustic noise signals from the ground microphone are amplified and multi-band selectively filtered by MicroCorr® to aid leak position confirmation.

TV MONITORS

The addition of a specially adapted monochrome or colour monitor allows simultaneous viewing of MicroCorr® data by the operator and client's representatives.

The monitor is ideal for vehicle based survey operations and at training and inspection establishments.

MicroCorr's extension TV monitors may be run directly from 220/240V AC domestic supplies or via a 12 or 24V D.C. inverter powered from the vehicle's batteries. Alternatively, the monochrome monitor can be powered directly from 12V D.C.

TAPE RECORDING

For specialist applications, unfiltered leak noise signals are available for recording at the "POWER" socket. We can supply a good quality portable cassette tape recorder and leads for connection to this socket to record the leak noise signals for later analysis.

The tape recorder, together with cassettes of pre-recorded noise signals, are valuable aids for training new operators in correlation techniques, and for confirming correct operation of the equipment.

OPERATING MICROCORR® 6

This section covers MicroCorr's start-up procedures and describes the functions and effects of the various keys and controls. MicroCorr's front and side panel layouts are shown in figures 1 and 2 of the sheets at the front of the Manual.

The basic system layout and connections between the correlator unit and other equipment are shown in Appendix 2. The optional equipment is also shown in Appendix 2.

Always press the keys with the flat end of a finger, not sharp objects. The screen will 'blink' (if this feature is selected) and the 'beep' sounds to confirm correct key operation.

SYSTEM POWER-UP

MicroCorr® 6 is supplied with a 12 volt, 2.3 Ah sealed lead calcium battery. Replacements if required should be the same as the type supplied or direct equivalents. The batteries are shipped separately and must be installed and charged before portable operation.

Please read the caution in Appendix 6.0 before proceeding

Then connect the Power - Charger Unit to MicroCorr® (and to either or both transmitter units if required) using the appropriately labeled socket and leads supplied with the Unit.

Switch-on the mains supply and move the switch to the ON position. The Red power indicator LED will illuminate.

BATTERY CHARGING PROCEDURES

When delivered, the MicroCorr® internal battery will only have a nominal charge and should be fully charged before mobile operations are undertaken.

Before attempting to charge the battery in MicroCorr® (and either or both transmitter units) follow all of the procedures in Section 4.

The three charge socket LEDs (lamps) should be lit if connected to the appropriate units. As the batteries charge up, the brightness of the LEDs will diminish. A fully charged battery will be indicated by a barely glowing LED.

Switching MicroCorr® ON or OFF during AC mains powered operations will not affect the battery charging function. **The Transmitters must be switched OFF** while being charged.

When MicroCorr® is being operated from its internal battery always switch-off the unit to conserve power when the system is not actually in use.

When the batteries are fully discharged, they should be recharged within 24 hours.

Provided the above instructions are followed carefully maximum battery life should be maintained.

BACK-LIGHT FACILITY

Press the 1-0 Key on MicroCorr® front panel and adjust the contrast control in the side panel until you can see the Liquid Crystal Display screen clearly. The angle of the display may be adjusted as desired.

If required press the LAMP ☼ key to back-light the display and all function keys. Press the LAMP key again to remove the backlight effect. To reduce the power drain on the MicroCorr® internal batteries the back-light facility automatically cuts-out after a selectable pre-determined time delay following the last key entry. (**See Section 4.0 or 7.0**). If the LAMP key is not pressed again then each subsequent operation of any key will illuminate the back-lighting for the pre-determined time.

The back-light should be switched-off during critical correlation runs on weak signal sources. This precaution removes any risk of sensor signal degradation by electrical noise from the back-light electro-luminescent display.

GETTING STARTED

You can review the MicroCorr® main screens in the sheets at the beginning of the Manual. All of the catalogued screens are numbered and we shall refer to these screen numbers throughout the Manual text.

It should be borne in mind that there are a number of user definable options that affect the way in which operating screens are displayed.

MicroCorr® is normally supplied with the following settings:

Date & Time	:	UK Local
Last Screen Recall	:	OFF
Auto Shutdown	:	OFF
Illumination Time	:	15 Seconds
Direct Entry	:	OFF
Correlation Mode	:	Enhanced
LCD Blink	:	ON

At switch on with these settings the initial SET UP SCREEN 2 will appear. Other information shown on the screen is:

The battery charge level.

The number of result files saved in memory.

The date and time the internal clock is set to.

What period of time the LCD illumination remains on

Press ENTER to move to screen 3.

SCREEN 3 requests that you key-in the signal source and sensor types. To speed up data entry all previously entered data and selections are retained and only those requiring change need to be selected.

If you are using the system for the first time do not press ENTER or MENU yet as this is a good time to examine the powerful HELP screen facility built into MicroCorr®.

If you are already familiar with the HELP screens features, or wish to select another MicroCorr® operating mode, press MENU and refer to Section 5.0 of the Manual.

You may at this stage wish to set the internal clock by reference to section 6.0 of the Manual.

HELP SCREENS

There are over 80 HELP SCREENS built into MicroCorr® and these can be called to assist you at most stages of operation.

One set of HELP SCREENS are accessed simply by pressing the HELP key. These screens are related to the particular operating screen they are accessed from and explain what data MicroCorr® requires next, or advises a particular procedure to obtain the best results.

The second set of HELP SCREENS are selected from the MAIN MENU by keying 07 ENTER. These screens provide application guidance for the various operating modes to help with unexplained or incorrect results. To use these, follow the on screen prompts, selecting symptoms of the problem and operating conditions in use at the time, and a probable cause of the result you achieved will be diagnosed.

These problems and solutions are based on the many years of experience our operators and customers have with MicroCorr® under most site conditions; to help with future MicroCorr® products, we would like to hear about any new problems not covered by these screens.

USING THE HELP KEY

If you are continuing from above, press the HELP key and MicroCorr® will display guidance to enable you to make full use of the functions available.

Now press ENTER to continue to the next help screen display.

Press ENTER once more and MicroCorr® will return to the initial set up screen. Press ENTER to continue and MicroCorr® will either proceed to Leak Position Mode SCREEN 1 or if the DIRECT ENTRY option is set, MicroCorr® will proceed to the direct entry SCREEN 10. For this exercise turn direct entry off (see section 17) from the configuration option selected from the MENU. Now select accelerometers as sensors by keying 4 and 9 and press ENTER again.

SELECT PIPE MATERIAL

MicroCorr® now displays SCREEN 4 and you simply key-in the appropriate number to select the pipe material.

For practice purposes key 02 and the hi-light screen cursor will move to Cast Iron. Press the HELP key and read HELP SCREEN 2. Press ENTER to return to the list of materials on SCREEN 4. Press ENTER again and MicroCorr® will display SCREEN 5 which asks you to input the pipe diameter.

STEP-BACK FACILITY

The UP ▲ key is used as a STEP BACK key.

This facility enables you to step-back through the program screens to change any entered data or to review data generated by MicroCorr®.

Following-on from above, MicroCorr® will be displaying SCREEN 5. Press the STEP-BACK ▲ key once to review SCREEN 4 and then press it again to step-back to SCREEN 3.

Now press ENTER to step-forward through the program to SCREEN 4. Press ENTER again to continue to SCREEN 5.

All previously keyed-in data is retained when you use the STEP-BACK key to page backwards or the ENTER key to page forwards through the programs.

CLEAR AND SET

SCREEN 5 asks you to select the pipe diameter and we could, for example, press key 6. Try this and the hi-light cursor will move to 500mm - 700mm diameter.

Press HELP for an explanation of the Unknown/Mixed and Manual Velocity options. Press ENTER to return to SCREEN 5 and, for practice, key 9 ENTER for the Unknown/Mixed pipe option. MicroCorr® will now display SCREEN 6 which asks you to enter the distance between sensors.

Key-in, for example, 210 metres as the distance between the sensors. Let's assume this is a wrong entry so press CLEAR. This erases the last entry, 210, and you can now enter your corrected figure, say, 230 metres.

SCREEN 6 also shows MicroCorr® has selected a Low Cut filter and a High Cut filter. These are preset values which are designed to suit the pipe details in the program. To find out how to change the filters press SET. This will display SCREEN 8.

Press HELP for advice on filter selection and then press ENTER to return to SCREEN 8. The right hand side of the screen displays two bar graphs when input signals are present and may be used to assist with the selection of suitable filter combinations.

Press ENTER which calls up SCREEN 9 and starts the correlation process or press FIX for AFS and FFT correlation SCREEN 34.

If you have sensor or tape noise inputs a correlation graphic with peaks will now form. The left-hand and right-hand cursors will also be displayed on the screen, indicating the sensor positions. An extra margin is allowed for small errors in distance measurement or sound velocity.

CORRELATION GRAPHIC

SCREEN 9 shows all the data entered and generated so far. The velocity value 'V', for example, may be shown as 1.280 M/ms. The left-hand diagram shows a length of pipe between the Red and Blue sensors with a small arrow indicating the leak position once the correlation function has formed a peak. The distance from each sensor to this position is also displayed. The moving cursor is automatically positioned on the best peak position, or it can be manually controlled by the ◀ ▶ keys.

When the cursor is activated (either automatically or manually) a Time Delay figure will be displayed in reference to Red or Blue sensor. It may, for example, show 8.4 milliseconds (Red).

Two horizontal, signal strength bar graphs above the respective red and blue sensor positions allow to continuous monitoring of the relative levels of the incoming leak noise signals.

We will discuss 'R' (Resolution) and Scale and Range in Section 8.0 of the Manual which covers Leak Position Mode operations.

The elapsed correlation time and the words 'CORRELATION RATE' are displayed at the top right-hand side of the display. The level of correlation activity is indicated (flashing) after "CORRELATION RATE" and will be either NIL, POOR, MODERATE or HIGH depending on the degree of similarity between the red and blue signals. The leak noise tape will give a HIGH rate (if the filters are correctly set).

Press ENTER and Cursor Correct? 1 = YES 0 = NO will appear, along with the "CONFIDENCE FACTOR" of O, LOW, MEDIUM OR HIGH.

Key 0 for NO and the correlation rate signal will flash again to indicate that correlation has recommenced.

PAUSE DURING CORRELATION

This technique of exiting the correlation function by using the 0 = NO key is a useful pause facility.

You can use the technique during practical site operations to pause at any time in the correlation. You would use it, for example, if background noise suddenly increased due to hydrant or service valves being opened. MicroCorr® 6 also incorporates monitoring of the signal input levels and will pause automatically if a sudden significant change in level is detected from either sensor.

Practice using the pause facility and returning to the correlating screen to move the cursors on the graphic display.

AUTOMATIC/MANUAL CURSOR

Normal cursor operation will automatically select the most appropriate peak as the correlation forms. This is not necessarily the highest peak, and the position of the cursor may take several seconds to steady depending on how well defined the correlation peak is. However, this automatic operation (AUTO CURSOR) can be over ridden by using the cursor ◀ ▶ keys (MANUAL CURSOR).

Press the Cursor Right key, ▶ and a cursor will move across to the right-hand side of the correlation graphic. You can now use the Left ◀ and Right ▶ cursor controls to place this cursor exactly where you like on the graphic display. A single press moves the cursor only one position (column). Holding down the Left ◀ or Right ▶ key continuously will move the cursor in large steps.

The end cursors remain fixed as they are only used as part of the Zoom function. (This is described fully in Section 8.0 of the Manual covering Leak Position Mode operations).

When the moving cursor is positioned correctly press ENTER which freezes the 'CORRELATION RATE' and displays Cursor Correct?
1 = YES 0 = NO.

Key 1 if the cursor is positioned correctly. This will stop the correlation and call up SCREEN 11 which lists 6 options. We will review these options fully in Section 8.0.

To return to AUTO CURSOR operation, press the ZOOM key twice.
Now press MENU and refer to Section 5.0.

AFS AND FFT CORRELATION

The AFS / FFT screen 34 offers 5 options, only the options available will be displayed e.g. option 5 to print will only be available if correlation data is available. To carry out an FFT based correlation press 1 for new correlation.

The MicroCorr® 6 will gather correlation data and display two graphs on the screen. The upper graphic will display the FFT based correlation graph showing the leak position and time delay, a dotted line will indicate the leak position. The lower graph displays coherence and can be used to determine the required filter settings.

Once a peak has been formed the enter key can be pressed to stop the FFT correlation and select a new filter setting, See SCREEN 35. The cursor keys are used to alter the filter setting bandwidth and frequency based on the coherence graph, once this has been done the enter key is pressed and SCREEN 34 is displayed showing the 5 main options again. Option 2 can now be selected to re-correlate using the new filter setting and the correlation process is repeated.

Option 3 allows the FFT Correlation data to stored and used to correlate at a later date.
Option 5 will print both the FFT and coherence graphics to an attached printer.

To return to the normal correlation SCREEN 6 press the UP ▲ key.

THE MAIN MENU

The MicroCorr® 6 has 16 options available from the Main Menu screen 1, this is called up simply by pressing the MENU key. The version number of the software version currently installed is displayed in the top right hand corner of this screen display.

To select any option from the Main Menu just key in the appropriate program number and press ENTER. For example to call up Listening Mode, you key 05 which moves the hi-light cursor to Listening. Then press ENTER; it is necessary to enter both digits of the menu choice, i.e. '05' and not '5'.

Pressing the 'SET' key whilst in main menu will access the single screen data entry facility in leak position mode, regardless of hi-lighted selection.

MENU - MANUAL REFERENCE

For quick reference to the programs displayed on MicroCorr® 6 Main Menu screens are detailed in the following sections of this Manual:

MAIN MENU SCREEN		MANUAL SECTION
01	LEAK POSITION	8.0
02	PRINT	18.0
03	VELOCITY MEASUREMENT	9.0
04	SURVEY	10.0
05	LISTENING	11.0
06	VELOCITY TABLES	12.0
07	HELP	4.5
08	COMPUTE EDIT	14.0
09	SELF TEST	20.0
10	CUSTOM PIPE CHOICE	16.0
11	VELOCITY CALCULATION	17.0
12	MEMORY ERASE	19.0
13	CONFIGURATION	6.0
14	DISTANCE MEASUREMENT	13.0
15	AUTO CORRELATION	15.0
16	SET UP SCREEN	7.0

CONFIGURATION

The Configuration program is called from the Main Menu by keying 13 ENTER which calls up SCREEN 25.

Using this option, the operator may review and change a number of basic MicroCorr® functions.

Option 1 allows the automatic shutdown facility to be enabled or disabled. Key 1 to change selection.

Option 2 allows control of the illumination timer, first key 2, then use the ◀ ▶ cursor keys to modify time between 15 to 120 seconds.

Option 3 displays the last screen recall off message. This option is no longer applicable to the MicroCorr 6.

Option 4 selects either normal or enhanced correlation modes. Normal operation will give a very clear peak for a leak but may miss the more difficult leaks. Enhanced mode is more sensitive but the correlation display will show more background 'noise'.

Option 5 enters the set date and time screen.

MicroCorr® 6 has a in-built real-time clock that is used to add dates and times to the hard-copy printout results. The clock continues to operate by a separate backup battery when MicroCorr® is switched-off, and even if the main battery is removed.

MicroCorr® is pre-set for the European style format showing Day - Month - Year.

Key in the Day, Month and Year: for example 16 09 93. If you type in a wrong digit you can clear the entry line by pressing CLEAR.

Now key in the time using 24 hour clock-code. For example, 17 06 for 17 hours 6 minutes, (5.06 PM).

To zero the seconds to the nearest minute press SET at the "ENTER NEW DATE" prompt, before entering any date.

Option 6 will allow the screen 'BLINK' to be selected as desired. This feature will confirm a key press by momentarily flashing the LCD display.

Option 7, direct entry allows rapid entry to the correlation screen retaining previously entered data. When selected, MicroCorr® will turn on to the SET UP screen 2 but will then proceed to screen 10, the Direct Entry screen. Any of the displayed settings or data can be changed before pressing ENTER to start correlating. This facility is available only for leak position or autocorrelation modes.

Headphone volume may be adjusted between levels 1 to 8 by using the ◀ ▶ cursor controls. The automatic gain control will then adjust any changing signal levels to maintain this level of volume at the headphones.

-Press MENU to exit the program. This will return you to the Main Menu screen which is detailed in Section 5.0 of the Manual.

SET UP SCREEN

This is accessed by keying 16 "ENTER" from main menu, and returns the operator to the initial set up Screen - screen 2. This gives the date and time, the number of print files stored and battery charge remaining. A check may be made on the illumination timer, automatic shutdown mode and any change made as necessary by following the on screen prompts.

