AMETEK®
POWER INSTRUMENTS

P&QR
POWER & QUALITY RECORDER

OPERATION MANUAL

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PURPOSE AND SCOPE

This manual describes the AMETEK Power Instruments P&QR and its accessories. If more data is necessary or special problems occur that are not covered in this manual, refer inquiries to:

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OVERVIEW

The P&QR is a power and quality recorder for monitoring the quality of an electrical supply and energy utilization. It is equally applicable to utility and industrial customers. The voltages and currents on a three-phase feeder or service entrance are recorded either directly or via standard instrumentation transformers.

The quality of supply is monitored by recording both short and long term events on the voltage supply, which may cause problems with, or be generated by the load. Other quality parameters such as harmonic content, imbalance and flicker are recorded continuously. Energy utilization is monitored by recording real power flow continuously and metering apparent, real and reactive power per phase.

There are a number of software applications that compliment the P&QR power & quality recorder. These run under Windows™ and are used to configure the P&QR, recover and analyze the recorded data. All the applications are compatible with other equipment from AMETEK Power Instruments – the TR-100 Fault Recorder, DL8000 Portable Fault and Quality Recorder, and TR2000 Multi-Function Recorder.

Triggered records

When an abnormal event is detected the voltage and current signals are stored in the P&QR's memory for a time starting before the event until after conditions have returned to normal. Waveform data are recorded for a time before and after a signal exceeds or returns from a set limit value. Details of longer events will also be recorded in an RMS file. This can be up to 60 seconds long. The waveform and RMS files may be downloaded to a PC for viewing and analysis.

Loggers

The P&QR is fitted with a large hard drive, which allows both input and computed power and power quality values to be recorded continuously. The input voltages, currents and system frequency are recorded as a maximum, minimum and average RMS value every minute. This log will save data for 16 weeks before it is overwritten.

Harmonic, flicker, imbalance and energy data are also recorded continuously in separate log files. These can be recovered separately or together. The storage interval is 1 or 10 minutes depending on the parameter. These logs give a very complete record of the state of a 3-phase transmission circuit, distribution feeder, factory supply or individual equipment supply.

Power quality monitor

The P&QR records the harmonic profile of voltage and current inputs continuously. This is used to measure trends with time or compare harmonic distortion at different locations. There are a number of applications as part of Display Station, which allow harmonic and other power quality data, such as flicker and imbalance to be viewed.

Voltage dips can be classified by depth and duration to provide a profile of performance. This can be used to compare performance at different sites and show trends with time.

The P&QR has a sensitive THD trigger mode that allows very subtle voltage distortions to be recorded which would otherwise be missed using normal triggering methods. This can indicate evolving faults before they cause a serious problem.

DISPLAY STATION

Display Station is a software application that runs on a standard Windows™ 95/98/ME/NT/2000 based PC. This provides a link to all P&QR monitors either directly via an RS232 or LAN or remotely via a dial up modem or WAN.

All the recorder parameters can be updated remotely and the analog signals can be viewed on line. Data records can be downloaded and partial information such as a profile or cameo can be viewed to reduce communications time.

Waveform, logger and harmonic data can be displayed, analyzed and printed using a range of functions. An expert system is used to classify faults into a number of categories for ease of interpretation. A Voltage dip database is updated for quality and maintenance scheduling.

Users with limited numbers of P&QR recorders may opt to use the lower cost P&Qs software. This is similar to Display Station but will only communicate with P&QRs and will support a maximum of 10 recorders in a network.

OPERATION MANUALS

There are three separate operations manuals to cover the P&QR and its application software. This is the first that deals with the P&QR Power & Quality Recorder installation, configuration and functionality. The second manual covers Display Station (DS32) communications and configuration software. This includes setting up the communications network, configuring the P&QR and downloading record data. The third manual deals with Display Station Analysis (DSA32), which is the graphical display application for the recorded waveform, RMS and logger data.

1 INTRODUCTION

The P&QR power and quality recorder is designed using leading edge computer hardware and software techniques. The high speed, high resolution recording, flexible triggering options and long term recording modes make it ideal for capturing all forms of line transients, power quality surveys, real time display of voltage and current values, metering, etc.

INPUTS

There are 8 analog inputs that may be connected to standard protection voltage and current transformers or directly to a Low Voltage (LV) supply. Current may be monitored using a range of interposing clamp current transformers. The voltage inputs may be configured as a three-phase star (wye) or delta connection. The standard configuration is 3-phase with neutral voltage, and 3-phase with neutral current.

There is a 'configuration wizard' in the Display Station software that simplifies the system configuration and checks that the input connections are correct. This simplifies the ease of use and ensures that the P&QR records the correct information.

FUNCTIONS

The P&QR provides multiple concurrent power monitoring functions in one system. This gives maximum functionality with minimum installation cost. Each of the recording modes works independently of the others. The functions include :-

Waveform recorder

The waveform recorder is mostly used for monitoring short power quality events. The VT & CT waveforms are recorded before, during and after the event. Expert System software can be used to analyze this data and report on any abnormalities. Other information can be extracted for Power Quality and system maintenance.

RMS recorder

Longer-term events are monitored by the RMS recorder. RMS and phasor information are stored twice per cycle per channel and these are used to compute a variety of power system quantities at Display Station.

This function is used for recording voltage dips and other extended quality events. It is also used to extend the pre and post fault times of a Waveform record. The RMS recorder is otherwise independent of the other recording modes.

Long term logger

The input and computed quantities are logged as maximum, minimum and average quantities every minute (or every 10 minutes, depending on the quantity). A 16-week log of data is saved by the system. This data can be retrieved at reduced sampling rates for trending and power quality analysis.

Power Quality monitor

The parameters that define Power Quality are recorded by the P&QR and processed and viewed by applications running on a PC. These include:-

Voltage variations
Frequency variations
Voltage dips
Voltage surges
Voltage steps
Loss of supply
Waveform distortion
Sub cycle drop out
Voltage & current Harmonics
Voltage flicker
Voltage imbalance

Flexible display options allow this information to be shown in a wide range of styles.

