



Magnaflux Quasar 4000 Material-Handling Interface Design Guidelines

This document is a summary of the material needed to use the Magnaflux Quasar 4000 Nondestructive Test System material handling system interface. It provides the top-level background needed to discuss the details of the interface with Magnaflux Quasar personnel. Additional material, particularly about the theory and operation of the Quasar System, is available in the Magnaflux Quasar 4000 Nondestructive Test System User's Manual. Detailed questions specific to a particular application should be resolved with Magnaflux Quasar technical personnel.

Magnaflux Quasar 4000 Material-Handling Interface Design Guidelines

A. Interface Philosophy

The Quasar PCRI system functions as an asynchronous independent element of a production process. The system is designed to operate as a stand-alone test system, however, an interface to a material-handling system is provided. Once a part is placed on the Quasar system, a material-handling system, if present, is not required to perform any Quasar system task until the part testing is complete. This means that the division of responsibilities between the Quasar system and the material-handling system is performed in a clean fashion at the loading and unloading of parts to/from the Quasar system.

Two methods for passing data between the material-handling system and the Quasar PCRI system are available. The Quasar PCRI system utilizes an Allen-Bradley DeviceNet network. Access to that network is provided on the Workstation electronics enclosure. A simple means for the material handling system to access this network is to place a scanner from the material handling PLC in the Quasar network. This provides complete access to all data in the MicroLogix controller. Alternatively, specific digital I/O points are brought out to one or two ILME connectors on the Workstation electronics enclosure. This is a more restricted interface since there are a limited number of available pins. This is also a less flexible solution since changes required after the system is built will require hardware changes in the Quasar system electronics enclosure and possibly the material-handling system. This indirect access to material handling signals is available at an extra charge and must be specified at the time of purchase.

B. Part Positioning and Alignment

Quasar PCRI testing is sensitive to the position and orientation of the part on the transducers. Parts that are symmetrical along one dimension must be placed on the Quasar system in the proper orientation. For example, a connecting rod may be slightly different on the top (A side) and the bottom (B side) along the long dimension (crank end to rod end). A Sorting Module developed to test the rod with side A up would not necessarily give the same results if the part is tested with side B up. In another example, a circular part that has asymmetrical cuts or holes may require placement with the cuts or holes in a particular orientation relative to the transducers.

For proper Quasar PCRI testing, independent of any locating tooling, the required part placement, is +/- 0.062 inch (+/- 1.6 millimeters) in each axis, X, Y & Z. Required angular alignment of the part to the transducer field is a quarter of a degree for rectangular plan form parts, for example, a connecting rod. For axially symmetrical parts, the required angular alignment could be less stringent depending on the level of part symmetry. Generally, Magnaflux Quasar designed locating tooling positions the part to a fraction of these linear and angular tolerances.

Quasar PCRI systems use many types of positioning systems in production testing. These include servos, robots, conveyors, indexing tables, air cylinders, and hydraulic cylinders. Magnaflux Quasar has no preference for any particular positioning design so long as the positioning constraints are met. However it should be noted that systems based principally on hard stop air

cylinders may produce excessive conducted vibration and noise through the base and through the air if not sufficiently isolated from the Quasar PCRI system. This mechanical noise can interfere with the PCRI testing and compromise test results.

C. Design Guidelines

After placing many PCRI systems into production, Magnaflux has acquired a number of material-handling system design and integration “lessons learned.” These are provided as guidance in order to facilitate a problem-free project for the material-handling vendor and the ultimate customer. These are guidelines are summarized in Table 1. below.