LEAK POSITION MODE

When MicroCorr® 6 is switched on, Screen 2 is displayed. Press ENTER to move on to Leak Position Mode (SCREEN 3). To call the program from Main Menu key 01 ENTER for the same display. You are now asked to select the Red and Blue channel signal sources and the types of sensors you will be using. Active sensors, i.e.: internally amplified or passive, i.e.: unamplified sensors, are automatically selected according to the type of sensor connected to the direct sensor input. The transmitters do likewise.

MicroCorr® 6 performs all operations in metric units and to assist operators who only have imperial data a Table of metric/imperial equivalents is provided in Appendix 8.0 of the Manual.

HELP AND STEP-BACK FACILITIES

Press the HELP key for advice as required and, in the early sections of the program, use the up cursor ▲ key to step-back to the previous screen. This facility allows entered data to be verified or changed. (In later parts of the program, as detailed in Section 8.0, the step-back facility is by-passed).

SOURCES AND SENSORS

Key in the signal source for both red and blue channels, whether from a radio transmitter, cable drum, or direct to the sensor input socket on the side panel.

MicroCorr® 6 can also be used with alternative GAS sensors, another type of active sensor. One of the LINE input sockets (the RED) has additional internal connections for these sensors and is used in place of the sensor socket. Plug in the gas sensor cable, select DIRECT, (in GAS operation the socket can be used by either channel) and press FIX to switch into GAS mode. The message DIRECT INPUT SET TO GAS will be displayed to confirm this. Press FIX again to return to normal operation with the SENSOR socket.

Select either accelerometer or hydrophone sensor by keying appropriately. The benefits of cable input and Hydrophone sensors for particular operating conditions are discussed in Section 3.0 of this Manual. Pressing the ZOOM key at this time will display signal level bar graphs to give an initial indication of the level of noise on the pipe from both sensors.

Section 8.0 gives an indication of the operating range that can be expected of MicroCorr® under typical conditions.

SIGNAL TEST TAPE

A pre-recorded cassette of leak noise signals, which cover a range of Time-Delay values, are supplied with the MicroCorr® system. In addition to checking MicroCorr's operation the tapes are very useful for training operators in Leak Location, Survey and Listening mode techniques.

The cassette should be played on a good quality tape machine with a stable tape transport system. Any variation in tape speed will produce different Time Delay Values to those indicated on the cassette label.

The cassette player connects to the sensor input sockets of the transmitter and MicroCorr® (or the second transmitter) using the special cable supplied - other cables WILL NOT work correctly.

If the tape is started after the correlator screen is entered, then the Noise Pause may automatically operate (see section 8.0).

Ensure the gain control at the RED (and BLUE, if used) transmitter(s) is set to 'AUTO'. The transmitter(s) should be set to 'TX LO'. Please refer to Appendix 4.0 for transmitter operating instructions.

STANDARD MATERIALS

Press ENTER and MicroCorr® displays SCREEN 4 which gives you a choice of standard pipe material options, under items 01 to 12.

The other options, Mixed Material, Unknown/Other and custom pipe menu, enable you to input supplementary data to make the correlation calculations more accurate. These options are reviewed in Section 8.0.

Select the appropriate material and ENTER to display SCREEN 5 which asks you to input the pipe diameter.

PIPE DIAMETER

A range of pipe diameters is displayed to suit the material selected. When you select and enter your required pipe diameter the velocity and filter values are set automatically.

You would select the Unknown/Mixed options if the pipe material is not known or if the pipe run consists of more than one diameter but details of length or diameter are not known. Selecting Unknown/Mixed sets the velocity and filter values to the most appropriate values.

The option for Manual Velocity enables you to enter a precise value which can be determined by the Velocity Measurement program as described in Section 8.0. Alternatively, although not as accurate as measuring the velocity, by pressing ZOOM after selecting Manual Velocity, MicroCorr's velocity tables are displayed and a value can be selected. For further information refer to section 12.0.

Select the appropriate pipe diameter and press ENTER which displays SCREEN 6. Press HELP for advice on accurate measurement techniques etc. as required. Then key-in the exact distance of the pipeline between sensors.

CORRELATING DATA

For our test example MicroCorr® 6 has pre-set the filters to optimum settings to suit the pipe size, length, material and types of sensor used. An initial correlation may be made by pressing ENTER.

The MicroCorr® screen will now show all your keyed-in data, the Time-Delay Td, a scaled diagram of the Red and Blue sensors and a real-time correlation display with three cursors. A typical example is shown on SCREEN 9.

MicroCorr® 6 has an auto-cursor that selects the best correlation peak automatically. The Leak Position is indicated by an arrow below the scaled RED ■----------■ BLUE pipe diagram.

The auto-cursor can be overridden at any time by pressing either of the cursor keys. To reactivate the auto-cursor press the ZOOM key twice. Auto cursor also reactivates when exiting from ZOOM.

The actual leak position distance will be given from both the Red and Blue sensor, and the measured Time-Delay (Td) will also be shown.

If the leak is outside of the section of pipe bracketed by the sensors the WARNING NON-BRACKET LIKELY alert will be displayed on the screen. If the correlation Time Delay (Td) is approaching zero the "WARNING CENTRE CORRELATION" will be displayed.

The correlation rate will flash on the display, giving an indication of the amount of leak noise signal information being processed by the correlator. The time that the correlation process has been running is also shown on the display.

At the bottom left-hand of the screen you will see three values, 'R', 'SCALE' and 'RANGE'.

'R' is the Resolution of the correlation graphic and relates to what length of pipe each column of the display covers. This value changes with the length and type of pipe between sensors, and what level of zoom is used. Values from 0.2 through to 24.0 may be displayed depending on the total time delay between sensors.

A resolution of 1.9, for example, means that the width of each vertical column on the correlation graphic is equal to 1.9 metres of pipeline. The resolution factor can be improved by decreasing the distance between sensors or by using the Zoom facility.

Scale refers to the compression of the correlation display. Zoom expands a selected area of the correlation graphic to a maximum scale of 1:1.

Range is the time delay range which is automatically selected by MicroCorr® to suit the pipe length and material and varies from 1 to 6.

Up to this point it is possible to Step-Back through MicroCorr's data screens to change data you have entered or to select different filters, etc.

Each time you press the ▲ key you step-back to the previous screen. By pressing the step-back key several times you can return right back to SCREEN 3 and change the sensor types and Red and Blue inputs.

MicroCorr® 6 also has a single screen data entry facility, (SCREEN 10) accessible by pressing 'SET' when in the correlation mode. This enables you to check and modify all the entered data, i.e.: distance, velocity, pipe material, filters, pipe diameter, signal source, sensor type, notch filter, normal or enhanced correlation and headphone volume. A single key-press moves to the required screen to allow changes as required. This screen is also accessible by pressing 'SET' from main menu or the start up screen, SCREEN 2.

To advance quickly through the program and return to the correlation graphic just press ENTER when you have verified or changed the data on each screen. MicroCorr® leaves all user programmed data the same to facilitate fast data entry.

SETTING FILTERS

The filters can be changed from the correlation SCREEN 9 by pressing SET which displays SCREEN 10, then press 4. This displays SCREEN 8.

The comprehensive audio filters in MicroCorr® 6 cover the frequency range up to 5000 Hz and are designed to eliminate background noise and to enhance the leak noise signals. Hz is the international abbreviation for Hertz which stands for cycles per second. Adjustment may be made to maximise the similarity between the two sound channels, to compensate for the modification of the leak noise by the pipe material. The filter settings below 20Hz are lower than human hearing can notice, although MicroCorr® 6 can analyze and correlate at these subsonic frequencies.

As an example of the range of MicroCorr's filters the third lowest filter setting is approximately the same as Bottom D (36.7 Hz) on the piano keyboard. The High filter setting of '01' (5000 Hz) is above Top C (4186 Hz) on the piano.

The filter settings are displayed as a graphic, with the pass band, or the range of frequencies not filtered out, displayed as solid. Each division represents an octave difference from the adjacent settings (think back to the piano).

The filters are set using the cursor keys. The ◄ ► keys move the filter pass band up and down the frequency range, keeping the width of the passband constant. The width is altered using the ▲ ▼ keys. Each press of the ▲ key will increase the width of the frequency passband by an octave. Likewise each press of the ▼ key will reduce the filter passband width by an octave.

With the headphones plugged into the MicroCorr® unit you can monitor the leak noise and hear the effects the various filter settings make to the signals, as well as seeing the effect on the two bar graphs displaying the signal levels. As you select filters that remove part (or all) of the incoming signals, the level of the signal bar graph drops.

If you do change the filter settings from the default settings, then MicroCorr® will "remember" this and use your settings for the next correlations, until you return to automatic filter selection. To remind you that manual filters are selected, a warning message is displayed when you enter the new distance. Simply viewing the filter setting will not override the automatic operation.

Pressing ZOOM from this screen will take you to the spectrum analysis display where the relative levels of the different frequencies contained in the leak noise signals may be visualized.

Alternatively, the leak noise signals can be displayed on the optional video monitor by pressing SET. This displays the signals as a wave pattern and allows leak noise to be identified from general noise by its unique appearance.

SPECTRUM ANALYSIS

This function enables you to observe the entire frequency spectrum used by MicroCorr® 6. Either or both red and blue channels may be seen, with the predominant frequencies identified with the lower scales, running from 0 Hz to 5000 Hz (5 kHz).

The vertical scale gives an indication of the amount of energy in the leak noise, at the different frequencies. It may be changed between a logarithmic (dB) scale and a linear (0-50) scale by keying option 2. The channels viewed may be changed by selecting option 3.

Interfering, extraneous noises may also be identified, and by selecting option 4, a variable width, notch filter is activated. Using the left and right cursor controls ◀ ▶, the notch may be swept across the entire frequency spectrum. The width of the notch and hence, the amount of signal filtered out, may be varied between wide, medium and narrow by using the up-down cursor controls.

Once the common band of frequencies has been identified, then keying 0 to exit, will enable you to return to the set filter screen. Using the headphones and display adjust the filters as required to maximise their effect on the leak noise.

Please note that due to the nature of this feature, the frequency is displayed with a different horizontal scale to the filter selection bar. Halving the frequency on the spectrum display (say from 5000 to 2500 Hz) is a drop of one octave, or one division on the filter graphic. Halving it again to 1250 Hz is another octave drop.

Key 0 to exit and then ENTER to correlate.

ZOOM CONTROL

To improve the resolution you can manually Zoom in to a particular section of the correlation peaks if the initial scale is greater than 1 to 1. Using Zoom changes the scale and gives improved leak position resolution which is particularly useful when the sensors are far apart.

First, move the cursor to the right side of the desired peak with the right Cursor key and then press FIX . Next, move the cursor to the left side of the peak with the left Cursor key and press ZOOM. This will expand the section of the screen between the cursors.

As an example, if our initial scale was 2:1 it may change to 1:1 and the resolution factor could change from 2.9m to 0.2m etc., depending where you position the cursors.

To return to the larger scale correlation graphic press ZOOM again. This will also reactivate the auto-cursor facility.
The Zoom function may also be used to suppress any desired area on the display to allow any secondary peaks to be examined in greater detail. Proceed as before zooming in on any peak that you wish to suppress. When 'zoomed', press "CLEAR" to significantly reduce the height of chosen area and then press "ZOOM" once more to return to the full display and observe the effect. Pressing "CLEAR" will now return the display to normal.

When "ZOOMED" at any time the option also exists of amplifying the chosen peak by pressing the ▲ key, and diminishing the peak by using the ▼ key.

CURSOR CORRECT?/PAUSE

When the correlation peak and data are acceptable and you have positioned the cursor accurately on the peak press ENTER. MicroCorr® will now ask Is Cursor Correct? 1 = YES 0 = NO.

A confidence factor (CF on the printout) is displayed (0, LOW, MEDIUM, HIGH). This is an indication of the degree of certainty that the result indicates a leak. A low or 0 level of confidence requires further checking. Note that moving the cursor manually off the peak will affect the level of confidence.

If you want to reposition the cursor or use the step-back facility again or reset the cursor from manual to auto, press 0.

When your correlation is completed, and you have the Cursor Correct? prompt again, press key 1 to select the save and store options, screen 11.

Once you press the 1 key the step-back facility is terminated until you restart a new correlation run or select another program from the Main Menu.

MicroCorr® 6 incorporates a "NOISE PAUSE" facility that automatically pauses the correlation process if a sudden increase in signal level is detected e.g. as from traffic or heavy draw off.

When the "NOISE PAUSE" warning is displayed press 1 to continue correlating, allowing the NOISE PAUSE to operate on a subsequent surge in signal level, or 0 to disable this facility for the duration of this correlation. If no action is taken, once the signal level returns to its previous level, MicroCorr® resumes correlating.

SAVE AND STORE DATA

SCREEN 11 displays six options:

1 To Store The Result press key 1 ENTER and MicroCorr® will store the correlation data and tell you the file number the data is stored under.

2 To return to Correlation (to continue the last correlation) press key 2 ENTER.

3 To Store With Site Details press key 3 ENTER. MicroCorr® will now display SCREEN 12 and you can select either Map or Site reference modes by pressing the SET key.

Spell-out the Map reference codes or Street codes using the ◀ ▶ cursor controls and the ENTER key. Use the ▲ ▼ keys to move the cursor to overwrite any character as desired or use the "CLEAR" key to delete the entire entry. When your map reference data are correct select 'END' and press ENTER. A specially modified PC style keyboard is available as an accessory to speed data entry.

Alternatively by pressing "SET" you can key in any Site reference number from 1 to 254 and "ENTER".
MicroCorr® now asks you for Red fitting and Blue fitting sensor reference numbers. Up to 10 numeric digits are allowed per reference. Press ENTER again after keying in these numbers and MicroCorr® will display the file number the results are stored under.

4 By selecting Option 4 you will return to Start Screen 3 without saving any data.

5 To store for compute press 5 "ENTER". A full explanation follows in section 8.0.

6 To change the distance or velocity of a completed correlation, select option 6 and "ENTER". This allows the operator to modify the result without having to re-correlate.

COMPUTE MODE

It should be noted that the Leak Position measurements described so far are based on the estimated velocity of sound within the Pipe. Greater confidence in the result is achieved if two or more correlation runs are conducted for the same leak. Please refer to Appendix 1.0 for detailed benefits of the Compute function.
During the extra correlation 'runs' carried out as part of a compute exercise, one sensor remains static on a selected pipe fitting and the other sensor is moved from fitting-to-fitting for each compute run.
Follow normal Leak Position methods

a) Select Signal/Sensor types

b) Select (Pipe) Material

c) Select Diameter (or insert own velocity - although this will have little effect on final result).

d) Enter Distance between sensors (accept filters at this stage).

e) Correlate and obtain definite peak.(Step back to previous screen and adjust filters as required to obtain good correlation peak).

f) Position cursor on peak using zoom facility if scale is not 1:1. NOTE THE DISTANCE to sensor that you will choose to remain fixed.

g) Press ENTER and verify cursor position press 1 - Yes when correct. This displays SCREEN 8.

Now start compute operation.

h) Select option 5 Store For Compute and ENTER.

i) Select which sensor will be used as the static reference sensor by using the SET button. In a compute exercise, the moving sensor must remain on the same side of the reference sensor for all runs.

j) Enter a site or map reference number if required.
Enter a Red fitting reference if required.
Enter a Blue fitting reference if required.

k) Move only the sensor indicated to the next fitting and enter a new fitting reference if required. Press SET if any change of signal source (radio/direct cable) is required at this stage.

l) Input the new distance which should be a change of at least 20% of the previous distance still keeping the leak position between the two sensors. Press ENTER to begin the second correlation and position the cursor on the peak as before. NOTE: In the event of more than one peak being present the distance to the peak from the fixed sensor should remain approximately the same as the previous run(s) using the same leak noise source.

m) Press ENTER once the cursor is accurately positioned on peak and verify the cursor position as correct by pressing 1 = Yes as before.

n) The display now shows both results plotted on a graph, SCREEN 13. The vertical (Y) axis indicates distance and the horizontal (X) axis indicates time delay (Td). The measured distances and time delays are shown on the left of the display and the computed result on the right.

o) Press ENTER to continue.

p) Move the reference sensor indicated, as before, to a different fitting, again changing its position by at least 20%, and still keeping the leak between the sensors. Do not re-use the same fitting for the moving sensor twice or the result will be invalid.

q) Enter the new fitting reference if required and change the signal source only if required.

r) Enter the new distance for the third compute run.

s) This begins the third correlation. Position the cursor as before (using zoom if scale is not 1:1.) Ensure that the same peak is selected as before by noting its indicated distance from the fixed reference sensor.

t) Press ENTER when the cursor is correct and verify its position by pressing 1 = Yes.

u) The display now shows the graph again (SCREEN 13), including all three plots, and the new computed result on the right of the display with leak position. L = ... m from the reference sensor and velocity V = ... m/ms. If the X-Y plots fall on a straight line you can assume that the leak distance and velocity values are accurate and the results would normally be accepted.