Real time metering & monitoring

As well as triggering and logging instruments the P&QR includes the ability to view the voltage and current inputs and computed values in near real time. Measured values and waveforms can be seen locally or remotely. These can replace or act as back-up systems for:-

Waveform oscilloscope
Panel meters
Vector displays
Energy meters

Energy meters

The real power values from the logger are used to compute energy demand over a variable interval. Peak demand and load profiles can be tracked to minimize energy costs. The P&QR also accumulates energy usage in five separate registers. These are:-

Apparent energy (kVAh)
Real power import and export (kWh)
Inductive and capacitive reactive energy (kVArh)

DATA STORAGE

The P&QR is fitted with a hard disk drive. This gives a very large non-volatile data storage capacity for Waveform and RMS fault records. It also stores the long-term logger data. The long-term logger saves the maximum, minimum and average voltages, currents and frequency every minute. It also records certain power usage and power quality data. This log is 16 weeks long and requires ~16 Mbytes of storage for the 8 input channels.

NETWORK

The P&QR can be part of an integrated monitoring network with multiple recorders at locations within a utility or manufacturing plant and Display Station located at the regional control center or plant engineer's office. Communications between Display Station and the P&QRs may be by dial-up modem on an internal or external phone system or by a TCP/IP network connection on a company wide area network (WAN).

EVENT LOG

The P&QR maintains a log of event and error messages, which may be read by Display Station. If an internal error is detected during a self-test, a message is placed in the event log. The messages include:

- When the system is switched on and off
- When the memory is full (stop mode)
- When the disk is nearly full
- When the system parameters are updated
- If the modem does not initialize properly
- If the triggering is disabled (disarmed)
- If the P&QR can't send an auto-call
- If there was a system watchdog reset

2 DESCRIPTION

The 8 channel P&QR is supplied in a panel or wall mounting enclosure. The front door of the enclosure may be released using the key provided. When the door is opened the internal layout of the P&QR may be seen.

To the left are two or three circuit boards. The top board is the processor board and the bottom board is the acquisition board. These boards are plugged into a three slot back plane and secured by a bracket at the top left of each board. The spare slot in the back plane is assigned for present and future options such as a data modem or network card.

The power supply is fitted at the top of the chassis with the power, input and auxiliary connectors mounted on a DIN rail at the right hand side of the case. The supply and voltage inputs are fused at the DIN rail. If the battery option is fitted the 12V rechargeable battery is fitted to the bottom right of the enclosure. The battery supply is located under the mounting plate. The battery will provide approximately 15 minutes of full system operation with no external power source. If a higher voltage a.c. supply is specified (i.e. 415 or 480V ac) an interposing transformer is fitted at the upper right of the enclosure.

To the right of the back plane is the input board that contains all the signal conditioning components for the voltage and current channels. It is connected to the acquisition board by a ribbon cable.

The signal input connectors are mounted at the top of the input board. These are linked to the DIN rail terminals. The external trigger and status outputs are connected from the acquisition board to the DIN rail.

EXTERNAL TRIGGER

There is an external switch input to the P&QR. This is used for remotely triggering the recorder that could be from an auxiliary contact on a protection relay or motor starter. The switch can be supplied from 20 – 148 Vdc.

STATUS LEDS

Depending on your model, there are either two or three indicators on the front panel that display the system status. The LEDs have the following functions:-

Power

This green LED is illuminated when the external power supply is present. The LED is connected to monitor the internal +5V supply.

On line

At turn on, this green LED will remain off until the P&QR has completed its internal self-tests. If everything is satisfactory, the light will turn on and will stay on as long as the P&QR is acquiring data. This process normally takes about 30 seconds. If triggering is disabled via Display Station or the memory is full, this LED will be switched off.

Data available

This amber LED is fitted to rack mounting units. When lit it indicates that the recorder contains triggered records. When the data are viewed, the LED is extinguished. The LED will also flicker when the P&QR is writing data to the hard drive. This normally happens every 10 minutes.

STATUS OUTPUTS

There are two status outputs on the P&QR. These are specified as normally open contacts when unexercised. The power relay is held closed when the P&QR is monitoring its inputs. The "Triggered" relay is closed momentarily when an active trigger is detected.

The two defined functions are as follows:-

Power & On line

This indicates that the recorder is active and is recording data. If the system power is lost or the unit is put off line this LED will switch off. If the P&QR is fitted with a battery, the LED will stay illuminated even if the input supply is lost.

Triggered

The relay is activated while the P&QR is triggered with a minimum on time of 500 ms. This relay has a slightly different function if recorder cross-triggering is enabled (see Section 2).

Waveform and RMS recording

For waveform recording, all the inputs are sampled at 128 samples per cycle (6.4k samples per second at 50 Hz or 7.68k at 60 Hz) and stored in a circular memory buffer. The input levels are compared with defined values to check for an abnormal condition (e.g. an under voltage or an over current). If one is detected, the P&QR triggers and starts storing the sampled data in a separate post-fault buffer. After a fixed time, the P&QR will stop saving data to the post-fault buffer and start a new circular buffer.

For the high speed version of the P&QR, the sampling rate is 256 samples per cycle (12.8k samples per second at 50Hz or 15.36k at 60Hz).

The data in the first circular buffer and the post-fault buffer form a data record that has saved data from the analog inputs before and after the time the trigger condition was seen.

This record may be sent to Display Station for display and analysis.

In the standard model, the P&QR will record 4 cycles before the trigger condition is detected (pre-trigger) and 12 cycles after the trigger (post-trigger). If the Extended waveform capture option has been requested, the pre- and post- recording times are adjustable up to a maximum of 2 seconds.

For extended faults, the P&QR will generate a second waveform record when the trigger condition returns to its normal state. This is also true for the external trigger if it is set as level sensitive (see Display Station manual).

RMS recording works in a similar way except that the RMS measurement for all channels is saved twice per cycle (100 samples per second at 50 Hz or 120 samples at 60 Hz). The recording time for an RMS record is selectable up to 60 seconds and is aimed at longer-term events such as motor starts and some power quality parameters such as extended dips. For more information on trigger settings, please consult the Display Station 32 Operation manual.

The Waveform and RMS recorder are connected so that the RMS record can act as an extended pre and post fault for the Waveform record. A single RMS record may span a number of waveform records. If a further edge trigger is detected during an RMS record, another Waveform record will be created.

Setting the triggering conditions and reading the data records is performed simply by plugging a portable computer running the Display Station software into the program port on the front of the P&QR. One computer can be used for many P&QRs, thereby reducing costs and making the parameter and record data more secure. All the functions available from the front port are also available remotely via a modem or data network.

PQ Logging

As part of the power quality and energy monitoring functions, the P&QR records critical parameters continuously. This allows limit excursions to be identified and permits the variation of PQ parameters to be viewed against time. This gives a much better indication of the quality of a supply than limit excursions alone.