Table 1. Design Guidelines

DESIGN GUIDELINES
Power and interlock designs should support safe, quick and easy manual tests. Access to the Quasar system is required during initial set-up and for periodic routine maintenance. Therefore, the system MUST have the capability to be operated by a person near the Quasar system in a safe mode. This generally means that door interlocks and safe mode material-handling states need to be incorporated into the material-handling system design.
To minimize integration time, alignment of the Quasar system subsystem requires a debug or single-step mode in the material-handling system. The material-handling system developer should incorporate a diagnostic panel or program in the PLC code (or human/machine interface software) that exercises all the outputs and senses all the inputs, independently from the main body of the control logic. If integration of these diagnostic panels is problematic, a separate program should be written.
The material-handling system CANNOT be mechanically connected or fixed to the Quasar system subsystem without introducing unacceptable noise into the data collected and compromising the test results.
Test parts cannot be dropped onto the transducers.
Test parts cannot be moved laterally or slid onto the transducers.
The test plane should be at a reasonable height (32 – 46 in, 0.8-0.9 m) above the floor.
All parties must provide adequate time in the implementation schedule for integration, test and correction of the Sorting Module in the integrated full system.
The customer must avoid locating the Quasar system near high current equipment such as magnetic particle inspection stations and induction heaters. If unavoidable, then either the Quasar PCRI system must be shielded from the radiating systems or it will be necessary to alternate between Quasar PCRI testing and operation of the high current flow systems.
The power off, no air pressure, lift default must protect the transducers (transducers are not to be exposed in this condition).
A customer preferred vendor list must be referenced in the design requirements provided at the outset of the project. This list must be made available to all parties responsible for any fabrication work prior to project initiation.
Quasar PCRI is a computer-based instrument; thus, the AC power must be clean and free of high current noise, spikes, or dropouts.
All inductive loads (relays and coils) driven by the PLC must be protected with back EMF diodes and in-line fuses to protect the PLC module.
All parties must avoid mixed voltage control logic wherever possible. That is, select 110 VAC or 24 VDC signaling and use that level exclusively. The Quasar PCRI system I/O is 24 VDC signaling.

Operation of a material-handling system without locating tooling requires a high accuracy multi-axis robotic system. This does not eliminate the need for locating tooling to accurately position hand-placed parts in a manual testing mode.
Isolation from high impact vibration sources may require cutting the concrete slab on which the Quasar system subsystem is mounted.
All parties should avoid the need for special tools and hardware to maintain the system.

D. Quasar System to Material-Handling System Decoupling

The design of the material-handling equipment must absolutely minimize transfer of acoustic energy to the Quasar system. The Quasar system must remain an isolated, separate physical structure. The material-handling equipment must not be fastened to the Quasar system structure, nor should there be any possibility of direct or indirect contact of any part of the Quasar Test Station by the material handling system on part placement or pick up. The Quasar system's only connection to the material-handling system should be via floor on which both are mounted. The Quasar system's isolation mounts allow the system to move slightly but not so far that it would impact material-handling system part placement.

CAUTION -- The material-handling equipment must not be fastened to or contact any part of the Quasar system structure.

E. Quasar System and Test Head Access

Several maintenance tasks require access to the Quasar system. The material-handling equipment must be designed so that adjustment and maintenance of the Quasar system can be efficiently performed. These activities include adjustments to the test head, as well as access to the electronics package in situ for trouble-shooting and repairs. Space must be provided to open access panels on the Quasar system and doors on the workstation. For multiple part systems, additional space must be provided to change the Quasar system test heads.

F. Multiple Part Test Heads

In some cases, a Quasar system may be used to test more than one part number. As described earlier, the locating tooling and transducer locations are unique for each part under test. If more than one part will be tested on a Quasar system but the parts are similar enough, they may be accommodated with multiple pins or other locating tooling and a single transducer location set. In this case multiple proximity switches can identify the part type. The Magnaflux Quasar standard design accommodates two part types but may be expanded to more depending on the design of the parts. Upon recognition, the part type is passed to the transceiver to select the proper Sorting Module.

In some multiple part cases the locating tooling must be changed and/or the transducer locations adjusted. This is accomplished by changing the removable Test Heads or a piece of the locating tooling. Each removable Test Head includes: the locating tooling, transducers, lift mechanism, and sensors. To change these removable heads, the operator slides the Test Head out of the Quasar system, disconnects the transducer, DeviceNet, and power cables from one head and reconnects them to another, then lowers the new Test Head back into the Quasar system. The Test Head is positioned by means of locating tooling in its base. The time required to perform this task is specified by the part customer but usually is in the range of 5 – 15 minutes.

Under some conditions it is possible to test two or more different parts in a mixed part stream. If the parts are similar enough that a single locating tooling set can properly locate the different parts relative to the transducers and proximity switches can determine which part is on a Test Head, then the software can select the proper Sorting Module for each part prior to testing.

One of the advantages of the Quasar locating tooling design is the ability to keep the part location the same for multiple parts even on different Test Heads. This enables the material-handling system to deliver different parts to exactly the same system X, Y, & Z coordinates.