(v) If any individual run has an error in distance or velocity used, the plot for this result will be noticeable by lying off the straight line formed by the other plots. It can be corrected by using the ▲ ▼ keys to select the incorrect result from the table with the highlight cursor. Press ZOOM to remove this run from the computed result and graph. An * shows that this result is excluded. Press ZOOM again to include the result once more, if desired. Alternatively press CLEAR and the result will be deleted permanently, and will not be saved for printout. **The greater the number of runs used, the more easily an erroneous result can be spotted.**

(w) The procedure may be repeated if required up to a maximum of six runs. At least three valid runs should be used to ensure an accurate result.

The resulting graph will be printed out at the end of the computed result files.

If MicroCorr® is switched-off during Compute Mode operation the unit will return straight to Compute Mode next time it is switched-on, upon pressing ENTER to exit the initial Set-up screen. To terminate Compute Mode press ENTER then MENU (if you only press MENU, the last result isn't saved).

MIXED MATERIAL

These procedures on Mixed Material follow on from paragraph two of section 8.0 From SCREEN 4 key 13 ENTER to display SCREEN 14 which asks how many sections of pipe are there between the sensors. The program can handle up to six sections, enter the required number, then press ENTER.

This calls SCREEN 15 showing a diagram of the sections of pipe between the Red and Blue sensors. Starting at the Red sensor enter the length of the first section, by keying in the known distance and ENTER. The screen now reverts back to SCREEN 4 to enable you to select the material for the first pipe length.

Select the known material and ENTER to call up SCREEN 5 so that you can input the pipe diameter. Now input the required diameter and ENTER. MicroCorr® now displays the pipe diagram again and asks you to enter the length for the next section.

Key in the distance and then select the pipe material and diameter as you did above. SCREEN 15 will now show two sections of pipe and the velocity value for each section.

Repeat this process for remaining pipe sections between the fittings.

When all sections are complete, stepping back from the distance entry screen takes you back to the start of the procedure (i.e. SCREEN 4).

Press ENTER again to return to the correlation procedures as described above. Using ▲ to step back from the correlation screen when correlating shows the leak position indicated in relation to the pipe sections. To return to the correlator screen use the ▼ key.

The filters are preset, but with the wide range of materials that may be combined, you may want to change the filters, using the method described in section 8.0 previously.

CUSTOM PIPE MENU

This option for an additional custom pipe menu follows on from paragraph two of section 8.0. From SCREEN 4 key 15 ENTER which displays the list of pipe choices that are available.

The pipe choices are programmed by you, the operator, using the main menu option CUSTOM PIPE CHOICE (see section 14) and are used where non-standard pipes or liquids are surveyed. Select the pipe option you wish to correlate with and the velocity and filter values programmed for that option will automatically be used. Selecting 01, ENTER will return operation to the standard pipe menu. Options in the custom pipe menu do not have an associated pipe diameter screen so it is serviceable to include the diameter as part of your custom pipe material description.

TYPICAL OPERATING RANGES

Using hydrophones, operating distance can be very high particularly during a quiet period of the day. For example, distances over 4Km of 4" iron can be achieved from leak to sensor.

Increasing the operating distance always decreases the chance of correlating successfully.

Actual operating ranges are influenced by a number of variables. The results will vary dependent, for example on pipe wall thickness, ground conditions, size and shape of the leak, background noise and other noises in the pipe system. Distances in excess of 2000 metres have been achieved on 8" PVC pipe using hydrophones.

The following table gives a general indication of maximum working distances. **It is stressed that the actual range achieved may be better or worse than indicated depending on the site conditions.**

General reliable maximum Pipe Materials working distances for pressures above 2 bar	
Urban Network	
Iron, steel, copper	400 metres accelerometers 800 - 1200 metres hydrophones
Lead, A/C, concrete	300 metres accelerometer 600 - 800 metres hydrophones
Plastic pipes	50 - 100 metres accelerometer 400 - 500 metres hydrophones
Trunk Mains	
Iron, Steel	500 - 800 metres accelerometers 2000 - 3000 + metres hydrophones
A/C, Concrete	400 - 600 metres accelerometers 1000 - 2500 + metres hydrophones
Plastic	100 - 200 metres accelerometers 500 - 1500 + metres hydrophones

VELOCITY MEASUREMENT

This operating mode enables the operator to measure the actual velocity of sound within the pipe and is a recommended procedure if only one correlation run is possible or if the Compute facility cannot be used due to the lack of pipe fittings. In this case, measure the velocity at a suitable location near the leak, ensuring that the pipe material and diameter is identical to the pipe section with the leak.

MicroCorr® is set up as described in Leak Location Mode in Section 8.0 of the Manual. A noise source has to be introduced either at, or beyond, one of the sensor positions, or within the bracket of the two sensors. The noise may be generated by mechanical means on the outside of the pipe or by opening a hydrant or other fitting to allow water to escape from the pipe under pressure.

RUNNING THE PROGRAM

The program is called by keying 03 ENTER from the Main Menu which calls up SCREEN 16. This asks for the known position of the introduced noise to be entered i.e. whether it is inside or outside the bracket of the two sensors and its exact distance from any sensor, if inside. Ideally, the position of any 'In Bracket' noise should be close to one of the sensors, or errors in the measured velocity may be large. The greatest accuracy is achieved using an "OUT OF BRACKET" noise. Pressing "ENTER" to continue will take the operator through the already familiar screens 1 to 5 making the necessary inputs in response to the on-screen prompts.

SCREEN 17 will now display a correlation graphic and a peak will form at the position of the created noise (or at the red or blue fitting for an out of bracket noise). Note the Time Delay (Td) and the Velocity (V) values as the cursor moves to align with the peak. When using a noise source within the bracket of the two sensors, the accuracy of the measured result will be indicated as a plus or minus percentage figure displayed alongside the velocity figure.

As the cursor moves, the Td and V values will change. When the cursor is aligned with the peak you can either note down the actual velocity value for manual input or save the data for display or printout. The Zoom facility may be used if required as detailed in Section 8.0.

An error message "Velocity Out Of Range" will be displayed on the screen if input data is incorrect, or a correlation peak is chosen that is not due to the introduced noise source.

SURVEY MODE

Survey Mode provides a correlation display that enables you to check large distances rapidly for the presence of leaks. Only an estimation of the maximum distance between sensors is required.

Accelerometers are the most practical signal sensors for quick operation and the distance between sensors should be kept reasonably short, ideally within Range 1 or 2 of the displayed distance options but generally up to 400 metres for metal pipes and 50-60 metres for plastic is a good maximum for accelerometers in this mode of operation. The sensors are attached to the pipe fittings and the first survey correlation is commenced. One sensor (A) is kept fixed and the other sensor (B) is leap-frogged over it to the next fitting position. A second correlation run is then performed. (B) then remains fixed and (A) is leap-frogged over it ... and so on.

It should be noted that no leak position calculations are performed in this mode although the time delay (Td) is measured should any correlation peak be formed, allowing the option of converting the survey run into a leak position file by entering the actual velocity and distance measured. This feature would be used if the correlation peak had taken a long time to form and allows the instantaneous conversion from survey to leak position mode.

SURVEY EQUIPMENT

The equipment for Survey Mode is set-up as for Leak Position Mode. Connect one sensor to the Red channel transmitter and the other to the Blue channel transmitter or direct into MicroCorr®.

RUNNING THE PROGRAM

The SURVEY program is run by keying 04 ENTER from the Main Menu. This calls up SCREEN 3. Select the correct Red and Blue Channel inputs for your signal sources then press ENTER which calls SCREEN 4.

Press HELP for assistance anywhere in the program and use the ▲ key to Step-Back to a previous screen, if necessary, during the data entry stages. Press MENU to escape from the program.

Select the appropriate material. Then press ENTER to call SCREEN 19. Now select the maximum distance between sensors, (this need only be an approximate estimation) by keying 1 to 4 and press ENTER. Remember to keep the sensors close together for effective correlation. Range 2 is generally the most suitable distance to use, to avoid overlooking a small leak.

CORRELATION DISPLAY

MicroCorr® now displays SCREEN 20 which shows the keyed-in information. If a correlation peak forms this indicates the presence of a possible leakage. The peak may be in the section of pipe 'bracketed' by the sensors or it may be 'out of bracket' further along the pipe.

At this stage, you would generally switch to Leak Position Mode to determine the actual leak position. Alternatively, you may convert the survey into a leak position by pressing enter and then choosing Option 6 which asks for the actual velocity to be input (or the default value accepted) and the actual measured distance to be entered. MicroCorr® may then display "CHANGING RANGE" before giving the actual leak position from both sensors. Alternatively you may store the survey results together with site and fitting references for later action. You can then continue with area survey operations.

PAUSE FOR INTERFERENCE

If interference occurs during Survey Mode operations you can pause the correlation process by pressing ENTER. The interference, for example, could be caused by consumer draw-off or passing traffic. Pressing ENTER stops the correlation and calls up SCREEN 21. When the interference has ceased select Return To Correlation by keying 2 ENTER.

NEXT SURVEY

When you have a satisfactory correlation result press ENTER again and return to SCREEN 21. To use the 'leap-frog' technique described in 10.0 above, select Next Survey by keying 5.

Then move sensor (A) along the pipe and 'leap-frog' it over sensor (B). When (A) is attached at its new position press ENTER. This starts a new correlation run using exactly the same sensor input, distance and material settings you used before. The Next Survey facility enables you to perform consecutive surveys with only two key-strokes. If you wish to change any of the previous settings call up SCREEN 21. Then key 4 ENTER to Return To Start. This will return you to SCREEN 3.

STORING SURVEY RESULTS

Keying 1 ENTER on SCREEN 21 will save the active survey data to memory file and display the File number the data are stored under. SCREEN 21 also gives you the option to Store With Site Details. To use this option, key 3 ENTER which displays SCREEN 12 then use the SET key to select either Site or Map references. As detailed in Section 8.0.

LISTENING MODE

In this mode, MicroCorr® operates as a sensitive electronic listening device and is used with one sensor input. This is connected directly to the sensor input at the left-hand panel of the correlator. The headphones are plugged into the Phones jack-socket on the same panel. MicroCorr® 6 will automatically determine if an active sensor is connected, i.e.: one containing a powered preamplifier and select active or passive as required.

For certain operations a hydrophone can be used instead of an accelerometer. Alternatively an MK4 ground microphone foot can also be plugged into MicroCorr® and this item of optional equipment is discussed in Section 3.0. of the Manual.

RUNNING THE PROGRAM

The Listening program is run by keying 05 ENTER from the Main Menu which calls-up SCREEN 22. The filters are pre-set automatically to the widest settings but these can be changed easily using the cursor keys as described in SECTION 8.0.

GAIN CONTROLS

The gain is automatically controlled and switches between high and low ranges as required. The signal level bar graph gives an indication of the amount of noise being received from the sensor. Numerical signal strength is displayed at the top of the screen and the chosen range indicated by a suffix H or L for High and Low respectively. These levels may be saved for comparison by pressing "ENTER". Ten readings may be stored in succession and enable the operator to make comparative measurements of different sites after repositioning the sensor. Press "CLEAR" to delete these readings.

Pressing "SET" gives manual override of the gain control, and changes the function of the cursor keys from controlling the filter frequency to controlling the Listening Mode gain, or volume.

The Gain Up ▶ and Gain Down ◀ controls are designed to adjust the signal level for optimum headphone listening and the actual gain setting is indicated on the bar graph.

These features enable the operator to set the gain for one sensor position and to note the relative change in leak noise as the sensor is moved to new locations.

FREQUENCY SPECTRUM

Pressing ZOOM will display the audio frequency Spectrum of the input signal (SCREEN 32). Care should be taken to ensure that any chosen filter settings do not affect the Spectrum display unintentionally. To view the complete frequency spectrum, set the filters to the widest settings. The dominant frequency to the nearest 30Hz may be viewed directly and its strength determined, either in a logarithmic or linear scale. The Spectrum may be saved for later analysis or printout.

This feature is useful in periodic surveys of a pipe, giving an indication of leakage by a change in the characteristic spectrum previously recorded. Leakage near a fitting will be particularly evident by an increase in noise at the mid and higher frequencies.

VELOCITY TABLES

MicroCorr® 6 is programmed in metric units and to assist operators who only have imperial data, a Table of useful metric/imperial equivalents is printed in the Appendix section of the Manual.

MicroCorr's Velocity Table program is called by key 06 ENTER from the Main Menu. This displays SCREEN 4 (options 1 to 12).

Key in your choice of pipe material, for example key 03 for Steel, and then press ENTER.

The Tables show the velocity in metres per millisecond (m/ms) for a range of common pipe diameters of different classes.

These tables are also available during Leak Position Mode by entering 'Manual Velocity' from the pipe diameter screen and using the "ZOOM" key as directed.

SCROLLING THE PAGES

The Tables cover pipe diameters from 10mm to 2190mm (dependant on material) and you can scroll forwards and backwards through the pages by pressing the ▲ and ▼ keys.

For operational flexibility MicroCorr® Velocity Tables are also included in the Appendix section of the Manual.

Press ENTER to quit the program and return to the Main Menu.

DISTANCE MEASUREMENT

This program allows the length of pipe between the sensors to be calculated. The main reason for incorporating this feature is to allow operation of MicroCorr® over sections of pipe that run under land or property where access to take measurements is not possible. It is not intended that this feature take the place of actual site measurement whenever this is possible. A noise source, e.g. open hydrant, is required outside the bracket of the sensors.

RUNNING THE PROGRAM

The program is called by keying 14 "ENTER" from the main menu which displays Screen 3. Select the signal source and sensor types as usual and progress through the already familiar screens 3 to 5 by entering the necessary data in response to the on screen prompts. The next screen (19) requests that an approximation of the distance estimated between the sensors is selected.

When the out of bracket noise source is produced and the cursor moves to the peak, (which should build at the extreme end of the display), the estimated distance may be read off directly and also saved for later printout as usual (SCREEN 33).

For increased accuracy it is advisable to first measure the velocity in an accessible section of the same pipe and enter this value by selecting 0 "ENTER" at the select pipe diameter screen (3).

COMPUTE EDIT

The program is called from the Main Menu by keying 08 ENTER which calls up the Result Edit screen. Detailed Compute Mode procedures are given in Section 8.0 of the Manual.

This lists the computed runs stored with the date and time stored, along with any site/map references. Use the ▲ ▼ keys to select any required compute run or compile a new compute run by moving the highlight cursor down to the end of the listed compute runs when the message "NEW RUN COMPILATION" appears.

This allows the operator to utilise any previously stored leak position files to compile a computed result. Simply enter in the relevant file numbers (up to six) followed by 'O' to produce the computed calculation and graphical plot. Remember to use at least three files for a valid result. Care must be taken to ensure that all files used are taken from the same leak site and that one sensor remained on the same fitting for all selected runs.

SCREEN 13 displays the entered and calculated file results and provides graph plot with the run numbers appended. You can select the correlation results you wish to review on the graph screen by using the ▲ ▼ keys to place the hi-light cursor on the relevant run. Then press "ZOOM" to include or exclude the result in the final calculation.

Any XY plots which are 'off-the-line' can be excluded from the computed results with the "ZOOM" key or erased from memory by pressing CLEAR when the hi-light cursor is on the relevant run number.

The final Computed Result is shown on the right-hand side of SCREEN 13. This gives the leak distance from the reference sensor and the velocity in metres per millisecond.

Press MENU to quit and exit the program.

AUTOCORRELATION

This program allows correlation to be carried out on a length of pipe where access to a fitting is only possible at one position, and the suspected leak position lies between this fitting and a stub end or closed valve.

RUNNING THE PROGRAM

The program is called by selecting 15 "ENTER" from the main menu. This displays the signal source and sensor type SCREEN 26 asking for selections to be made for the blue channel only, as the red channel is not used in this mode. Make the selections as usual and progress through Screens 4 to 9 by entering the necessary data in response to the on screen prompts.

The distance entered will be that measured from the accessible fitting to the stub end.

Use the 'HELP' button to explain the operation of this function, if required.