This is the same philosophy as industrial statistical process control (SPC). By continuously monitoring key process parameters, the state of the process or system can be kept under control.

The standard logger records the RMS voltages and currents and system frequency every minute. This is saved as a maximum, minimum and average measurement. The max and min are single cycle values.

Separate log files record the voltage flicker (Pst) and voltage imbalance every 10 minutes. Imbalance is also a max, min and average value over the interval but flicker is a single measurement as defined in EN61000-4-15.

The harmonics logger records the max, min and average value every 10 minutes as well as the harmonic vector magnitudes and angles at the start of the interval. Harmonics are recorded for the three phase voltages and currents up to the 63rd.

The energy logger records the max, min and average circuit total real power every minute.

The logger data are recovered from the P&QR on demand. If the interval of interest is long, the effective sampling rate may be reduced to 5, 10 or 15 minutes for 1-minute quantities, and 30 or 60 minutes for 1 and 10 minute quantities to reduce the data download time. The system will re-compute the correct max, min and average for the new interval. If more detail is required, the logger data may be recovered again at the higher sampling rate.

The harmonic log can be recovered in a number of different formats. Again, this is to reduce the data download times. The maximum harmonic number may be reduced and the data format selected from:-

- Average
- Max, min & average
- Max, min & average, magnitude and angle
- Magnitude and angle

For more details on data recovery, see the Display Station 32 Operation manual. For more details on the measurement methods, see Appendix II in this manual.

3 INSTALLATION

The P&QR is delivered in a range of enclosures. These include wall mounting, rack mounting and portable cases. For the wall mounting unit all main supply, input and output connections are via DIN rail terminals inside the right hand side of the case. The communications connector located on the front panel.

The P&QR is available with a number of options. To check the actual specification of a particular system, consult the User Specification in Appendix IV of this manual. Please confirm that the Serial number on the inside of the door matches that on the Specification.

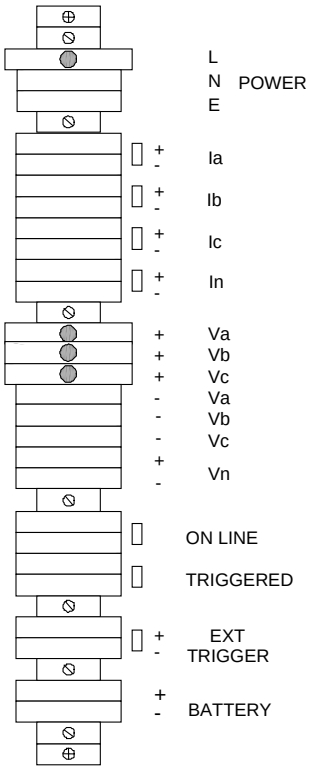

Figure 3.1 DIN rail terminations for wall mounting enclosure

POWER SUPPLY CONNECTION

The power supply is connected to the terminal block at the upper right of the side panel. If a DC supply is being used the polarity should be observed. Incorrect polarity will not damage the supply. The actual voltage specified will be indicated in the User Specification sheet in Appendix IV of this manual. The specified voltage must be used, and damage may occur if an incorrect voltage is applied. The maximum cable diameter is 4 mm^2 (12 AWG). The earth connection must be made for correct operation of the device.

ANALOG INPUT CONNECTIONS

The analog input cables are connected to the terminal connectors at the right hand side of the P&QR. The sequence of voltage and current transformer inputs is indicated in Figure 3.1 above for the wall mounting enclosure and Figure 3.2 below for the rack mounting enclosure. The maximum cable diameter for all analog and digital inputs is 4mm^2 (12 AWG).

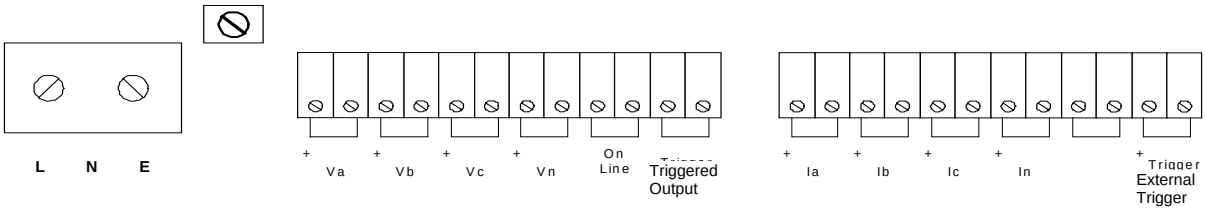

Figure 3.2 Terminations for 3U rack mounting enclosure

Voltage

The voltage inputs are connected directly to three phase bus bars or to standard 57 – 120V secondary windings of protection or metering VTs. The P&QR is configured at the factory to have full-scale inputs of 150, 300 or 600V ac. The neutral voltage may have a different range to the phase voltages. The actual full-scale voltages are given in the User Specification in Appendix IV.

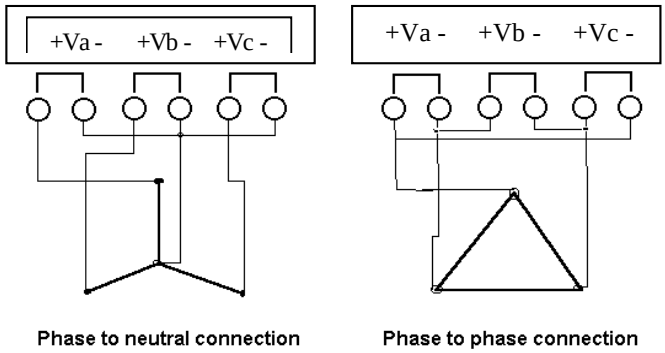

Figure 3.3 Voltage wiring options

Since all inputs are isolated from each other, both phase - phase and phase - neutral windings can be connected. The connection scheme is shown in figure 3.3 above.

Because the P&QR is calibrated at its given range, changing the input range in the field is not recommended. If a change is necessary, please contact the factory for a complete set of instructions and software.

Current

The current inputs are derived from an interposing CT connected to either the 1A or 5A secondary winding of a protection (or metering) CT, or directly around a bus bar or load conductor. In the former case, the protection CT is termed the primary transformer and the interposing CT is the secondary transformer. The secondary CT may be a voltage or current output device.

If a wedding ring or current output clamp CT is used, a burden resistor may be fitted either inside the P&QR or on the CT module. The CT ratio and burden resistor values are chosen to suit the required current level and protection CT ratio at a particular location. Again, the actual nominal and full-scale values for the current inputs are given in the User Specification.