G. System Integration

Integration includes several tasks:

- Definition of the specific interface elements.
- Specifying the interface.
- Validation of those interfaces.
- Physical integration of the hardware and software both at the material-handling contractor and the end user.

Tasks to be performed by Magnaflux Quasar must be identified and included in contracts with either the material handling contractor or with the ultimate customer. The level of support than can be provided by Magnaflux Quasar is limited, and dependent on these contracts. The following discussion identifies typical activities that should be included in these support contracts. **This discussion is included for example only. Magnaflux Quasar does not provide these support activities as part of a basic hand loaded system purchase unless explicitly called out in contract documents.**

Of particular concern in early interface document development is identification of customer equipment requirements and the determination how these will be folded into the final complete testing system. For example, if the customer requires that the new material-handling/Quasar PCRI system be physically integrated directly with existing customer conveyors, chutes, belts, or other equipment, the design of material handling and PCRI systems becomes much more challenging. This can be very difficult if examples of the customer equipment or even documentation of the customer equipment are not available at both the material handling and Quasar PCRI system development sites prior to the design of the Quasar PCRI and the material handling systems.

Validation of the control structure is typically straight forward since there is a clear delineation of responsibilities at the load and unload points. One means of validation of the interface is a structured walk-through of the total process logic. For each step in the process, each contributor identifies which signals are in play, what the signal states are, and which part of the system is in control of which process. This careful paper validation of the interface will help avoid problems in the actual hardware integration.

Magnaflux Quasar will develop an acceptance test Sorting Module on the Quasar PCRI system used in the production system. To do this, the customer must provide Magnaflux with an adequate number of properly classified parts for Sorting Module development. The quality of a Sorting Module is a function of how well the good and bad part variability is captured in the test part set. The actual number of good and bad parts required will vary with the part and the type of manufacturing process. The test part sets should represent the good and bad part variability possible in defects within batches and defects across batches. A minimum combined good and bad part set is at least 100 parts. See the Magnaflux Quasar User's Manual for a detailed discussion of these requirements. (See the Magnaflux Quasar Users Manual for a more detailed discussion of the sort development process also.)

Magnaflux Quasar assumes that an acceptance test will be conducted at the material-handling system developer's site. Any acceptance testing at the Magnaflux facility must be specifically identified and scheduled in addition to acceptance testing at the material-handling developer and customer sites.

To assist Magnaflux in integrating the Quasar PCRI system with the material-handling system, and the PLC or other control program, the material-handling system developer must provide a debug monitor to easily control and identify the states of each material-handling system input and output. Using this tool, any wiring issues or mismatches in signal definitions are easily identified and corrected. Another tool that the PLC or other controller programmer must have available is a process stepper which provides the means to quickly step through the overall material-handling process so the physical relationships between parts handling and Quasar PCRI can quickly and easily be established. Of particular interest are those steps associated with loading and unloading the Quasar system.

Acceptance requirements for the Quasar PCRI system at the material-handling contractor site must be specifically identified in the material-handling contractor/Magnaflux or Customer/Magnaflux contract. These acceptance requirements must include and identify which specific customer requirements flow directly to Magnaflux Quasar, and any material-handling system vendor requirements imposed on Magnaflux Quasar in the Magnaflux Quasar Systems Requirements Document.

Breakdown, repacking and shipping from the material-handling contractor site is the responsibility of the material-handling system contractor.

Magnaflux expects the ultimate customer and the material-handling system developer to provide power, air, and other utility connections or drops as required for the system. Acceptance requirements at the ultimate customer installation site must be established in the contract documents.

Magnaflux Quasar experience suggests that after the initial few set up days there is a period of several days to a few weeks during which the customer will require some level of on-site assistance. Subject to the terms of the contract, Magnaflux staff will be available for phone support and Magnaflux application engineers can be available to support this effort until the Quasar PCRI System is operating satisfactorily.

During the period immediately following installation, Magnaflux application engineers will be available to resolve issues, support changes, etc. After acceptance, Magnaflux Quasar has support personnel that can be made available via support contracts available that can be tailored to the needs of the material-handling contractor and the customer.

H. Development Scheduling

Typical durations of the various activities in manufacturing, delivering, and integrating a Quasar system with a material-handling system are as shown in Table 2 below.