CUSTOM PIPE CHOICE

This program enables you to create your own selection of pre-programmed pipe materials with a velocity value and default filters for each entry. This user pipe menu is accessed by selecting custom pipe menu at the pipe material selection, key 15 in Screen 4.

To program an entry, or change an earlier entry you have made, key 10, ENTER from the main menu. The custom pipe menu screen is displayed showing entries already programmed.

Key in the number of the entry you wish to store (or change). Note that entry 01 is not available, as this is reserved for exiting to the standard pipe menu. Press ENTER to move on to screen 23. This enables you to spell out the title of your entry, either by using the cursor controls to select the letters/numbers of the title with the moving arrow or by using the optional keyboard to spell out the entry. To correct a mistake, use the ▼ key to select DELETE, which allows you to delete the last character(s) entered. Once complete, select END.

You are then prompted to enter the velocity you wish to enter. If you have previously measured the velocity, or used VELOCITY CALCULATION to calculate the velocity for your entry, this value is displayed. Press ENTER to accept this value. Alternatively, you can enter a different value to any displayed by keying CLEAR, then your required velocity value. For a value of 1.254 metres per millisecond (or 1254 metres per second) key 1, ., 2,5,4 then ENTER.

You will now be prompted to enter the filter values you want your entry to use as defaults (SCREEN 24). Select the values in the same way as described before and press ENTER. The help screen will show some typical settings for different pipe types.

Your entry is now complete, and can be used as any other pipe selection, although different diameters must be entered as separate menu options.

Note: Your entries can be removed by writing a new entry over top of the old one, or by performing a RAM CLEAR in self test, **which will erase ALL entries and defaults programmed by the user**. You are, however, prompted before RAM is cleared to avoid accidental erasure.

VELOCITY CALCULATION

All velocity calculations with MicroCorr® are conducted in metric units. To assist operators who only have imperial data a Table of useful metric/imperial equivalents are printed in the Appendix section of this Manual.

The program is run by keying 11 ENTER from the Main Menu. This displays SCREEN 29 and asks you to select the type of liquid carried by the pipe. Call HELP for advice in the program. Use the ▲ key to step-back to the previous screen if required.

LIQUID OPTIONS

If the liquid is listed in options 1 to 7 key the appropriate number and press ENTER. This will display SCREEN 4 and you then select the pipe material.

If the liquid is not listed, select 'Other' liquids by keying 8 ENTER. Then key-in the Bulk Modulus of Elasticity and Relative Density data as requested. (Note *).

Press ENTER again to select the pipe material.

MATERIAL OPTIONS

If the material is listed in options 01 to 12 on SCREEN 4 just key-in your choice and press ENTER to display SCREEN 28. Then enter the pipe outside diameter and the wall thickness in millimetres.

Press ENTER again and MicroCorr® will display SCREEN 29. This shows the information you have entered and gives the calculated velocity of sound.

If the pipe material is not listed on SCREEN 4 then key 14 ENTER for Unknown/Other materials. MicroCorr® will ask you to enter the Modulus of Elasticity for the pipe material. (Note *)

Enter this data and press ENTER to display SCREEN 28. Then enter the pipe outside diameter and wall thickness as you did above. Press ENTER to calculate the velocity.

Note *: These data will be found in engineering reference books for your specific industry or application.

STORE UNDER CUSTOM PIPE CHOICE

Option 1 on SCREEN 29 is Store Under Custom Pipe Choice. Selecting this option saves the calculated value and proceeds to the CUSTOM PIPE MENU programming utility described in section 16.0.

STORE FOR PRINTOUT

Option 2 on SCREEN 29 is Store For Printout. Just press 2 to store the data for later output to the printer and then press ENTER to return to the Main Menu.

PRINTER

The thermal printer supplied with MicroCorr® is a compact, fully portable unit which operates from internal, rechargeable nickel cadmium batteries. A 115 or 240V AC Power - Charger Unit is also supplied.

The printer is equipped with an RS 232C serial type interface and may be used for an immediate (or later) print-out. Two rolls of thermal paper are provided with each unit and spare rolls are available from Palmer Environmental Services Ltd. or your local MicroCorr® distributor.

Full details for loading paper, and for operating the printer direct from mains or batteries are given in the Printer Operating Manual supplied with each printer and reproduced in Appendix 3.0 of this Manual.

PRINTER CONNECTION

Check that the AC voltage on the printer's Power - Charger Pack matches your mains supply. Charge the batteries fully on delivery as described in Appendix 3.0.

Connect the printer to MicroCorr® with the RS 232C plug lead provided.

Switch-on the printer and confirm that the power LED is glowing. Then switch-off the printer.

On the DIP switch settings at the rear of the printer, switches 6 & 7 must be ON, i.e. down, and the rest OFF. Set these before turning the printer on.

PRINTER SELF-TEST

Check the paper roll is installed correctly and then hold down the paper-feed button while you switch-on the printer again. This sequence will initiate the Printer Self Test program which directs the unit to print the entire character set.

PRINT MODE

The print option is called from the Main Menu by keying 02 ENTER which calls up SCREEN 18. This shows the 7 options listed below. To run options 1-5 the printer must be switched-on if connected. However to examine stored information on screen the same menu selections can be used without the printer connected. If you do this the data will be displayed on the screen for a short while before SCREEN 18 is redisplayed.

1. Print List
2. Print File Number
3. Print Site Number
4. Print All Of Date
5. Print All Files
6. Download To Computer
7. Examine All Files

Key in the program action you require and press ENTER. Press MENU to escape from the program.

A message advising that a service/calibration is due, may be printed at the end of a printout.

The MicroCorr® equipment should be returned to Palmer Environmental Services or one of its appointed distributors at your earliest convenience for this to be carried out.

OPTION 1: PRINT LIST

This option gives a listing of files stored in MicroCorr's memory. The files are printed in numerical order and show the date and time saved and if stored the site or map reference.

Each file has a prefix to show what type of file it is:

L leak position

V velocity measurement

S survey

C computed compilation (leak position files only, see section 14.0)

VC velocity calculation

D distance measurement

F frequency spectrum

OPTION 2: PRINT FILE NUMBER

To examine a particular file from the Print List, Key-in that file number and press ENTER.

OPTION 3: PRINT SITE NUMBER

Selecting option 3 prints all files with the selected site number references. The list starts with the earliest file number.

OPTION 4: PRINT ALL OF DATE

This option allows you to print all the files that were stored on a particular date. Key-in the Day-Month-Year using zero's if necessary to give a six figure date code. For example, the 6th of September 1993 would be keyed in as 06 09 93.

OPTION 5: PRINT ALL FILES

This option allows you to print all of the files stored regardless of file or site number.

OPTION 6: DOWNLOAD TO COMPUTER

This option enables you to transfer the stored results rapidly to a PC style computer. The computer must be running suitable support software available from Palmer Environmental Services Ltd., or it's authorised distributors.

When the program is run it sets the RS 232C output port parameters to 9600 Baud - No Parity - 8 Data Bits - 2 Stop Bits.

OPTION 7: EXAMINE ALL FILES

This program recalls to the screen all of the stored files sequentially, commencing with the first (oldest) file in memory and displays the file contents. Other options then enable you to:

1. Print out the file
2. Move on to examine the next file in memory
3. Erase the particular file from memory
4. Re-activate the cursor controls

Re-activating the cursor controls allows you to position the cursor to other points of interest on the display. You can also save any new time delay and leak position measurements as a separate new file without losing the original correlation results, particularly useful with another peak, or incorrectly positioned cursor.

MEMORY ERASE

The Memory Erase program is called from the Main Menu by keying 12 ENTER which calls up SCREEN 30.

NOTE THE WARNING ABOUT ERASING ALL PRINT FILES

Key 0 if you wish to exit the program and return to Main Menu.

Key 1 and **ALL STORED RESULTS** will be erased from the MicroCorr® memory. NOTE: Custom pipe entries and user defaults will be unaffected.

SECTION 20.0

SELF TEST

MicroCorr® has a number of inbuilt Self Test programs which allow you to test and evaluate possible causes of failure of the correlator unit.
These Self Test programs are divided into two parts. Part one is executed automatically to test MicroCorr's program content and to warn you if the internal battery voltage is low.
Part two of the self diagnostic program is initiated by calling up Self Test from the Main Menu.

TEST PROGRAMS INDEX

The system's power supply and microprocessor are not included in the Self Test routines as they are needed to run the programs.

A failure of the power supply components will stop MicroCorr® powering-up correctly. Spurious displays on the screen or incorrect key operation indicates a defect in the microprocessor. In either event, please contact Palmer Environmental Services or your local MicroCorr® distributor.

TEST 1: PROGRAM AND LIQUID CRYSTAL DISPLAY

At switch-on the contents of the memory holding the programs are automatically checked. If they are correct, MicroCorr® confirms this status by calling up the "SET UP" screen. The contrast control should be adjusted for optimum clarity.

If the program memory is corrupted a warning message will be displayed on the screen.

TEST 2: BATTERY VOLTAGE

The Set Up screen incorporates a bar graph indicating the amount of battery charge remaining. A warning message will be displayed on MicroCorr's screen if the battery voltage is too low. When this occurs the battery should be recharged or exchanged immediately.

Only approximately 30 minutes battery power remains after the warning message is first displayed. When the battery is recharged to the correct level the warning message is switched off.

TEST 3: MEMORY FUNCTION

This is the first of the Self Test programs and is called from the Main Menu by keying 09 ENTER. This tests the memory and displays a pass or fail message (SCREEN 31). Press ENTER to continue or press FIX to test the DSP/AFS card.

Alternatively, to clear ALL machine contents including custom pipe menu etc. Press 1-2-3-4 in order. This displays the WARNING that this test erases all memory contents, and would normally be used only when any equipment is returned for repair/service.

Key 0 if stored information is required for later analysis. If you do key 1 to test the memory it should display 32768 which is the correct value. All memory contents, including the custom pipe menu, are now erased, and MicroCorr® settings are returned to the factory defaults. The service/calibration due date or the date/time ARE NOT reset by this procedure.

TEST 4: KEY OPERATION

This program verifies correct operation of the front panel keys and follows on directly from Test 3. Press the keys in any order and the particular key function will be displayed on the screen.

The ON/OFF and Headphone switching keys are not tested. Press MENU then CLEAR to end the test. This will take you to the printer test program below. If you wish to exit the program now press MENU.

TEST 5: PRINTER

This test follows on from Test 4. The printer must be connected and switched-on for this program to run correctly.

The MicroCorr® will now print the full character set.

If an error is noted, refer to the Printer Manual and carry out the printer self-test procedures. This will establish if the fault is in the printer itself, or in MicroCorr® or the connecting cable.

Note: If the printer is connected but not switched-on you cannot progress to the next Self Test program. To exit the program, either switch-on the printer, or unplug the lead to MicroCorr®.

TEST 6: VIDEO MONITOR (COLOUR BAR TEST)

This program tests the video monitor and the connecting cable.

With MicroCorr® connected to the specially adapted double RGB extension monitor (which is available as optional equipment) a 16 colour bar pattern will be displayed on the TV screen.

Press ENTER to exit the program and move to the next test.

TEST 7: CORRELATION CIRCUIT

This test displays a double correlation block which drifts from right to left. An example of this display is shown in SCREEN 36. This extensive test program runs for approximately 45 minutes but you can proceed to Test 8 at any time by pressing ENTER.

Initially, the full correlation range is displayed and a correlation peak will form. This display is then divided into 8 equal blocks (or windows) and each block is a Zoomed portion of the complete range.

The double correlation drifts across each of the blocks until it reaches the left-hand side of the graphic area. Then the next block is displayed.

Examine these blocks to ensure that all correlation columns are used and that all the blocks are symmetrical. Any column displayed as a permanent blank indicates a failure in correlation memory location.

The block number from 0 to 8 is shown on the left side of the screen. Press ENTER to quit this test and move to the next program.

TEST 8: SIGNAL CONDITIONING CIRCUIT

This program tests the filter and signal input circuitry. Two peaks are displayed each centered on a cursor and High and Low filter settings are shown on the left side of the screen.

The test commences with High set to '04' and Low set to '17'. Press ENTER and the filters will increment in a pre-set order. First, the High filter setting remains fixed and the Low filter is incremented through six settings up to '11'.

Then, the Low filter moves two steps to '15' and the High filter starts off from a lower value of '07' and steps through six settings to '01'. During this stage both peaks should be symmetrical and centered on the cursors.

As the High filter setting is increased the shape of the peaks become generally sharper. These changes are difficult to observe precisely, but all you need to do is to confirm that the peaks actually change shape as the High filters change.

As the Low filter setting increases, the width of the peaks will become narrower. Once again, if the peaks change shape as the filters change, the test is positive. No peak should occur exactly central between the cursor positions.

At the conclusion of the signal conditioning tests, the Spectrum analysis diagnostic tests followed by the notch filter tests are performed. Progress through these tests by pressing 'ENTER'.

The spectrum is analyzed for each of three test frequencies, and the level and accuracy of the test signal is displayed, with results for both channels taken simultaneously. The same tests are then performed with the notch filter operating at these frequencies, to check for notch filter operation by the filtering out of these frequencies and a lack of the previously noted peaks.

When all the tests are complete MicroCorr® returns to the initial setup screen.

DSP CARD TEST

The DSP card test offers 5 separate tests for the FFT/AMS card, if any of these tests fail then the unit should be returned to the manufacturer for service.

A P P E N D I C E S

APPENDIX 1.0

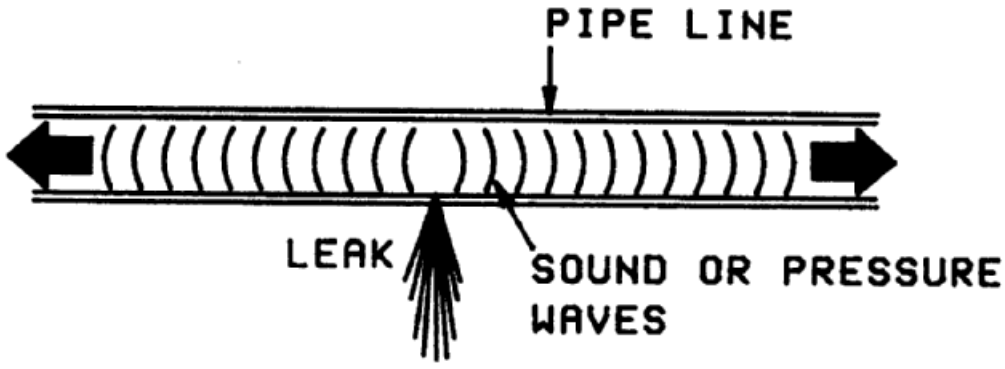
THE BASIC PRINCIPLES

This Appendix section of the MicroCorr® Operating Manual provides an overview of the basic theory and principles of leak location using noise correlation techniques.

LEAK NOISE

When a liquid under pressure escapes from a pipeline it creates a sound pressure wave (leak noise) which travels along the pipe from the exit point. The velocity at which the sound travels within the pipe depends mainly on the pipe diameter and material.

Diagram 1

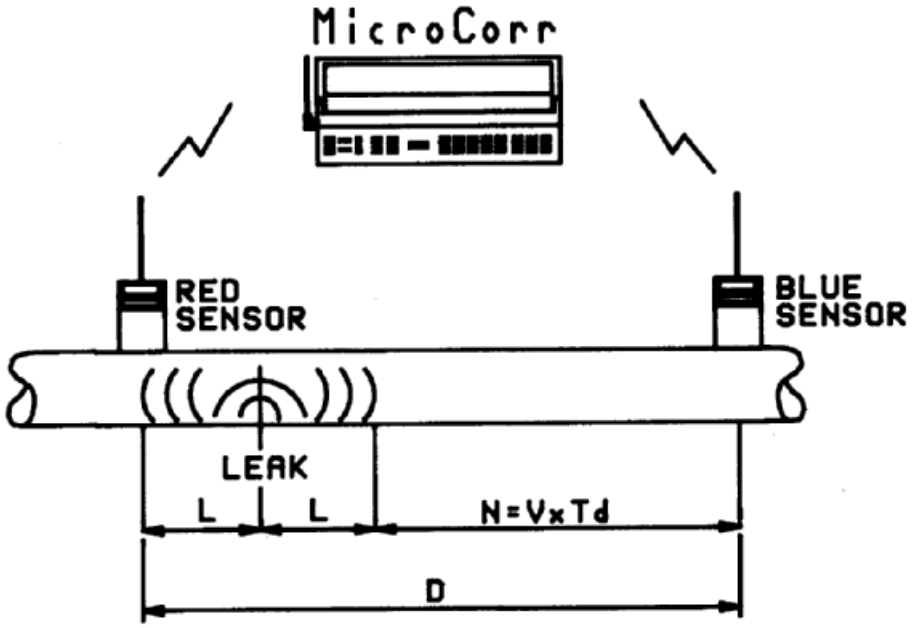


The MicroCorr® system detects these leak noise sound signals with two sensors which are attached to the pipe on either side of the leak point. The sensors can be attached to pipe valves, hydrants or stop taps etc.