There are a number of options available for interposing CTs. The most common is the clamp type. These are available with ranges from 1A to over 3000A. These are most suitable for temporary installations. For permanent installations, the toroidal or 'wedding ring' type provides a more cost effective solution. Four of these are normally fitted to a DIN rail mounting assembly.

Multiple primary turns can be fitted to extend the sensitivity. This type requires either shorting switches or a line outage so that the protection CT secondary can be wired to the interposing CT module.

The maximum measured input to a current channel in the P&QR is 1.4142V RMS. This allows standard 1V nominal output clamps to be used with ~40% over range. It also offers compatibility with other equipment from AMETEK Power Instruments. For other types of CT, the secondary ratio and burden values are chosen to give 1.4142V RMS at the maximum required primary current level. If the maximum current is exceeded, the signal will be seen to 'clip'.

The P&QR is designed to record current at load levels. This ensures the maximum accuracy for power and other measurements. The inputs may be scaled for fault current levels, but the system may not meet all its accuracy specifications at load level currents.

EXTERNAL TRIGGER INPUT

There is a single digital input to the P&QR. This is used for remotely triggering the recorder via an auxiliary contact on a protection relay or motor starter. The digital input must have a DC supply within the range of 20 – 148V connected externally. The polarity of the terminals must be observed. When the contact being monitored is closed, up to 10mA will flow through it.

The 'external trigger' must be enabled from Display Station for external triggering to operate. The input can be set for edge or level sensitivity.

STATUS OUTPUT CONNECTIONS

Two status relay output circuits are available on the DIN rail connector at the right of the enclosure. The output terminals are linked as normally open contacts when unexercised. Under normal conditions the 'On line' contact will be closed. There is no requirement for an external wetting supply for the P&QR. The functions of these relays are described in the previous chapter.

AUXILIARY CONNECTIONS

A PC running Display Station may be connected to the programming plug located on the front panel. A serial null-modem cable is supplied with the P&QR. The connector conform to the IBM PC format for RS232 serial ports. The communications port has the following pin configurations:

Pin	Use
1	DCD
2	Rx
3	Tx
4	DTR
5	Gnd
6	DSR
7	RTS
8	CTS
9	RI

The Programming connection uses hardware handshaking (RTS & CTS). The data format is: -

Baud rate	57600*
Parity	None
Data bits	8
Stop bits	1
Handshake	Hardware

* The actual baud rate is set on configuration switches in the P&QR (See Chapter 4)

SWITCHING ON

When all the relevant connections have been made, the system is switched on by applying power and moving the supply toggle switch in the indicated direction. This is found on the mounting plate inside at the bottom of the wall-mounting unit, and inside the rack-mounting unit at the front right. If the battery option is fitted, there will be a second switch.

This should also be moved in the indicated direction. To switch off the unit, both switches must be moved together in the opposite direction.

When the P&QR is switched on, it performs a series of internal self-tests to check the processor, the memory, and the acquisition system. This takes about 30 seconds after which, if no fault is found, the P&QR will illuminate the green 'On line' lamp and start acquiring data.

The sampling rate, channel labels and scaling and other parameters may have been set at the factory. If these are to be changed, Display Station must be connected to the 'Programmed' plug on the mounting bracket. Parameters may also be changed over a remote connection. See the Display Station 32 Operation manual for details on programming the P&QR.

Configuration Wizard

Display Station includes a simplified configuration procedure for the P&QR. This calculates the nominal and full scale values required from the voltage and current transformer ratios. It also sets trigger levels based on power quality standards. The Wizard checks that the voltage and current connections are correct so as the information recorded is useful. This configuration may be done locally or remotely, but any errors in the connection can only be corrected locally.

Real time display

The real time display function in Display Station may also be used to check that the signal levels reported by the P&QR are correct. The phase relationships of the voltages and currents may also be seen. For more information on this and the configuration wizard, see the Display Station 32 Operation manual.

Test record

To generate a permanent copy of the signal inputs, the manual trigger may be used. This is available in Display Station. A short waveform and longer RMS record can be created. When this is downloaded to Display Station, the inputs can be displayed and measured using Display Station Analysis.

4 CONFIGURATION

The P&QR is available in different configurations with different default and user defined options. The values set for this machine at time of delivery can be found on the User Specification sheets in Appendix IV of this manual. The common P&QR recorder software detects the hardware configuration through a set of 8 DIP switches on the acquisition board. They have the following functions:-

Switch	Function	Off	On
1	System frequency	50Hz	60Hz
2	Cross trigger	Disabled	Enabled
3	(Undefined)	0	1
4	Com 1 baud rate	See Table below	
5	Com 1 baud rate		
6	Internal modem	No	Yes
7	(Undefined)	0	1
8	Force default settings	No	Yes

Switch 4	Switch 5	Baud rate
Off	Off	9600
On	Off	19,200
Off	On	38,400
On	On	57,600*

* Default factory setting

EXTERNAL TRIGGER

The P&QR may be triggered from an external event like a motor starter or protection relay. A 16 cycle transient record is created when a voltage is applied to the external trigger terminals. An RMS record is also taken which will extend as long as the external trigger voltage is applied. When the voltage is removed a second 16 cycle transient record is created.

CROSS TRIGGER

Any number of P&QR recorders may be coupled together to form a system with any number of inputs (in multiples of 8). This system uses the 'Triggered' status relay outputs and the external trigger of each recorder. They are connected thus:-

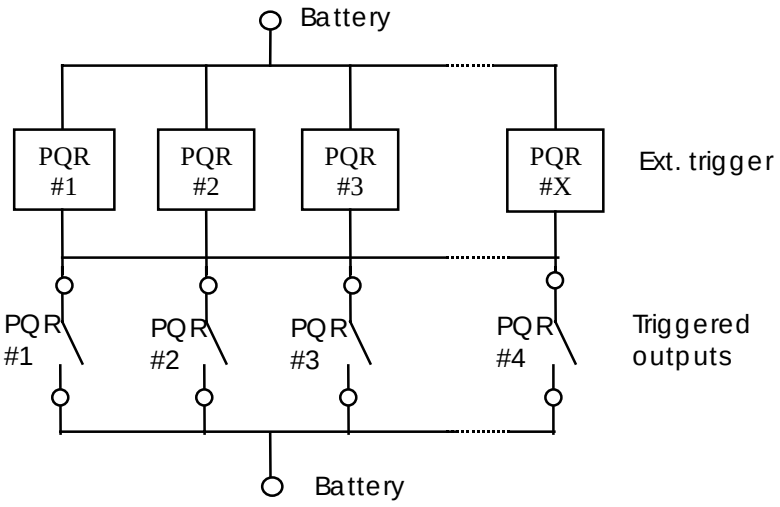

Figure 4.1 Cross-triggering wiring showing multiple PQR systems

Note: See Figure 3.1 or 3.2 for terminal positions

Switch 2 on the acquisition board must be ON for every machine connected together in this way.