ACTION	TIME REQUIRED	CALENDAR TIME
Initial interface definition	1 week	
Build up of Quasar system	4 weeks	
Sorting Module development	1 week	
Packing and shipping	4-5 days	
Delivery to material-handling developer		6 weeks
Integration with material-handling system	2-3 days	
Material-handling plant acceptance testing	1 day	7 weeks
Re-packing and shipping	2-6 days	
Customer plant acceptance testing	1 day	8-10 weeks

Table 2. Typical Simple Part Quasar PCRI System Delivery Schedule

These durations assume a parts handling system that does not require design modifications to the standard Quasar system for simple metal parts. The schedule also assumes a single part type, that the part's longest dimension is 12 inches (0.3 meters) or less, a part mass of 15 lbs (6.8 kg) or less, and that the other requirements described in this document are met. Additional inspections, such as Ontario Hydro Power will add time beyond these numbers. Figure 1 and Figure 2 below show a collection of simple and complex parts respectively. Specific schedule dates will be established upon purchase order acceptance.



Figure 1. Simple Parts, requiring simple Quasar system design.



Figure 2. Complex Parts, requiring complex Quasar system design.

I. Material-Handling Interface Tasks

Table 3 is a summary of the tasks performed by Magnaflux, a material-handling system developer and, in some cases, an outside third party such as a material handling equipment supplier. The boxes to the right indicate where coordination outside Magnaflux may be required. The

responsibilities assigned to Magnaflux and the material-handling developer must be established in the contract between these two parties prior to initiation of the project.

Table 2 Material-Handling Interface Tasks.

#	TASK	MagnaFlux	M-H Dvlp'r	End User	3rd Party
	In approximate order of completion				
1	Marketing & Production – gather customer requirements; testing specifications, design of & number of parts, timing, operational scenarios; schedule, quantities, environment; customer preferences, logistics, interface requirements to other equipment, establish footprint restrictions; qualification test requirements, number of parts, false accept and fail rates, time per part; get part drawings & samples, measure part samples; negotiate acceptance test procedure and acceptance criteria	X	X	X	
2	Accounting Financial & Cost Controls – set up project control, track costs, get invoice authorization, invoice customer; audit job costs & inventory	X			
3	Analyze requirements – develop functional flow, timing requirements, control computer implications, constraints driving hardware & software, customer requirements	X	X	X	
4	Design & document a top level specification – assemble customer hardware & software requirements, resolve conflicts, produce appropriate system level drawings and specifications	X	X		
5	Complete System Design Form – review all entries in the System Requirement Form (SRF) and answer all elements, obtain customer approval where required	X	X		
6	Sales – negotiate contract & purchase order, maintain liaison with ultimate customer, issue and receive P.O. technical confirmation in co-op with Magnaflux production, monitor project to assist in resolution of problems	X		X	
7	Develop conceptual approach – establish consensus on transducer location, establish capture & fixturing methods, specify top level layout, man/machine interface, timing allocations	X	X		
8	Develop mechanical & electrical approach – identify candidate systems, compare candidate capabilities; trade cost, performance, safety, availability; match systems to customer requirements, document approach	X	X	X	X
9	Develop software approach – identify candidate systems, compare candidate capabilities; trade costs, performance, safety, availability; match systems to customer requirements, document approach	X	X		X
10	Inventory control – coordinate project requirements with inventory, identify inventory issues or roadblocks to project, maintain adequate parts and raw material stock; research second sources; establish accounts; track order backlogs; identify shortages to production management	X			
11	Assimilate hardware data – gather vendor data, read documentation, identify specific hardware requirements, identify specific hardware and software interfaces, discuss capabilities and limitations with vendor representatives	X	X		X