TIME-DIFFERENCE

Diagram 2 shows the Red and Blue colour-coded sensors which are attached to the pipe on either side of the leak. The sensors detect the sound wave signals and transmit this information to MicroCorr® by radio or by cable links.

In our illustration the leak is situated at L distance from the Red sensor. MicroCorr® determines L by measuring the time for the sound wave to reach each sensor.
Diagram 2



If the leak was exactly between the two sensors the sound pressure wave would reach each sensor at precisely the same time. In this theoretical situation we should say there was zero time- difference between the two signals.

Diagram 2 shows the leak closer to the Red sensor so the sound wave reaches this sensor first and MicroCorr® measures the exact travel-time. At that precise moment, of course, the sound wave has also traveled L distance towards the Blue sensor.

MicroCorr® now determines the time for the sound wave to travel the extra distance N to reach the Blue sensor. This extra travel time creates a time-difference between the signals arriving at the Red and Blue sensors. The time-difference is referred to as Td.

VELOCITY-TIME-DISTANCE

As the velocity of sound V for various liquids and pipe systems is known we can now determine distance by applying the formula: Distance = Velocity x Time (D = V x T). As we are interested in the time-difference between sensor signals our formula becomes D = V x Td.

Distance N is determined simply from N = V x Td. The total distance between the Red and Blue sensors is given by:

$$D = 2L + (V \times Td)$$

As we wish to find L, which is the distance between the Red sensor and the leak point, we rearrange the equation to:

$$L = \frac{D - (V \times Td)}{2}$$

So we can measure the distance between the sensors D and estimate the velocity V from our knowledge of the pipe size and material. We then measure the time-difference Td between the sound waves reaching each sensor and apply all these data to calculate L which gives us the actual leak location.

In practice, MicroCorr® performs all of the time measurements and calculations for you.

In diagram 2 the leak point was shown nearer to the Red sensor. In fact, it doesn't actually matter if the leak point is nearer the Blue sensor as MicroCorr® automatically deals with either situation.

SENSOR BRACKETS

In order to locate leaks precisely the two sensors must 'bracket' the leak point. This means that the leak should be between the Red and Blue sensors.

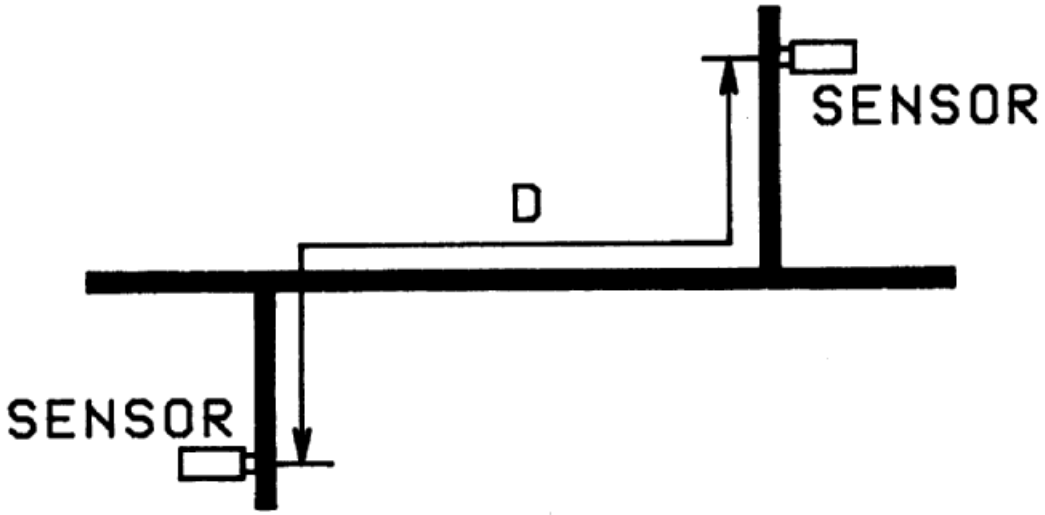
If the sensors are incorrectly positioned MicroCorr® will detect the 'non-bracket' condition and warn you by displaying a message on the screen. MicroCorr® will also indicate which sensor is nearest to the leak so you know which one to move.

If the leak is shown fairly near to one sensor it is good operating practice to treat this as a non-bracket condition. In these instances you should move the near sensor away from the indicated leak position and re-correlate.

'T' CONNECTIONS

The distance D which you have to key-in to MicroCorr® refers to the total length of pipe between the sensors. If the sensors are attached to T connections then the length of the T network must be included in D.

Diagram 3



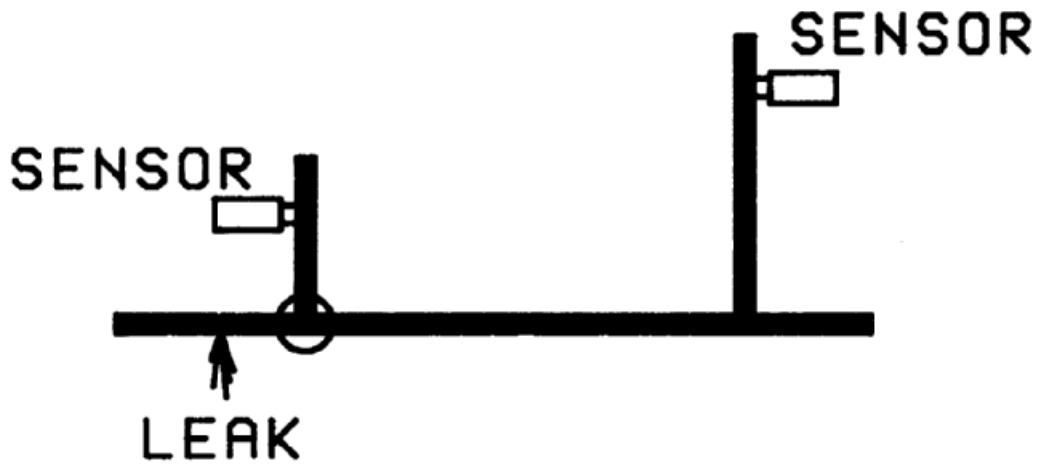
Sensors Connected to Fittings on T Connections

Care is required when interpreting the results from T connection surveys. The following illustrations demonstrate predicted results for various pipe-work layouts and shows recommended actions.

Diagram 4

Leak indicated correctly.

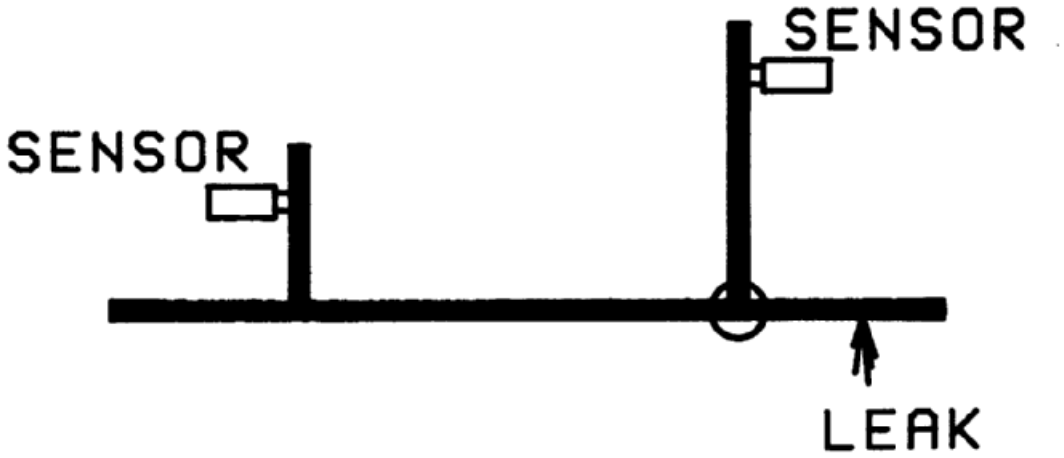
Diagram 5



The Leak will be indicated at the left T connection 'O'.

Action: Move the left hand sensor further to the left and try again.

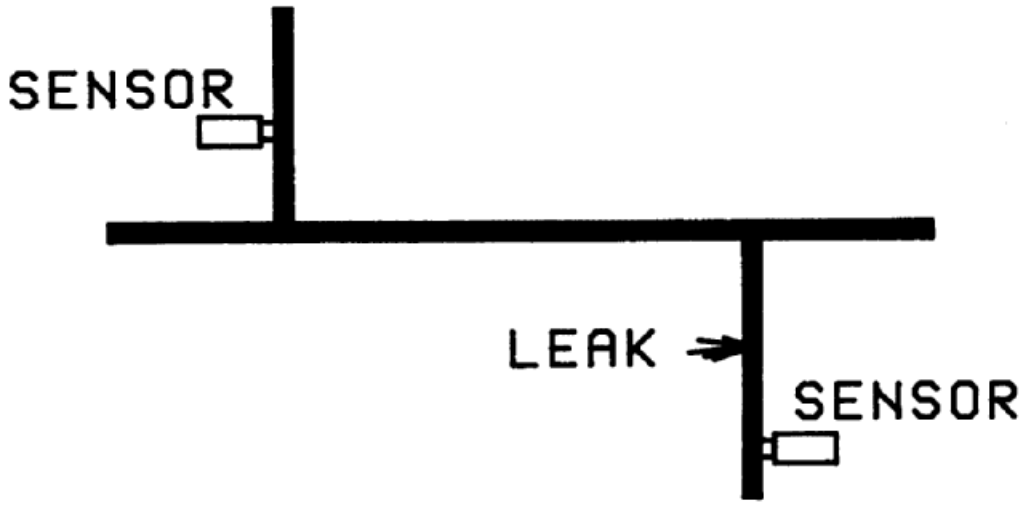
Diagram 6



The leak will be indicated at the right hand T connection 'O'.

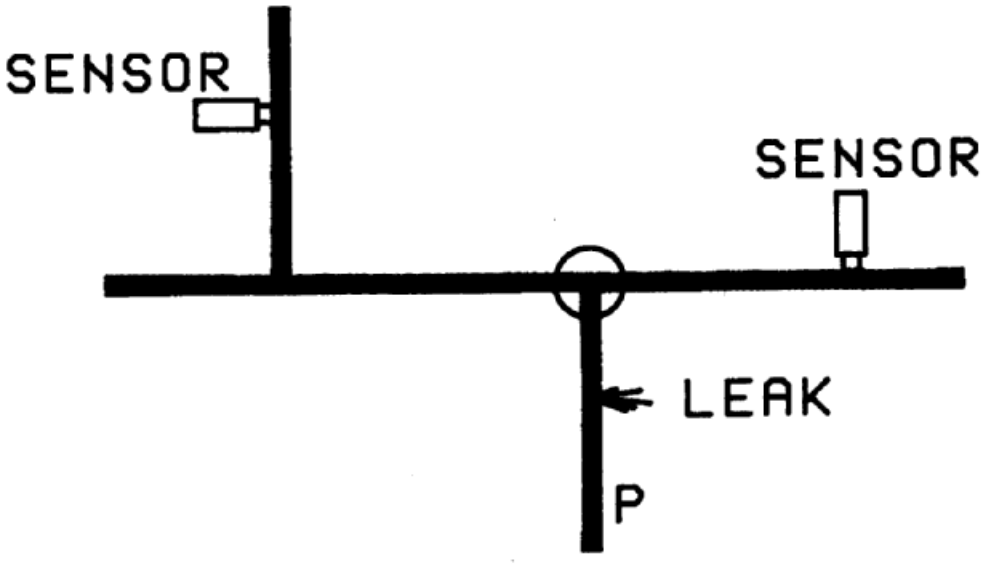
Action: Move the right hand sensor further to the right and try again.

Diagram 7



Leak indicated correctly

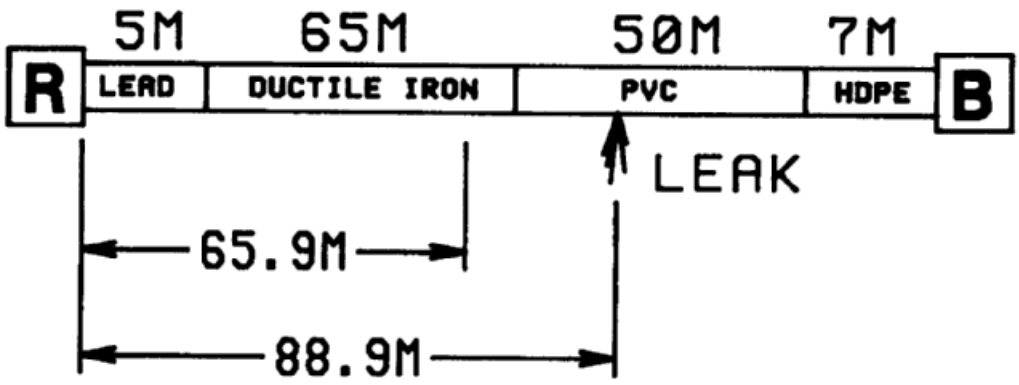
Diagram 8



Leak indicated at T connection.

Action: Move either sensor to a fitting down the T connection (P) and try again.

Diagram 9



The speed or velocity at which leak noise travels is greatly dependent on pipe material.

Different pipe materials give different velocities.

To locate a leak in a pipe run made up of mixed materials, the velocities applicable to each material must be used. This is not the same as using an average velocity.

Using an average velocity a leak was indicated at 65.9 metres from the red (R) sensor.

In fact, MicroCorr® 6 in Mixed Pipe Material Mode under identical conditions calculated the true leak position at 88.9 metres from the red (R) sensor.

COMPUTE MODE THEORY

Compute Mode is a special MicroCorr® operating feature which can improve the overall accuracy of correlation surveys.

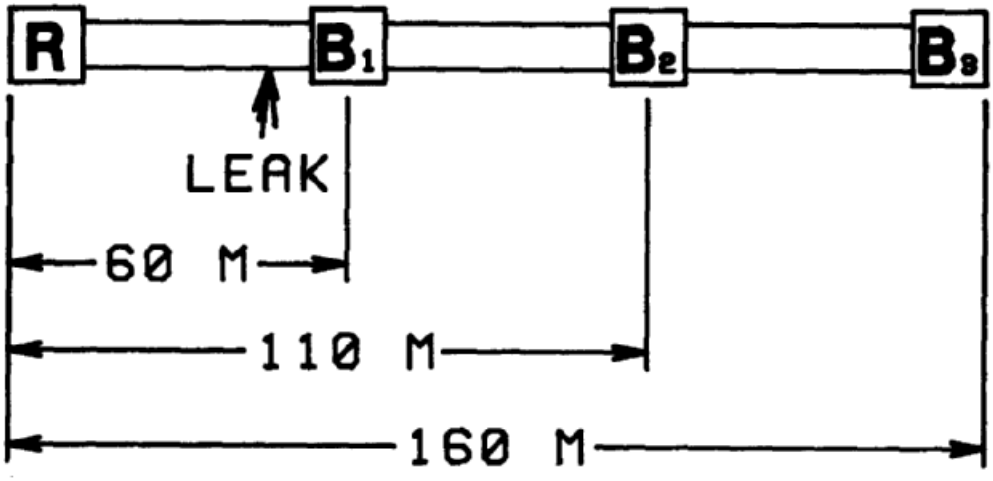
In Compute Mode the data from two or more correlation runs are combined to produce a result which is totally independent on the velocity of sound V. The effects of any error in the measurement of the distance D between sensors is also significantly reduced. In practice at least three results are needed.

MicroCorr® takes the basic equation $D = 2L + (V \times Td)$ and solves the equation for two or more values of D and Td.

The additional values for D and Td are obtained by keeping (in this example) the Red sensor on one fitting while the Blue sensor is moved from fitting to fitting (B1, B2, B3). In practice either sensor can be selected to remain fixed as the reference sensor. The sensors must bracket the leak for the Compute Mode runs to be valid.

The new values of D and Td generate a very accurate figure for V which is then used to calculate the leak position from the fixed sensor.