Operation

When a connected recorder is triggered, its 'Triggered' relay will pulse immediately, which will cause the external trigger on each recorder to go into the alarm state. This will cause the other recorders to trigger, but their status relays will not be activated. If a valid trigger is detected on a recorder other than that which started the process, its Status relay will activate, thus extending the post fault period of all recorders if necessary.

The originating recorder will have a normal cause of trigger, but the others will show 'Cross-trigger' to identify the source of the original trigger.

When the fault records are downloaded to Display Station, they may be viewed and printed individually. Because the status relays have a switching time of up to 2 ms, the effective pre-fault period will be slightly shorter than specified.

If cross triggering is enabled, a manual trigger caused by selecting 'Manual trigger' from Display Station will not cause the 'Triggered' relay to operate.

5 CALIBRATION

The P&QR is calibrated at the factory before dispatch and should not need to be altered. The calibration procedure is performed by software and no potentiometers are used. The offset and gain values are saved in a non-volatile memory on the acquisition board.

The system calibration is set for its defined input voltage range (150/300/600V). Changing ranges in the field may cause a loss of accuracy.

The calibration program is described in a separate document.

6 MAINTENANCE

The P&QR does not require any regular or preventative maintenance. The system calibration should be checked every 6 – 12 months using the real time display functions.

FAULT FINDING

The front panel indicators show the status of the P&QR. The green 'Supply' and 'On line' lamps will be illuminated during normal operation. For remote interrogation, the P&QR must be contacted by Display Station to read the event log to determine the source of the problem.

If no lamps are illuminated, the supply input should be checked with a multimeter. If power is present and the internal fuse is intact, the fault is with the power supply. This may be confirmed by checking the +5V and +/-12V supplies at the input connector on the back plane. There are three LEDs on the back plane that indicate the presence of +5V and +/-12V (wall mount only). There is also a fourth LED that is not used and will not be illuminated.

If the 'Supply' lamp is illuminated but the 'On line' lamp is not, the data memory may be full. This condition will occur if the 'overwrite' switch is off or the system is in ‘Stop’ mode, so that old records will not be overwritten. In this case, the P&QR will stop acquiring data and will switch off the 'On line' lamp. If the P&QR does not respond to Display Station, the fault may be with the modem or processor board.

The P&QR processor board has a watchdog function that will cause a system reset if the software fails to access a specific memory location within approximately 30 seconds. This means that the P&QR will recover from a noise spike, which causes the processor to momentarily maloperate.

If the fault is seen in only one channel, the problem is probably on the input board. If no obvious physical fault is seen on the board, the relevant test point should be examined with an oscilloscope.

For more information on faultfinding, see Appendix IV.

Batteries

The standard P&QR has 2 semiconductor packages that contain lithium batteries. These have a guaranteed hold up time of ten years without any external power. These are the real time clock on the processor board, which is an M48T86PCI; and the parameter and profiles memory on the acquisition board which is an M48Z08-100PCI at location U3. It is recommended that these batteries be replaced after 8 to 9 years of operation.

APPENDIX I - P&QR SPECIFICATIONS

Analog Inputs

No. of channels	(8) 3-phase & neutral voltage, 3-phase & neutral current
Voltage inputs (factory options)	150/300/600 V RMS maximum Star (Y) or delta connections (Phase & neutral inputs may have different ranges)
Current inputs (options)	1A or 5A RMS nominal 100/200/500/1000 A RMS nominal (all via interposing CTs) (1.414 V fsd. Int or ext burden)
Frequency response 128 spc	(Voltage): 30 Hz - 3 kHz. +0 dB, -3 dB. (Current): DC – 3 kHz, +0dB, - 3 dB
Frequency response 256 spc	(Voltage): 30 Hz - 6 kHz. +0 dB, -3 dB. (Current): DC – 6 kHz, +0dB, - 3 dB
Accuracy	Better than 0.2% of full scale

Recording

Recording resolution	14 bits
Recording accuracy	+/- 1 least significant bit
Sample rate (128 spc model)	128 samples per cycle 6.4/7.68 k samples per second
Sample rate (256 spc model)	256 samples per cycle 12.8/15.36 k samples per second Locked to voltage signal
Configuration switches	System frequency Modem connected Serial baud rate Cross triggering

Data storage

Program memory	8 Mbytes Flash (remote updates available)
Parameter memory	8 Kbytes battery backed SRAM
Buffer memory	16 Mbytes DRAM
Record memory	Minimum 4.0 Gbytes IDE hard drive

Recorded data

Power quality measurements	Voltage & frequency profile Waveform faults Voltage dips & surges Harmonics (to 63rd) Flicker Imbalance
Recorded values	Voltage & current (true RMS) Frequency, Flicker (Pst) Imbalance, real power, harmonics
Harmonic options	Average, max min & avg, magnitude & angle. All at 10/30/60 min intervals
Metered values energy	Apparent energy (kVAh), Imported & exported real (kWh), Inductive & capacitive reactive energy (kVArh)
Computed values	Demand (sliding or fixed window) Phase angle, power factor, sequence components, X/R ratio, etc.

Event Triggering

Trigger parameters	Over/under level with hysteresis Rate of Change & THD
Accuracy	Better than 1%
Pre-fault time (waveform)	4 cycles (25 cycles – option)
Post-fault time (waveform)	12 cycles (2 sec – option)
Pre-fault time (RMS)	1 second
Post-fault time (RMS)	Up to 60 seconds

External trigger	On digital input

Digital input

Function	External trigger
Input voltage (nominal)	20 – 148 V dc

Status outputs

Functions	On line (recording) Triggered / Data available
Contact rating	300 V dc, 240 V ac 0.5 A, 10 W max

Front panel indicators

Type	2 or 3 LEDs, depending on model
Functions	Supply on (Green) On line (Green) Data available (Amber); rack-mount version only

Real time clock

Clock source	32.768 kHz crystal oscillator
Resolution	1.0 mS
Range	Time and date (including leap year and day of the year)
Hold up	10 years from internal battery
Synchronization	50/60 Hz from voltage input
Time setting	Time & date set via comm port
Y2K	The clock is Y2K compliant

Communications

Serial port	RS232 type
Speed	9600/19.2k/38.4k/57.6k Baud
Modem (option)	Hayes compatible type internal (up to 57.6k Baud)

Network (option)	TCP/IP, 10BaseT, 10Base2, or fiber optic

Power supply

Voltage range	88 - 300 Vdc, 85 - 264 Vac 24 Vdc & 48 Vdc (optional) 415 – 480 Vac (optional)
Power requirement	21 W (without battery option)
Battery backup (option)	15 mins (internal 1.2 AHr)

Electrical environment

Isolation		Channel to channel (voltage). Channel to ground. 2 kV RMS for 1 minute (IEC 255-5/IEEE C37.90 1989)
Impulse voltage withstand		Channel to channel (voltage) Channel to ground 5 kV, 1.2/50 µs. 0.5 Joule (IEC 255-5/IEEE C37.90.1 1989)
Electrical fast transient (EFT)		4 kV, 5/50 ns. 15 ms burst length (IEC 255-22-1/IEEE C37.90.1 1989)
Surge withstand (SWC)		2.5 kV, 1 MHz HF burst disturbance (IEC 255-22-1/IEEE C37.90.1 1989)
RFI immunity		10 V/m 20 MHz - 1 GHz (80% AM @ 1 kHz) (BS EN 50082)
RFI emission	- radiated	40 dB µV/m (27 - 130 MHz) 47 dB µV/m (130 MHz - 1 GHz) EN 55022B (class 'B' limits) (BS EN 50081-1)
	- conducted	(150 kHz - 30 Mhz) EN 55022B (class 'B' limits)
	- harmonics	(100 Hz - 30 MHz) (IEC 555 class 'A' limits)
Electrostatic discharge (ESD)		8 kV contact, 15 kV radiated discharge (IEC 801-2/EN 61000-4-2)

Enclosure

Steel Panel/wall mounting

Size (external terminations)	250 x 300 x 120 mm 9.8 x 11.8 x 4.7 ins
(internal terminations)	300 x 400 x 210 mm 11.8 x 15.8 x 8.3 ins
Weight (internal terminations)	11 Kg. 25 lbs.

3U rack mounting

Size	355 x 482 x 135 mm 14 x 19 x 5.3 ins (including handles & flanges)
Weight	11 Kg. (25 lbs.)

Environment

Operating temperature	-10 to 50 °C (14 to 122 °F)
Storage temperature	-40 to 70 °C (-40 to 158 °F)
Humidity	5 - 95% RH (non condensing)

Due to continuing development, AMETEK Power Instruments reserve the right to alter the specification without notice.

APPENDIX II - PARAMETER CALCULATIONS IN THE P&QR

Introduction

The Power & Quality Recorder (P&QR) is a high performance instrument that can monitor the quality of supply and energy usage in a sub-station or an industrial plant. It can be configured and interrogated locally or remotely over a dial up modem or corporate LAN/WAN.

Inputs are connected to standard VT and CT secondaries or directly to LV bus bars. For the CT signals, an interposing 'wedding ring' or clamp type CT can be used. Derived quantities (frequency, sequence components, power etc.) are computed internally and no external transducers are required.

Conventions

Because of the range of differing techniques for computing derived quantities (especially power) and the lack of world wide accepted standards, Display Station Analysis uses mostly fundamental calculations; i.e. parameters computed from the current and voltage vectors at the present system frequency. Therefore, power factor is actually displacement power factor (not true power factor) in most cases.

Reactive power into an inductive load (current lagging voltage) is treated as positive. Exported real power (voltage and current in phase) is treated as positive.

Phase to neutral vectors are shown pointing outwards from the neutral point. Phase to phase vector Vab is shown pointing from a to b; i.e. It is the resultant vector of Vb - Va.

Three voltage or current channels are defined as a phase group. These are listed in positive sequence order and the first channel is the reference phase. One voltage and one current phase group are defined as a line group. These groups are used when defining the sources for sequence component, power & impedance calculations etc.

Time measurement

The acquisition system in the P&QR is phase locked to the incoming mains supply. This ensures that there is exactly the same number of samples in every cycle. If the grid system to which the P&QR is connected has an equal number of cycles per day then the P&QR will keep perfect time in the long term. This scheme is used to ensure that electric clocks keep good time. Due to the normal frequency variations on the grid the P&QR clock will drift fast and slow by a number of seconds relative to real time. This variation will be the same for all systems connected to the same grid.

If the measured supply is lost or the input is disconnected, the P&QR will run at the

nominal frequency until the signal is restored. If the P&QR is switched off, time is maintained by an internal battery and crystal.

Frequency measurement

The P&QR has a frequency channel that is calculated from a defined voltage channel. The P&QR uses the zero crossing method for extracting frequency. The signal is first filtered with a recursive IIR filter to remove non-50 Hz or 60 Hz components. The exact position of each zero crossing is found using similar triangles to determine the sub sample position. Both positive and negative crossings are measured. The four period measurements over two cycles are averaged. The inverse is taken to yield the frequency. Any measurements that fall outside the fundamental frequency +/- 5 Hz are ignored, and the P&QR assumes a nominal 50/60 Hz for the remaining calculations until the system frequency returns within the +/- 5 Hz range.

Vector measurement

The Cartesian vectors for every channel are generated twice per cycle. The angle is corrected for 180° inversion. This form can be converted into the polar notation for calculation of the derived parameters.

The data for one cycle are multiplied by sine and cosine tables to give the Cartesian co-ordinates. The reported angle is that at the left hand end of the data window. The magnitudes are divided by √2 to give the equivalent RMS value.

RMS measurement

The true RMS value for every channel is generated twice per cycle. The data for one cycle are squared and summed. The square root is taken of this value divided by the number of samples per cycle.

$$V_{rms} = \sqrt{\frac{\sum_{n=1}^{128} V_n^2}{128}}$$

Frequency correction

Because the system frequency varies by small but finite amounts during normal operation, uncorrected RMS and vector measurements will have an error that is a function of frequency deviation. Since the P&QR is locked to the supply frequency, these errors are minimized. The P&QR does not compensate for them beyond what is done with the phase-locked loop sampling.

Calculation of derived parameters

A range of fundamental quantities may be computed from the fundamental voltage and current vectors.