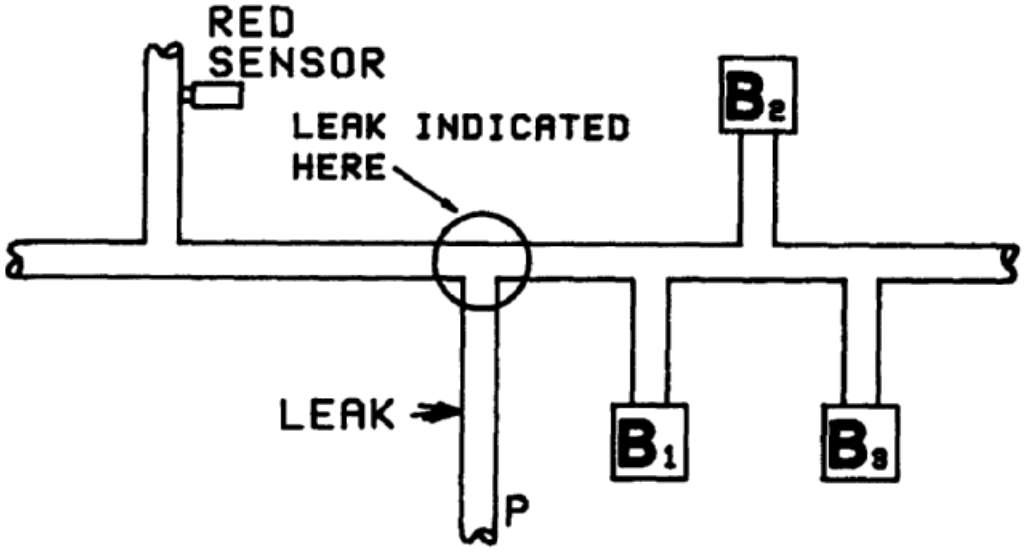
Diagram 10



Distance from the Red

Indicated leak position R - B1 : 52.8M)
R - B2 : 48.4M) Average position 47.8M
R - B3 : 42.4M)Computed position 49.0M

Particular care should be taken when using Compute Mode with T connection pipe-work. If a leak is indicated near to a T connection it is quite possible that the leak is actually down the T as shown below.
Diagram 11



If this situation occurs the Red sensor should be moved to a fitting down the T connection (P) and a complete re-run in Compute Mode should be carried out.

APPENDIX 2.0

CONTROLS AND CONNECTIONS

DIAGRAM 1

THE SYSTEM

1. MICROCORR CENTRAL UNIT
2. 1 RADIO TRANSMITTER (RED)
3. ACCLEROMETER SENSORS WITH SHROUDS
4. 1 POWER SUPPLY/BATTERY CHARGER
5. 1 SET OF HEADPHONES

OPTIONAL ACCESORIES

6. SECOND RADIO TRANSMITTER (BLUE)
7. 2 HYDROPHONE SENSORS AND ADAPTORS
8. PRINTER AND CHARGER
9. GROUND MICROPHONE
10. 1 CABLE DRUM
11. COLOUR MONITOR
12. VEHICLE MOUNT AERIALS
13. WOODEN INSTRUMENT BOX (NOT ILLUSTRATED)
14. MEASURING WHEEL (NOT ILLUSTRATED)
15. TRANSPORT CASES (NOT ILLUSTRATED)
16. TAPE RECORDER (NOT ILLUSTATED)

COLOUR MONITOR ONLY APPLIES TO MICROCORR SUPER SYSTEMS

APPENDIX 3.0

THERMAL PRINTER - NOTES ON USE

Please observe the following precautions, to keep your printer in optimum condition.

1. If any problems should occur during operation, turn the power off immediately and contact your distributor.
2. Avoid operating or storing the printer in damp places,
3. or when exposed to excessively high or low temperatures.
4. Avoid exposing the printer to direct sunlight.
5. Do not operate the printer near heaters.
6. Avoid operating or storing the printer in dusty places.
7. Do not expose the printer to excessive vibration.
8. Install the printer on a level surface.

POWER SUPPLY

The printer power supply consists of a built-in NiCad battery pack. The NiCad battery pack should be handled correctly, as described below.

Please recharge the pack with the AC adapter supplied before using the printer.

Ensure that the adapter matches the mains supply voltage.

Charging procedures

Turn off the printer's POWER switch. Plug the AC adapter into an AC outlet and connect the cable to the printer. The battery pack takes 6 to 7 hours to become fully recharged.

NOTES:

- Make sure you turn off the POWER switch before charging the battery pack.
- Do not charge the pack longer than 24 hours, or the batteries may deteriorate.
- The room temperature should be between 5 to 40◦C during charging.
- Do not leave the printer with the POWER switch on for long periods since this discharges the pack, resulting in deterioration of the batteries.
- The printer can be used immediately after the AC adapter is connected. However, if the battery pack is not fully charged, printing may stop if high duty printing is performed.

INTERFACE CABLE CONNECTION

Observe the following precautions when connecting the printer to MicroCorr®.

The MicroCorr® power switch should be off.
The printer power switch must be off.
Use the correct interface cable supplied.
Ensure all connectors are inserted correctly.

PAPER LOADING

The printer uses Epson thermal roll paper (P40REP) or equivalent. A red mark printed on the paper appears when only 30cm of paper remains. Load a new roll when this mark is visible.

Paper Loading Procedures

1) To remove the printer top cover, lift the rear of the cover by pressing the positions marked '▲'.

2) Turn on the printer POWER switch.

3) Cut the leading edge of the paper so that it is parallel to the roll shaft.

4) Align the paper so it is straight when you insert it into the paper inlet. Do not insert paper with the wrong surface facing up.

5) Press the PF switch to feed the paper until the leading edge of the paper passes the paper cutter.

6) Replace the printer cover so that paper exits through the slit.

Notes on handling paper

Make sure you use the specified paper (Epson thermal roll paper R40TRP) (Palmer Environmental Part No. PTR002). Observe the following precautions when storing paper rolls.

1) Do not store paper rolls in places subject to high temperature or humidity.
2) Do not store paper rolls in places exposed to direct sunlight.
3) Observe the following precautions when handling printed paper.
4) Do not use pastes containing organic solvents such as alcohol, esters or ketones.
5) Do not allow the paper to come in contact with vinyl chloride.
6) Do not allow printed paper to come in contact with diazo copy paper which has just been processed.

REAR SWITCH SETTINGS

These 8 D.I.P. switches do not normally require adjustment. However they should be checked for correct settings if maladjustment is suspected. The correct settings for MicroCorr® operation are 6 and 7 ON and other switches OFF. This selects odd parity, 8 bits, 2400 baud rate.

SELF-TEST FUNCTION

The printer is equipped with a self-test function which makes it possible for the user to check the following.

1) Control functions

2) Printer mechanism functions

3) Print quality

Self-test Procedures

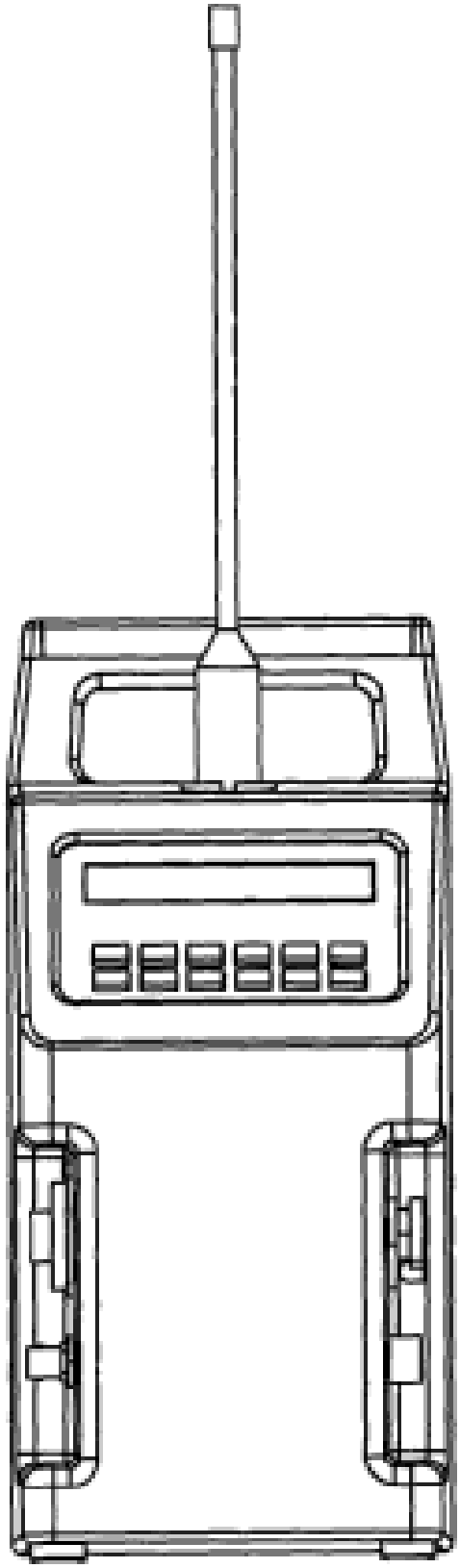
It is not necessary for the printer to be connected to MicroCorr® for this test.

To start the self-test, turn on the power switch while pressing down the PF switch. During the test, ASCII characters are repeatedly printed in the condensed print mode with 2-dot character spacing, and a line spacing of 1/6 inch.

NOTE: Do not perform the self-test without any paper in the printer To stop the test, turn off the power switch.

Successful operation of this test confirms printer performance. Carry out printer test in MicroCorr® self-test routine to check entire system (i.e. MicroCorr®, printer and cable).
Transmitter diagram

Transmitter Diagram



USE OF TRANSMITTERS

The MicroCorr® transmitters are colour coded red and blue for ease of channel identification during operations. They are identical in operation (but with different transmission frequencies - each matched to its appropriate receiver built into MicroCorr®). The transmitter unit contains micro-processor controls, amplifier, filtering and transmitter modules. The various controls and connections are described below and shown in the enclosed front panel drawing.

DO NOT operate the transmitters in "Tx HI" or "Tx LO" positions with the aerial disconnected, as the transmitters may be damaged.

The cover for the line/charge socket should be screwed in place at all times when the socket is not being used to avoid ingress of water or dirt.

An accelerometer carrying hook is provided on the side of the transmitter and a magnet for keeper retention on the back of the transmitter.

KEYBOARD

The twelve operating keys control the following transmitter functions:

"1-0" Pressing this on/off key switches on the microprocessor, amplifier and filter modules.

The first screen display confirms the current software version installed. This information will be useful in the unlikely event of any faults developing.

The LCD display visibility can be adjusted using the contrast control knob located in the inset rear panel. Every time the transmitter is switched on the microprocessor selects "LINE" and "AUTO" gain options. Alternative options must be selected manually.

A bar graph indicates the signal level being measured by the sensor device connected to the sensor input socket. The signal level is also displayed in digital form as a voltage value (in millivolts).

Either passive or active sensors may be used. The transmitter will automatically sense which type of sensor is connected and select the appropriate internal amplifier. If an active sensor is used, "Active Sensor" will be displayed for a short while after the sensor is initially connected.

On disconnecting the active sensor, the "Passive Sensor" message is displayed. This confirms that the correct internal circuits have been selected.

"TEST" Pressing "TEST" will display the remaining charge in the battery - as a bar graph - at any time during operation, with one block on the graph representing approximately 5% of the total charge.

NOTE: The battery charge remaining is approximate and varies between batteries and conditions of use.

The battery normally supplies sufficient power for approximately 7.5 hours continuous use, this would be reduced to 6.5 hours if the flashing safety warning lights were in continuous use.

The sealed battery is interchangeable with the battery used in MicroCorr® 5, and is removed from the transmitter by releasing the two screws retaining the cover plate on the base of the unit then gently pulling on the battery ejection ribbon. The battery will only operate if correctly inserted with its contacts in the correct position. Excessive force should not be used to push it fully home as damage could occur if the battery is not correctly aligned.

The "TEST" key will also give an indication that radio frequency power is being radiated when on "TX HI" or "TX LO".

"MAN" Pressing "MAN" will select the manual gain option. This allows control of the signal level using the ▲ ▼ keys and displays the level of gain set by the operator as a percentage of the maximum available. Pressing "MAN" again reverts to fully automatic operation.

Manual gain sets the level of gain, which then remains constant irrespective of external factors including increase or decrease in signal from the sensor. The level should be set to the highest level without causing the bar-graph to go "off the scale".

Manual gain control should be selected when using the "listening" facility to evaluate difficult site conditions but normally "AUTO" gain should be selected when in "LINE", "TX LO" or "TX HI" modes. Only trained and experienced users should operate in these modes using manual gain.

NOTE: The bar graph and digital signal level displays will take a few moments to settle and stabilise after switching between manual and auto gain modes.

"TX LO" Pressing "TX LO" will transmit the sensor signal to the MicroCorr® unit at low power. This should be used when MicroCorr® is within approximately 30 metres of the transmitter to avoid possible central correlation problems due to radio interference between red and blue channels.

"TX HI" Pressing "TX HI" will transmit the sensor signal to the MicroCorr® unit at high power. This is used for longer range operations, in excess of 30 metres from transmitter to correlator.

"Hz" Pressing "Hz" will display the current filter settings which normally will not require adjustment. The upper display line shows the "Low cut off" and the "High cut off" frequencies selected. All frequencies between these two limits will be amplified while frequencies outside these limits will be discarded.

The lower display line indicates whether the "50Hz Filter" (60Hz in some overseas countries) is in circuit. Normally the 50Hz (60Hz) filter is required to reduce "noise" picked up by the amplifier from mains electricity supply sources. This "hum" can be so great that it may "swamp" any leak noise being picked up. However, under certain circumstances (i.e. in remote locations and/or when the leak noise is predominantly low frequency), it may be an advantage to have this filter set to "OUT".

Pressing "Hz" while the filter settings are displayed steps progressively through the filter range selected to the next option. There are five options which are:

1)	**LOW 0Hz**	**HIGH 5000Hz**	**50Hz FILTER IN**
2)	**LOW 150Hz**	**HIGH 5000Hz**	**50Hz FILTER IN**
3)	**LOW 0Hz**	**HIGH 625Hz**	**50Hz FILTER IN**
4)	**LOW 0Hz**	**HIGH 5000Hz**	**50Hz FILTER OUT**
5)	**LOW 0Hz**	**HIGH 625Hz**	**50Hz FILTER OUT**

The unit always powers up in the default setting (No.1 in the table above).

Exit this routine by pressing "TX LO", "TX HI" or "LINE" as appropriate.

"LINE" Press the "LINE" to operate with cable links instead of radio transmitters. In this mode the micro-processor, amplifier and filter modules are used but the transmitter module is not powered up.

"MEM" Press the "MEM" key to store up to eight separate signal level readings. A new value is stored and displayed every time the "MEM" key is pressed. This allows the operator to position the sensor in the optimum position on a large valve or fitting or to check the relative noise levels on a number of different fittings in the same area. Entering "MEM" mode freezes the amplifier gain at its present level so that all readings taken while in "MEM" mode are comparable.

It is recommended that this facility is used in conjunction with the headphones. Exit this routine by selecting "TX LO", "TX HI" or "LINE" as appropriate.

" ☼ " Press the ☼ key to illuminate the liquid crystal display screen and keyboard to enable operation at night. Press the ☼ key again to turn off the illumination if required, otherwise automatic switch off will take place after approximately 20 seconds.

" △ " Press the △ key to activate the flashing safety warning lamps built into the carrying handle. These give high visibility to the unit for safer working after dark. Press the △ key again to turn off the lights.

SIDE PANEL CONNECTORS

The cable connections are located with the contrast control on either side of the transmitter in recesses to provide some waterproofing protection. The connections comprise:

SENSOR INPUT SOCKET

The Sensor Input Socket is used for connecting either a "Palmer" accelerometer, hydrophone sensor or gas sensor to the transmitter.

HEADPHONE JACK SOCKET

The system headphones are plugged into this socket to enable monitoring of the leak noise before it is transmitted to the correlator unit. The headphone signal level is adjusted by the amplifier gain control, either automatically or manually, as desired.

Line/Charge Socket

This socket serves a triple function.

1) it is used to connect the mains charger unit to the transmitter to charge up the internal battery.

2) it is used for connecting the transmitter unit to MicroCorr® accessory cable drums which would be directly connected to MicroCorr®.

3) It provides an external power supply for use with an optional gas sensor.

RADIO TRANSMISSION MODE

Use the following checklist when operating the transmitters in RADIO mode.

1) Check that there are no restrictions on the use of the radio transmitters in this location. If there are it will be necessary to use "LINE" transmission.

2) Check that the aerial is connected.

3) Connect an accelerometer or hydrophone sensor to the transmitter.

4) Press the "1-0" key to switch on the transmitter and check the battery charge level using the "TEST" key.

5) Select the "TX HI" key for normal operating ranges. However, if the transmitter is closer than approximately 30 metres to MicroCorr® the "TX LO" key must be used to avoid interference between the red and blue channels.

6) The automatic gain control will set the level of signal for optimum results and no adjustment is normally required. Manual override is possible by selecting "MAN" if required.

7) The transmitter is now set for use. Monitor the leak noise signals with the headphones plugged into the transmitter "phones" socket if desired.

8) Plug the headphones into the MicroCorr® phone socket (on MicroCorr® side panel) and select "Radio" link so that you can monitor the noise signals being received from the transmitter.

LINE OPERATION MODE

Where radio transmission cannot be used, the sensor signals can be fed directly from the transmitter unit to MicroCorr® using the hard wire cable drum connections rather than radio signals.

1) Connect an accelerometer or hydrophone sensor to the transmitter input socket.

2) Connect the Cable Drum free plug to the Line/Charge socket.

3) Connect the Cable Drum to MicroCorr® using the drum connecting lead.

4) Press the "1-0" key to switch on the transmitter and check the battery charge level using the "TEST" key.

5) Press the "LINE" key.

6) Continue as with radio transmission mode.

APPENDIX 5.0

USE OF HYDROPHONES

IMPORTANT SAFETY PROCEDURES

Working with water and other fluids under pressure can be hazardous. Recommended safety procedures for the working conditions must be followed at all times, and operational procedures described in this manual should not take precedence over current safe working practices or company procedure. If in doubt, ask your safety officer.

Use of MicroCorr® equipment with the water supply must be subject to the hygiene procedures applicable to any objects coming into contact with drinking water supplies. Hydrophone sensors and adapters should be appropriately sterilised prior to use and applicable procedures should be followed during their installation. Use of MicroCorr® with other liquids or gases should follow national and company safety procedures for operation in proximity with these substances.

DO NOT use your hands for installing the sensors in valve/hydrant chambers or meter boxes without checking for foreign objects. Sharp objects such as disused syringes can easily pierce gloves. If any excavation is required, use suitable tools.

The basic UK hydrophone kit comprises.

1) 2 x Hydrophones
2) 2 x Hydrophone adapters
3) 1 x tommy bar
4) 2 x 1 1/2 inch BSP nipple
5) 2 x 1 1/2 inch to 1/2 inch reducer (fitted with 'O' ring seal)
6) 2 x 1/2 inch BSP nipple
7) 1 x tube silicone grease
8) 1 x reels PTFE tape
9) 1 x carry case

The hydrophones can be connected to fire hydrants using standard London thread adapters. Alternatively, by use of the other adapters provided they can be connected to air valves or flowmeter fittings. Fitting instructions for the hydrophones and adapters are as follows.

The basic UK hydrophone kit is supplied with a range of adapters to suit a variety of fittings. The London round thread adapter (or the meter box adapter - if supplied) is fitted with a sealing washer.

DO NOT seal the threads between the Hydrophone sensor and the London round thread (or meter box) adapter with PTFE tape or any other sealing material, as this could irreversibly lock the threads together.

Connection to Hydrant

1) Remove hydrant cap and gently open hydrant valve to flush out dirt. Close hydrant valve. Inspect the hydrant thread for dirt or debris.

2) To use the LONDON ROUND THREAD adapter with the hydrophone sensor, first lightly coat the internal rubber seal fitted to the lightly round thread adapter with silicone grease. Remove the plastic thread protectors. Do not use any sealing material between the adapter and the hydrophone sensor screw threads, but apply a regular, light coat of silicone grease to lubricate them.

   Fit the London round thread adapter to the hydrophone sensor taking care not to damage or cross the threads. Tighten the adapter until the castellations fitted to the top of the adapter are secured by the quick release mechanism fitted to the hydrophone sensor. The hydrophone may then be fitted to the hydrant and tightened by using a valve key or tommy bar.

3) Connect hydrophone lead after unscrewing waterproof cap.

4) Open hydrant valve fully to allow water into hydrophone. Remove trapped air via the bleed valve. Close bleed valve. A fully open hydrant valve will allow the best transmission of sound to the hydrophone.

5) Ensure hydrophone does not leak from the main thread, tighten as necessary. Ensure that hydrant valve gland is not leaking. If the hydrant frost plug is 'blown' this must be re-inserted to prevent another source of leak noise.

6) Connect lead to input on transmitter.

7) After use ensure the cap is replaced onto the electrical connector, and the plastic thread protector replaced on the hydrophone sensor.

Connection to Air Valves and Flowmeter Fittings

1) Connect nipple and/or reducer to the hydrophone sensor as required. Use PTFE tape on all threads (except the London round thread (or meter box adapter) to hydrophone sensor thread).

2) Screw assembly onto pipe fitting. Open valve and bleed. Check for leaks and tighten as necessary. As in 4 above, a fully open valve will allow best transmission of sound to the hydrophone.

Note: Should the hydrant location be flooded the hydrophone lead should be connected to the hydrophone before it is submerged. The hydrophone sensor connector is only waterproof when connected.

APPENDIX 6.0

ROUTINE CARE AND MAINTENANCE

The following care and maintenance procedures are designed to keep your MicroCorr® system in good general working order. If any part of your MicroCorr® system does not work correctly please contact Palmer Environmental Services Limited or your local MicroCorr® Distributor.

Do not open up any part of the MicroCorr® system as this invalidates any repair warranty in force for your particular operating area. Please be extra careful with items of the system which are connected to mains electricity supplies as the high voltage currents involved can be lethal.

If MicroCorr® equipment which is connected to the mains electricity supplies fails to operate get a qualified electrician to check the power circuits and the cables to the equipment.

An annual calibration should be carried out by Palmer Environmental or their appointed distributor to check operation and tuning of the radio equipment and condition of sensors, cables and equipment generally.

ACCELEROMETERS

The accelerometers supplied with MicroCorr® are sensitive to sudden shock or impact and these sensors should be handled with care at all times. Ensure the connecting sockets are clean and dry and do not clean the sockets with water based solvents.

Check the accelerometers daily before conducting any field operations. Connect one of the accelerometers to a transmitter and monitor the signals on the headphones as you gently stroke the base of the sensor with your fingers.

Then plug in the other accelerometer and repeat the test. If there is a large difference in the signal levels from the accelerometers please contact Palmer Environmental Services Limited or your local MicroCorr® Distributor.

To preserve the strength of the magnets they should always be stored with their 'keeper' plates fitted. Do not place accelerometers near to cassette tapes as the magnets may erase the information recorded on the tapes.

The system can be further checked by placing both sensors together on a desk (or fitting) and correlating whilst "scratching" the surface of the desk or fitting. A rapid centre correlation should be produced.

HYDROPHONES

Before use check that the rubber sealing washer is undamaged and lubricate the washer with silicone grease provided to ensure you obtain a good watertight seal.

Check the washer regularly during use and apply a little silicone grease at frequent intervals during the daily operations. This simple maintenance will ensure good watertight seals and will reduce wear on the seals themselves.

Always chlorinate the hydrophones before contact with the drinking water supply.

CABLES

The sensor cables should be checked regularly for physical damage to the insulation and protective coverings. Use an ohm-meter to test for short circuits and continuity or get a qualified technician to make the tests for you.

BATTERIES

The lead acid batteries fitted to the MicroCorr® 6 and transmitters are interchangeable between units. **Recharge only with the supplied MicroCorr® 6 charger. With the exception of MicroCorr® 5 AND 4 units, previously supplied chargers are NOT suitable.** The chargers supplied for earlier MicroCorr® units with Nickel Cadmium batteries have different wiring connections to prevent accidental charging from the wrong type of charger.

CAUTION

IMPORTANT SAFETY CONSIDERATIONS:

1) **Do not incinerate.**
2) **Do not directly connect the positive and negative terminals.**
3) **Do not use other than the specified battery charger.**

TO PREVENT DETERIORATION OR DAMAGE TO THE BATTERY:

1) **Do not drop or subject to strong physical shock.**
2) **Do not use to power equipment other than MicroCorr® 4 and its transmitter units.**
3) **Do not use below -10◦C (15◦F or above +40◦C (105F). If the temperature exceeds +40◦C a safety device will prevent operation of the battery.**

TO ENSURE LONG BATTERY LIFE:

1) **Do not discharge completely.**
2) **Recharge battery immediately after use.**
3) **Do not invert the battery during recharging.**

IMPORTANT

The sealed lead acid batteries used with MicroCorr® equipment may vent gas if overcharged. If charging a battery containing over 50% charge, the battery access covers should be released, or the battery charged out of the equipment to avoid build-up of explosive concentrations of gas.

It should be noted that regular overcharging will reduce the battery life.

CLEANING

MicroCorr® and its accessories must not be cleaned with any solvent or abrasive type cleaners as these may damage the equipment. **For safety, ensure that all items are disconnected from the mains electricity supplies before you start cleaning.**

MicroCorr® equipment should be cleaned with a soft cloth which has been lightly moistened with water and a mild household detergent. Use only light hand pressure when cleaning all items and be particularly careful when cleaning The MicroCorr® display window to avoid scratching the surface.

All electrical connectors should be cleaned with a 'no deposit' type electrical cleaner.

ENVIRONMENT

MicroCorr® front panel is waterproof but care should be taken to keep water off the unit's connector side panel. To avoid water accumulating on the front panel wipe it regularly with a soft cloth. **Always dry the equipment carefully before storing it away.**

The Liquid Crystal Display used on MicroCorr® and the transmitter unit operates effectively between 0◦ and 50◦ Celsius but you may need to adjust the contrast control for clear viewing as the ambient temperatures changes. At temperatures below 0◦ and above 50◦ Celsius the screen display may become erratic and **extreme temperatures will eventually damage the system.**

Do not leave MicroCorr® behind glass in direct sunlight as temperatures above 50◦ Celsius may be exceeded even in the U.K.

In very hot climates the battery charge capacity may be reduced and you will have to re-charge the units more frequently.

APPENDIX 7.0

SYSTEM FAULT FINDING

This section enables you to check the MicroCorr® system for basic faults and provides quick procedures for maintaining optimum correlating performance. It is assumed that you have access to a good electrical multimeter and, while analogue meters are efficient, you will find that a digital meter is more convenient for the tests described.

Throughout the following section we will use the abbreviation R.T.Q.P. which means Refer To Qualified Personnel at Palmer Environmental Services Limited or at your local MicroCorr® Distributor.

MICROCORR BATTERY CHECK

A warning is given on the MicroCorr® screen if the unit's battery potential falls below 10 volts. If the battery does not appear to be holding its charge you can determine whether the battery is at fault with the following test.

Recharge the system fully for 14 hours as described in Section 4.0 then disconnect MicroCorr® from the Power/Charger Unit and remove the battery compartment cover plate on the left hand side.

Remove the battery by pulling the tab and check with the meter for a voltage reading of at least 12.8 volts across the two contacts at the end of the battery. If this voltage is not present then the battery should be substituted with a new one of the exact type: (LCS-2312APC) and the test repeated.

If the voltage still does not meet the specification then a possible problem may exist in the battery charger or interconnecting lead.

When the test is complete, refit the battery compartment cover plate.

TRANSMITTER BATTERY CHECK

If the transmitter internal battery pack does not appear to hold its charge examine the Battery Test Bar Graph on the front panel of the transmitter. The normal voltage for the transmitter battery pack is 12.8 volts and the unit will automatically switch off to prevent battery damage when the voltage falls below 10.5 volts. Ensure the unit is fully charged for 14 hours before testing the battery voltage.

To measure the battery pack voltage with your multimeter, proceed as in Section A8.1. after removing the cover plate on the bottom of the transmitter unit.

As an approximate guide, one segment of the battery test bar graph represents 30-40 minutes battery life.

If the battery measures 12.8 volts but the transmitter is not functioning correctly R.T.Q.P.

Please note that radio transmitters and MicroCorr's inbuilt receiver should be returned to Palmer Environmental Services Limited or submitted to your local MicroCorr® Distributor for calibration and adjustment at regular intervals.

As a guide, the units should be calibrated at least once every 12 months or more frequently to comply with local radio licensing requirements. To help you comply, a service/calibration message is displayed after a year's service.

CONNECTING CABLES TEST

The interconnecting cables used with MicroCorr® can be tested for continuity and short circuits with the multimeter switched to the resistance ranges. Ensure that all items of equipment to be tested are disconnected from the electrical mains supplies before you start the tests.

To test a cable for continuity disconnect both ends of the cables from the equipment and examine the socket or plug ends of the cable to establish how many conductors are involved. The cable on MicroCorr's Cable Drum, for example, consists of two balanced wire lines encased in an outer screen sheath. The sheath is also a conductor so, in this instance, you would check a total of three conductors.

Switch the multimeter to a low impedance range, for example 100 ohms or less, and touch both meter prods together. If this meter is working correctly this short circuit will be shown as zero ohms on the digital or analogue meter scales.

Now connect the positive meter lead to one end of the cable and the negative lead to the other end of the same conductor. If the lead is continuous the meter will show zero ohms again or a very low resistance reading. Repeat this process with all other suspect leads. If the meter shows that any particular cable is discontinuous try another lead or R.T.Q.P.

To test multi-core cables for short circuits switch the meter to a high impedance range, for example higher than 750K ohms, if available. Short circuit the leads as you did above to check that the meter is working correctly.

For this test you only work at one end of the cables but ensure the other cable end is disconnected from the equipment. Connect the positive meter lead to one conductor end and then touch the negative lead to every other conductor in turn in the socket or plug.

Then move the positive lead to the next conductor and repeat the process until all conductors have been tested. Remember to check the outer screen conductor where appropriate. If the meter shows any indication at all the cable probably has a short circuit and you should try another cable or R.T.Q.P.

ACCELEROMETER TEST

Accelerometers are susceptible to damage if dropped. Failure will usually result in no signal being produced. However, a partially damaged sensor will detect only low frequencies and be quite insensitive. Use the listening mode spectrum option to check the range of frequencies a suspect sensor detects. Failure to detect frequencies over 1-2 kHz indicates a faulty unit.

OVERALL SYSTEM CORRELATION CHECK

This short test series confirms that the correlation function is operating but it does not check the equipment for frequency response and processing integrity etc.

Connect the component parts of the MicroCorr® system together but do not plug in any accelerometer or hydrophone sensors at present. Insert one of the Palmer Leak Noise Calibration tapes into a suitable stereo cassette player and connect the lead supplied into the headphone socket of the player.

Connect the other end of the lead to the sensor input socket in MicroCorr's side panel and one transmitter sensor input socket. Alternatively, the lead may be connected to the sensor input sockets of both transmitters if required. Select the appropriate Red and Blue channel 'Transmitter/Direct' options as for normal operations, and select TX LO on the transmitter(s).

Key-in a distance between sensors of 200 metres and select Cast Iron pipe material. Switch-on the cassette tape player, plug the earphones into the correlator and check you can hear leak noises in both earpieces.

Now examine the correlation display and note the Time Delay (Td) values shown on the screen. These should be similar to the Td figures listed on the tape cassette box but, in practice, slight variations in tape speed may create some discrepancies between the listed and displayed Td values.

You can now also check the zoom function, and by using the last track on the tape cassette which gives a listed Td value of 29.0ms, the velocity measurement facility. Key-in a distance of 38.0 metres and this should display a velocity of 1.35m/ms approximately.

During practical field operations, where leak noise is present, you can quickly check the correlation function in Leak Position Mode by attaching two sensors to the same pipe fitting. This should provide a Td of 0.0ms and show a correlation peak in the centre of the display.

FAULT FINDING

In some cases where MicroCorr® appears faulty, the condition can be "cured" by entering the self test procedure, and at the memory test prompt, select 1-yes. This will totally clear the battery-backed up memory and with it any illicit condition, usually caused by the memory battery discharging, or by an external power supply with high electrical 'noise'.

NOTE: As this procedure erases all stored results, they should be printed-out beforehand if wanted for reference. This will also erase any programmed CUSTOM PIPE MENU information.

WARNING:

There are no user serviceable parts inside MicroCorr® 6 and no attempt should be made to open the case as the internal circuits may be damaged by static discharge.