Sequence components

$3\bar{V}_{+1} = \bar{V}_a + a\,\bar{V}_b + a^2\bar{V}_c$ Positive

$3\bar{V}_0 = \bar{V}_a + \bar{V}_b + \bar{V}_c$ Zero

$3\bar{V}_{-1} = \bar{V}_a + a^2\bar{V}_b + a\,\bar{V}_c$ Negative

$\bar{V}_a$ represents the vector form of the a phase voltage

(operator **a** rotates the vector by 120°)

Power (fundamental)

Apparent

$S_f = V_f * I_f$

Real

$P_f = V_f * I_f * Cos\Phi$

Reactive

$Q_f = V_f * I_f * Sin\Phi$

For delta VTs real power is computed using the two-wattmeter method.

Displacement power factor

$PF = Cos\Phi$

Impedance (fundamental)

$Z_f = V_f / I_f$

Imbalance

$I_m = V_{-1}/V_{+1} * 100\%$ (Ratio of NPS to PPS)

Harmonic measurement

A single cycle window is used to calculate the harmonic content of all phase voltages and currents. A standard Fast Fourier Transform (FFT) technique is used to calculate the

amplitude and angle of each component. A number of samples are taken over the integrating interval (10 mins for EN50160) and averaged.

Since the P&QR is phase locked to the supply frequency, the errors caused by frequency variation are minimized. The data windows are taken at the same time so the vector values are synchronous.

The maximum, minimum and average amplitude are stored every 10 minutes. The phasor magnitudes and angles are also stored at the 10-minute boundary. Data for the fundamental and up to the 63rd harmonic are recorded. THD, thd, TDD and K factor are computed on the host PC by the Harmonics Analysis application.

The averaging interval of 10 minutes conforms to the measurements for short-term harmonics (Tsh) in EN61000-4-7 and the limit values given in EN50160. The maximum and minimum values give an indication of very short-term harmonics with an interval even shorter than 3 sec (Tvs).

For the standard model (128 samples per cycle), the harmonic response at the top of the range will not be as accurate as the rest of the range due to the effects of the anti-aliasing filter. This does not affect the 256-sample model.

Flicker

Flicker is measured using the technique defined in EN61000-4-15. This corrects some errors that were in the original standard IEC60868. The sub-synchronous spectrum is extracted and weighted using the defined curves. This instantaneous flicker value is recorded for 10 minutes, and a statistical average is taken. Again, this average is defined in the standard. This short-term flicker value - Pst, is recorded per phase voltage in a separate long-term log every 10 minutes. A Plt value can be computed in Display Station Analysis.

Real power

True power is computed by multiplying individual current and voltage samples and then averaging over one cycle.

$$P = \frac{1}{128}\sum_{n=1}^{128} V_n * I_n$$

Real power for a circuit with a delta wound VT is derived using the two-wattmeter method. This makes two power measurements using two of the line currents. It can be proved that the sum of the two powers is same as the total circuit power:-

$$P = V_a I_a + V_b I_b + V_c I_c \quad \text{Total circuit power}$$

$$I_a + I_b + I_c = 0 \quad \text{Currents sum to 0}$$

Substituting the second equation into the first and collecting terms yields:-

$$P = (V_a - V_b)I_a + (V_c - V_b)I_c$$
$$P = V_{ab}I_a + V_{cb}I_c$$

The total circuit power can be measured using two wattmeters on the phase-to-phase voltages. Note that the phasing of the VTs is important for the correct calculation of power.

Apparent power

Apparent power is computed from the RMS voltage and current.

$$S = V_{rms} * I_{rms}$$

Reactive power

Reactive power is computed by multiplying individual current and voltage samples offset by 90°, and then averaging over one cycle.

$$P = \frac{1}{128}\sum_{n=1}^{128} V_n * I_{n+32}$$

Reactive power for a circuit with a delta wound VT is derived using the two-wattmeter method.

Power factor

True power factor is the ratio of real to apparent power.

$$PF_{True} = \frac{P}{S}$$

This value can be quite unrealistic in the presence of distorted waveforms. This will increase the apparent power more than the real power and cause a reduction in PF that is caused by the harmonics and has nothing to do with phase angle. This will also cause a difference between the displacement and true power factors.

Total harmonic distortion (THD)

The THD for an input may be derived from the RMS and vector magnitude (V):-

$$THD = \sqrt{\left[\left(\frac{Vrms}{Vf}\right)^2 - 1\right]}$$

The formula above shows the IEEE calculation of THD. In Display Station Analysis, the form of THD can be selected from the IEEE or ANSI standards.

APPENDIX III – FAULT FINDING IN THE P&QR

The first indication that a P&QR is not functioning correctly is normally that it will not make a remote connection. Before going on site, it is worth checking the phone line by ringing the P&QR's number and listening for the phone to be answered by the modem followed by a series of tones. If these are heard, then the phone line and modem are OK and there is power to the P&QR. If a data switch or DTMF switch is being used, then the phone may be answered but no tones will be heard.

If this is successful, contact the P&QR using a terminal package such as HyperTerminal in Windows. After the modem has issued a 'CONNECT' message, press <Enter> 3 or 4 times. The P&QR should return with a list of configuration parameters. If this is successful, the fault may be with the Comms Manager set up of Display Station. To disconnect from the P&QR using a terminal, type "quit" and then press <Enter>.

For a network connection, the 'ping' utility may be used to check whether the IP address is seen. If this is successful, the 'Telnet' utility may be used to establish a low level connection. If 'ping' is unsuccessful, the problem may be with the network routers, hubs or data switches.

Off site checks

Problem: Modem doesn't answer.

Check: Correct phone number?
Telecom wiring at location?
If a data switch is used is it powered up?
Is P&QR powered up? (see below)
Is initialization string at P&QR correct? (S0=1)

Problem: Modem answers but is unable to communicate with P&QR.

Check: Are initialization strings at Display Station & P&QR correct?
Is P&QR active? (see below)

Recommended initialization string for Pace modems:-
AT&F^M~~~~ATS0=1^M

Recommended initialization string for US Robotics modems:-
AT&F1^M~~~~ATS0=1&G2&W^M

All Hayes compatible commands must begin with 'AT'. The ^M symbols are interpreted as if the <Enter> key has been pressed. The ~ symbol is interpreted as a short delay.

On site checks

Start with test 1). Follow the test numbers depending on the result of each test. After a change is made start with test 1) again.