APPENDIX 8.0

TABLE OF EQUIVALENTS

PRESSURE

1 bar = 100000 Newtons/square metre (N/m²) = 100000 Pascal (Pa)

1 atm = 14.696 psi = 33 feet 10.8 inches head of water = 101325 Pa

LENGTH

1 yard = 3 feet (ft) = 36 inches (in) = 0.9144 metre (m)

1 metre (m) = 1000 millimetres (mm) = 1.09361 yd = 3.28084 ft = 39.3701 in

1 mile = 1760 yards = 1.609344 km

1 kilometre (km) = 1000 metre = 0.621371 mile

1 inch = 25.4 mm

VOLUME

1 cubic metre = 1000 litres = 219.969 imp. gallons = 264.172 US gallons

1 cubic metre = 1.30795 cubic yards = 35.3147 cubic feet

1 imp. gallon = 8 pints = 4.54609 litres

PIPE DIAMETERS

The approximate equivalent metric and imperial sizes are listed. True sizes of pipes vary between manufacturers.

Imperial (in.)	Metric (mm)	Imperial (in.)	Metric (mm)
1/2	12	10	250
3/4	20	12	300
1	25	14	350
1 1/2	40	16	400
2	50	18	450
3	75	24	600
4	100	30	750
6	150	36	900
8	200	48	1200
9	225	72	1800

APPENDIX 9.0

VELOCITY TABLES

The velocity values contained within these tables have been calculated from information supplied by manufacturers of pipes for the water industry, and apply to pipes in good condition.

The user may find that the velocity of sound through pipes decreases as the pipes age, or varies with pipes of the same material but from different manufacturers. As such Palmer Environmental Services Limited cannot be responsible for any inaccuracies in these tables.

Please note that velocities are calculated in metres/second. As MicroCorr® displays velocities as metres/millisecond, then for example 1338 metres per second would be entered as 1.338m/ms.

Polyethylene pipes are particularly prone to variation of velocity between manufacturers, due to different material properties (also varying between manufacturers' batches) and wall thickness. Time in service can have effects on velocity and as a consequence, the accuracy of results is dependent on measuring velocity for a site. Note that the "ageing" effect on the velocity of leak noise does not infer any change in pipe performance for its normal use.

Ductile Iron Pipes V.1

Internal Diameter	Class K9 Wall Size	Velocity	Class K12 Wall Size	Velocity	Class K14 Wall Size	Velocity
80	6.0	1313	7.0	1326	8.1	1338
100	6.1	1291	7.2	1308	8.4	1323
150	6.3	1243	7.8	1272	9.1	1291
200	6.4	1201	8.4	1244	9.8	1265
250	6.8	1171	9.0	1220	10.5	1244
300	7.2	1148	9.6	1201	11.2	1226
350	7.7	1129	10.2	1185	11.9	1211
400	8.1	1113	10.8	1171	12.6	1198
450	8.6	1099	11.4	1159	13.3	1187
500	9.0	1087	12.0	1148	14.0	1177
600	9.9	1067	13.2	1130	15.4	1161
700	10.8	1051	14.4	1116	16.8	1148
800	11.7	1039	15.6	1105	18.2	1137
900	12.6	1028	16.8	1095	19.6	1128
1000	13.5	1019	18.0	1087	21.0	1121
1100	14.4	1012	19.2	1080	22.4	1114
1200	15.3	1005	20.4	1074	23.8	1108
1400	17.1	994	22.8	1064	26.6	1099
1600	18.9	986	25.2	1056	29.4	1092

Cast Iron V.2

Internal Diameter	Class 1 Wall Size	Class 1 Velocity	Class 2 Wall Size	Class 2 Velocity	Class 3 Wall Size	Class 3 Velocity	Class 4 Wall Size	Class 4 Velocity
80	7.2	1273	7.9	1284	8.6	1293	10.0	1308
100	7.5	1250	8.3	1264	9.0	1273	10.5	1291
150	8.3	1205	9.2	1221	10.0	1234	11.7	1255
200	9.2	1173	10.1	1189	11.0	1204	12.8	1228
250	10.0	1146	11.0	1164	12.0	1180	14.0	1207
300	10.8	1125	11.9	1144	13.0	1161	15.2	1190
450	11.7	1109	12.8	1128	14.0	1146	-	-
400	12.5	1095	13.8	1116	15.0	1133	-	-
450	13.3	1082	14.7	1104	16.0	1122	-	-
500	14.2	1074	15.6	1094	17.0	1113	-	-
600	15.8	1056	17.4	1078	19.0	1098	-	-
700	17.5	1044	19.3	1067	21.0	1086	-	-

Steel V.3

Internal Diameter	Wall Size	Velocity	Internal Diameter	Wall Size	Velocity
13	3.3	1395	500	5.0	1014
55	2.9	1307	550	6.3	1048
70	3.2	1292	600	6.3	1027
80	3.2	1271	650	6.3	1007
110	3.6	1252	700	6.3	987
130	3.6	1221	750	6.3	969
160	3.6	1187	800	7.1	984
180	4.0	1181	850	7.1	968
210	4.0	1156	900	7.1	953
240	4.0	1134	1000	7.1	924
260	4.0	1110	1200	8.0	907
320	4.0	1070	1400	8.8	892
350	4.5	1076	1600	10.0	891
400	4.5	1044	1800	11.0	885
450	5.0	1041	2000	12.5	891
			2200	14.2	900

Copper V.4

Internal Diameter	Wall Size	Velocity
4	0.8	1373
6	0.8	1354
8	0.8	1335
10	-	1317
13	1.0	1265
16	1.0	1237
20	1.2	1170
26	1.2	1118
32	1.5	1013
39	1.5	965
50	2.0	819
72	2.0	723
103	2.5	575

Spun Reinforced Concrete V.5

Internal Diameter	Class L Wall Size	Velocity	Class M Wall Size	Velocity	Class H Wall Size	Velocity
150	25	1181	-	-	-	-
225	29	1136	-	-	-	-
300	35	1117	35	1117	-	-
375	44	1125	44	1125	44	1125
450	65	1164	65	1164	65	1164
525	75	1161	75	1161	75	1161
600	54	1068	54	1068	54	1068
675	51	1025	56	1050	56	1050
750	70	1081	70	1081	70	1081
825	63	1031	63	1031	70	1058
900	67	1025	67	1025	80	1065
975	71	1020	71	1020	85	1061
1050	73	1010	80	1026	90	1057
1125	76	999	85	1029	85	1029
1200	83	1007	86	1016	86	1016
1275	76	968	87	1005	92	1020
1350	89	993	100	1024	108	1044
1425	95	995	106	1025	106	1025
1500	95	983	102	1002	108	1017
1575	102	988	114	1019	114	1019
1650	102	977	102	977	121	1023
1725	108	980	121	1011	152	1059
1800	114	984	127	1012	127	1012
1875	114	973	127	1002	133	1015
1950	115	966	133	1005	140	1019
2100	126	972	126	972	126	972
2550	165	992	165	992	165	992

Class 6							
Diameter	700	800	900	1000			
Wall Size	21	24	27	30			
Velocity	735	735	735	735			
Class 10							
Diameter	500	600	700	800	900	1000	
Wall Size	18	21	23	26	27	30	
Velocity	783	776	759	756	735	735	
Class 12							
Diameter	200	250	300	350	400	450	500
Wall Size	10	11	12	13	15	17	22
Velocity	870	836	811	791	794	796	836
Class 15							
Diameter	150	200	-	250	300	350	400
Wall Size	10	11	-	12	14	16	18
Velocity	943	894	-	859	852	846	842
Class 18							
Diameter	125	200	250	300	350	400	450
Wall Size	10	13	14	16	19	22	24
Velocity	988	937	899	886	891	894	886

Class 20							
Diameter	100	125	150	200	-	250	300
Wall Size	10	12	13	16	-	17	20
Velocity	1039	1030	1006	988	-	948	943
Class 24							
Diameter	600	700	800	900	1000		
Wall Size	48	54	62	71	79		
Velocity	988	979	980	984	985		
Class 25							
Diameter	80	100	125	150	200	250	300
Wall Size	10	12	12	15	19	21	25
Velocity	1087	1078	1030	1039	1028	999	997
Class 30							
Diameter	80	100	125	150	200	250	300
Wall Size	11	14	14	17	22	25	30
Velocity	1106	1109	1064	1066	1060	1039	1039
Class 36							
Diameter	80	100	125	150	200	250	300
Wall Size	12	17	18	22	29	30	36
Velocity	1122	1145	1114	1118	1116	1078	1078

Imperial Sizes - Asbestos Cement

V.8

Class A

Size	8"	9"	10"	12"
Diameter	203	228	253	296
Wall Size	14.5	15.5	16.5	19.0
Velocity	960	948	938	934

Class B

Size	4"	6"	8"	9"	10"	12"
Diameter	97	154	203	228	253	296
Wall Size	12.5	11.5	14.5	15.5	16.5	19.0
Velocity	1093	971	960	948	938	934

Class C

Size	3"	4"	6"	8"	9"	10"	12"
Diameter	75	97	154	195	219	243	296
Wall Size	10.5	12.5	11.5	18.5	20.0	21.5	24.5
Velocity	1109	1093	971	1027	1019	1011	996

Class D

Size	3"	4"	6"	8"	9"	10"	12"
Diameter	75	97	147	195	219	243	296
Wall Size	10.5	12.5	16.5	24.5	24.5	26.0	30.0
Velocity	1109	1093	1064	1088	1063	1054	1042

Lead

Internal Diameter	4.5 Bar Wall Size	Velocity	7.5 Bar Wall Size	Velocity	9 Bar Wall Size	Velocity	10.5 Bar Wall Size	Velocity
10	-	-	5.0	1214	-	-	-	-
12	4.8	1187	5.6	1206	-	-	6.7	1226
20	5.3	1125	6.4	1155	8.5	1195	-	-
25	-	-	8.0	1155	10.0	1187	-	-

Lead Silver/Copper Alloy

Internal Diameter	7.5 Bar Wall Size	Velocity	10.5 Bar Wall Size	Velocity
10	-	-	5.0	1214
12	4.8	1187	5.6	1206
20	5.3	1125	8.5	1195
25	8.0	1155	10.0	1187

Internal Diameter	6 Bar Wall Size	Velocity	10 Bar Wall Size	Velocity	16 Bar Wall Size	Velocity	20 Bar Wall Size	Velocity	24 Bar Wall Size	Velocity
25	2.5	1344	2.5	1344	2.5	1344	2.5	1344	-	-
32	2.5	1324	2.5	1324	2.5	1324	2.5	1324	-	-
40	3.5	1334	3.5	1334	3.5	1334	3.5	1334	-	-
50	3.5	1314	3.5	1314	3.5	1314	3.5	1314	-	-
65	3.5	1287	3.5	1287	3.5	1287	3.5	1287	-	-
80	3.5	1262	3.5	1262	3.5	1262	3.5	1262	-	-
100	3.5	1230	3.5	1230	3.5	1230	3.5	1230	-	-
125	4.9	1246	4.9	1246	4.9	1246	4.9	1246	-	-
150	4.9	1219	4.9	1219	4.9	1219	6.0	1249	-	-
200	5.0	1172	6.0	1205	6.0	1205	6.0	1205	7.0	1230
250	6.0	1165	7.0	1193	7.0	1193	7.0	1193	8.0	1215
300	8.0	1184	7.0	1159	8.0	1184	8.0	1184	10.0	1222
350	9.0	1178	9.0	1178	9.0	1178	10.0	1196	11.0	1213
400	10.0	1172	10.0	1172	10.0	1172	11.0	1190	13.0	1218
450	11.0	1168	11.0	1168	11.0	1168	12.0	1184	14.0	1211
500	12.0	1165	12.0	1165	12.0	1165	13.0	1180	15.0	1205
600	14.0	1159	14.0	1159	14.0	1159	15.0	1172	18.0	1205
700	16.0	1155	16.0	1155	15.0	1143	18.0	1178	21.0	1205
800	18.0	1152	18.0	1152	17.0	1141	20.0	1150	24.0	1205
900	21.0	1159	20.0	1150	20.0	1150	22.0	1168	26.0	1198
1000	23.0	1157	22.0	1148	22.0	1148	24.0	1165	29.0	1199
1100	25.0	1154	24.0	1146	24.0	1146	-	-	-	-
1200	27.0	1152	26.0	1145	26.0	1145	-	-	-	-
1300	30.0	1157	29.0	1151	28.0	1144	-	-	-	-
1400	32.0	1155	30.0	1143	30.0	1143	-	-	-	-
1500	34.0	1154	32.0	1142	32.0	1142	-	-	-	-
1600	36.0	1152	34.0	1141	34.0	1141	-	-	-	-
1700	38.0	1151	36.0	1140	36.0	1140	-	-	-	-
1800	40.0	1150	38.0	1140	38.0	1140	-	-	-	-
1900	42.0	1149	40.0	1139	40.0	1139	-	-	-	-
2000	44.0	1148	43.0	1143	42.0	1138	-	-	-	-
2100	46.0	1147	44.0	1138	43.0	1133	-	-	-	-
2200	49.0	1150	47.0	1142	46.0	1138	-	-	-	-
2400	53.0	1149	51.0	1141	50.0	1137	-	-	-	-
2500	55.0	1148	53.0	1140	52.0	1137	-	-	-	-

Polyethylene Pipe Velocity Values

	M.D.P.E. (PE80)		H.D.P.E.		H.P.P.E. (PE100)			
	SDR17.6	SDR11	SDR17.6	SDR11	SDR17.6		SDR11	
DIA.					LOW - HIGH		LOW - HIGH	
16		357		391				
20		315		346				
25		280		307				
32	264	283	290	310				
50	227	280	249	307				
63	226	278	249	305				
90	221	260	243	286	236	274	302	350
110	204	260	224	286	237	276	301	350
125	203	261	223	286	236	275	302	350
160	203	261	224	286	236	275	302	350
180	203	260	223	286	236	274	302	350
200	204	260	224	286	236	275	301	350
225	203	260	224	286	236	275	302	350
250	203	260	223	285	236	275	302	350
280	203	260	223	285	236	275	301	349
315	203	260	224	285	236	275	302	350
355	203	260	223	286	236	274	301	350
400	203	260	223	286	236	274	301	350

WARNING: Polyethylene pipe velocity values vary considerably between manufacturers and can have variations between batches. Polyethylene pipes also vary with age and with conditions in service. A prolonged usage at higher pressures will result in a higher sound velocity. These figures have been calculated from manufacturers data, and apply to new pipe.

FOR MAXIMUM ACCURACY OF RESULTS, YOU SHOULD PERFORM A VELOCITY MEASUREMENT ON SITE!

Vitreous Clay

Internal Diameter	Wall Size	Velocity
100	15	1291
150	8	1266
200	21	1249
225	24	1251
250	28	1258
300	32	1251
375	38	1244
400	40	1243
450	47	1249

Pre-stressed Concrete

Internal Diameter	Wall Size	Velocity
400	60	1164
500	70	1152
600	54	1065
700	60	1055
800	60	1024
900	67	1023
1000	80	1039
1100	80	1333
1200	86	1014
1400	100	1013
1600	110	1004
1800	127	1010

PVC V.13

Internal Diameter	Class B 6 Bar Wall Size	Velocity	Class C 9 Bar Wall Size	Velocity	Class D 12 Bar Wall Size	Velocity	Class E 15 Bar Wall Size	Velocity
10	-	-	-	-	-	-	1.9	718
12.5	-	-	-	-	-	-	2.1	683
19	-	-	-	-	-	-	2.5	668
25	-	-	-	-	-	-	2.7	627
30	-	-	-	-	2.7	565	3.2	610
35	-	-	-	-	3.0	558	3.7	613
50	-	-	3.0	504	3.7	554	4.5	607
60	-	-	3.5	490	4.5	549	5.5	601
75	3.4	446	4.1	487	5.3	548	6.6	600
100	4.0	429	5.2	485	6.8	548	8.3	599
125	4.4	407	6.3	482	8.3	547	10.1	597
150	5.2	404	7.5	480	9.9	545	12.1	596
175	6.0	404	8.7	481	11.4	544	13.9	595
200	6.1	384	8.8	457	11.6	519	14.1	567
225	6.7	382	9.8	457	12.9	519	15.8	569
250	7.5	382	10.9	455	14.3	516	17.5	566
300	8.8	380	12.9	455	17.0	517	20.8	567
350	9.6	378	14.1	454	18.6	516	22.8	566
400	10.9	377	16.2	455	21.1	515	26.0	566
450	12.3	378	18.2	455	23.8	515	-	-
500	13.7	378	20.2	455	-	-	-	-
550	15.0	377	22.1	453	-	-	-	-
600	16.3	377	24.1	453	-	-	-	-