1) Is the green 'Power' light on? Yes 2) No 5)

2) Is the green 'On line' light on? Yes 9) No 4)

3) The P&QR is working correctly. The fault is with the modem, data switch or phone line. Is the internal modem board seated correctly? (This is the board in the center of the unit with the gray phone connection.) Yes 8) No 11)

4) Is the green flashing light on the processor board operating? (This is the board at the top of the P&QR) Yes 7) No 11)

5) Is the power switched on? Yes 10) No 6)

6) Switch system on 1)

7) Restart the P&QR by switching off the supply waiting a few seconds then switching it on again. The processor should 'beep' several times as it checks its memory. After this there is short delay then the 'On line' light will be illuminated. Did this work correctly? Yes 8) No 14)

8) Ring the person with Display Station and ask them to contact the P&QR. The phone should ring once then the modem should answer. If a line share device is being used then an 'M' should be displayed on its front panel. The modem will respond with a number of tones followed by a 'hash' sound (like an AM radio not tuned to a station). This should end and a few seconds later the P&QR 'Communications' light will come on. This indicates a valid connection. Was the connection completed? Yes 20) No 13)

9) Connect a laptop computer running Display Station to the port inside the P&QR. Check the 'Comms Manager' settings. The port should be COM1 or COM2 and the speed should be 9600, 19200, 34800 or 57600. The actual values will depend on the computer in use and the speed set on the internal DIP switches in the P&QR. Make a 'Direct' connection. Is the connection successful? Yes 3) No 15)

10) There is no power to the P&QR. Check the incoming supply and the fuse that supplies the unit. There is also a fuse inside the power supply that is at the top of the case. Was everything correct? Yes 12) No 16)

11) Check that all the boards on the processor tray are seated correctly and all the ribbon cables are in place. If boards need to be re-seated switch the system off first. 7)

12) There is a fault in the power supply or supply wiring. Replace and re-test. 1)

13) If the modem did not answer, the fault may be with the initialization string (see above). If this is correct there is a fault with the modem. Replace it and re-test. 1)

14) There is a fault with the processor board. Replace it and re-test. 1)

15) There is a fault with the wiring to the front port. Check that the ribbon cable is plugged into the processor board. 1)

16) Replace fuse etc. and re-test. 1)

20) The P&QR is OK

Check for intermittent resetting

Measure the +5 volt supply on the back plane with a multimeter. The +5V wire is red and the 0V wire is black. The +12V wire is yellow and the –12V wire is blue.

The +5V supply should not be below 4.9V. If the voltage is low, the fault may be with the power supply, connectors, or wiring.

APPENDIX IV - USER SPECIFICATION SHEET

Project Number: _____

Serial Number: _____ Firmware Version_____

Hard Drive Type: _____ Size_____ Heads_____ Cyl_____

Modem: _____ Init String_____

Ethernet: _____ Factory IP Address_____

Voltage Settings: V1, V2, V3 =_____ Vn =_____

Type of CTs: _____ Value_____

Burden Resistors:
(Current Inputs) Installed_____ Value_____

Package style: Small box_____ Large Box_____ Rack Mount_____ Portable_____

Ext. Trigger Voltage Range: _____

System Options

Extended Waveform Capture _____

1MHz Peak Detect _____

Backup Battery _____

480V Transformer Power _____

24/48 Vdc Power _____

256 Samples per Cycle _____

IRIG-B Time Sync _____

Cross Triggering Enabled _____

As-Shipped Settings for Switches 1 through 8

1 _____

2 _____

3 _____

4 _____

5 _____

6 _____

7 _____

8 _____

Switch Definitions

Switch	Function	Off	On
1	System frequency	50Hz	60Hz
2	Cross trigger	Disabled	Enabled
3	(Undefined)	0	1
4	Com 1 baud rate	See Table below	
5	Com 1 baud rate		
6	Internal modem	No	Yes
7	(Undefined)	0	1
8	Force default settings	No	Yes

Switch 4	Switch 5	Baud rate
Off	Off	9600
On	Off	19,200
Off	On	38,400
On	On	57,600

APPENDIX V

TELEPHONE / FAX NUMBER LIST

This errata sheet provides an easy-to-use reference for all major departments. Use these numbers for ordering equipment, application assistance, technical support, and scheduling field service

Please Note: Your instruction manual may contain other phone and fax numbers; this list will take precedence.

MAIN OFFICE

AMETEK Power Instruments – Rochester
255 North Union St., Rochester, NY 14605

DEPARTMENT/PRODUCT LINE	TELEPHONE	FAX
MAIN PHONE	585-263-7700	585-262-4777
FIELD SERVICE	800-374-4835	585-238-4945
REPAIRS/RETURNS	888-222-6282	585-238-4945
SALES SUPPORT	800-950-6676	585-454-7805

FAR EAST OFFICE

AMETEK Power Instruments
271 Bukit Timah Road, #03-09
Balmoral Plaza, Singapore 259708
Tel: 65-732-8675
Fax: 65-732-8676

UK OFFICE

AMETEK Power Instruments
Unit 20, Ridgeway
Donibristle Industrial Estate
Dunfermline, UK
Tel: 1383-825630
Fax: 1383-825715

PROCEDURES FOR FACTORY REPAIR AND RETURN

A. Obtain a Returned material Authorization (RMA) number by calling AMETEK Repair Sales and giving the following information:
   1. ***Model*** and ***Serial Number*** of the equipment
   2. Failure Symptom – **Be Specific**
   3. Approximate date of installation
   4. The site name and address of the failed equipment
   5. Complete shipping information for the return of the equipment if other than the operating site
   6. Name and telephone number of person to contact if questions arise.

B. Enclose the information with the equipment and pack in a commercially accepted shipping container with sufficient packing material to insure that no shipping damage will occur. Mark the outside of the container with the RMA number. Ship to the appropriate location: **Attention:** Repair Department

AMETEK Power Instruments
255 North Union Street
Rochester, New York 14605 USA
Tel: (888) 222-6282
Fax: (585) 238-4945

C. Your emergency equipment will be tested, repaired and inspected at the factory. Factory turnaround is ten working days or less (excluding shipping time).

D. For emergency service or repair status information, please contact the AMETEK Repair Sales Engineer at (800) 374-4835.

WARRANTY

AMETEK warrants equipment of its own manufacture to be free from defects in material and workmanship, under normal conditions of use and service. AMETEK will replace any component found to be defective, upon its return, transportation charges prepaid, within one year of its original purchase. AMETEK will extend the same warranty protection on accessories that is extended to AMETEK by the original manufacturer. AMETEK assumes no responsibility, expressed or implied, beyond its obligation to replace any component involved. Such warranty is in lieu of all other warranties expressed or implied.