#	TASK	Magnaflux	M-H Dvlp	End User	3rd Party
12	Assimilate software data – gather vendor data, read documentation, identify specific software requirements, identify specific hardware and software interfaces, discuss capabilities and limitations with vendor representatives	X	X		
13	Identify & order off the shelf hardware – select specific hardware from vendor catalogs, create POs, coordinate order and delivery, track order progress	X	X		X
14	Identify & order off the shelf software – select specific software from vendor catalogs, create POs, coordinate order and delivery, track order progress, follow-up on incorrect orders and changes	X	X		X
15	Conduct customer review – review design package with customer; obtain design approvals prior to start of fabrication process	X	X	X	
16	Design & document out-source hardware – develop top level and detailed designs for custom hardware, discuss project and manufacturing requirements with job shops, document designs and requirements, verify work accuracy & progress	X	X		
17	Design & document out-source software – develop top level and detailed designs for custom software, discuss the project and manufacturing requirements with the job shop, document designs and requirements, verify work accuracy & progress	X	X		X
18	Develop & document in-house software – convert system & subsystem level requirements to a top level language; code, test, and document interfaces; code, test, and document modules; identify & correct deficiencies	X	X		
19	Test in-house software – test assembled code, verify interfaces, design & build interface simulators, design & build hardware simulators, identify & correct deficiencies	X	X		
20	Build up hardware subsystems – integrate custom and off the shelf hardware, add interface openings, add hardware, identify & correct deficiencies	X	X		
21	Build up interconnecting subsystems – mark & wire cable bundles, mark & wire terminal connectors, fasten into bundles	X	X		
22	Integrate software with customer hardware – load, configure, and checkout software in customer hardware, identify & correct deficiencies	X	X		
23	Integrate hardware & software in the subsystems – connect & verify hardware & software interfaces, verify low level operation to requirements, identify & correct deficiencies	X	X		
24	Integrate subsystems together – connect & verify subsystem hardware & software interfaces, verify subsystem operation to requirements, identify & correct deficiencies	X	X		

#	TASK	Magnaflux	M-H Dv/pr	End User	3rd Party
25	Internal system level test – get, handle, & store statistical sample parts set, verify parts test operation to system level customer specification, identify & correct deficiencies	X	X	X	
26	Customer qualification test – conduct customer monitored test to verify operation to system level customer specification, conduct customer monitored test of a statistically significant sample to the customer specifications; correct deficiencies if required	X	X	X	
27	Documentation – gather subsystem documentation, system drawings, parts lists, develop system operation materials & maintenance materials; establish single configuration management file	X	X		
28	Prepare system for shipping – arrange for shipping, gather destination data, disassemble subsystems, package, and mark for shipment	X	X		
29	Shipping – ship to material-handling developer and/or to ultimate customer				X
30	Off-site training – train customer personnel in Quasar PCRI testing, basic software operation, Sorting Module development, and production software operation	X		X	
31	On-site installation & training – install the system at the customer site, resolve issues with the site environment, checkout subsystems, verify system operation, train customer personnel in system operation, software modification paths & limits	X	X	X	
32	Customer qualification test – conduct customer monitored test that repeats the in-house acceptance test to verify operation to system level customer specification, conduct customer monitored test of a statistically significant sample to the customer specifications, correct deficiencies if required	X	X	X	

J. Timing

Given a stream of parts presented to the Test Head, the sequence of events in a typical Quasar PCRI test is as shown in Table 3.

Table 3 PCRI Test Sequence

1.	Place a part on the Test Head; the part proximity switch goes true and the thermocouple equilibrates to part temperature.
2.	Delay for manual material-handling if required.
3.	Measure part temperature.
4.	Move the part into the test position; wait for the part to settle.
5.	Request a Quasar test; set the Quasar busy line true.
6.	Acquire the Quasar test data.
7.	Issue a Quasar test result.
8.	Set the Quasar busy line false.
9.	Return the part to the load position.
10.	Remove the part from the Quasar system; the proximity switch goes false.

The time required to test a part is dependent upon the part shape, material, size of the defect to be detected, coupled with the part handling time. The actual Quasar test time is typically between one and six seconds depending on the part. Many fully automated Quasar systems overlap material-handling activity with PCRI testing. This imposes additional noise isolation requirements on both the Quasar system and the material-handling equipment to assure that material-handling generated vibration noise does not affect the PCRI testing. In addition to the actual Quasar test, other requirements that may increase the overall test time and reduce throughput include:

- Time for communication with the transceiver.
- Waiting while the thermocouple equilibrates at the part temperature.
- Time to lift or lower the part onto the transducers.
- Time to allow the part to settle onto the transducers.

Table 4 lists the typical times required for each of these process elements. Usually, the Quasar test time dominates the total test cycle. Where the test time total is not critical, additional delays may be inserted to improve material-handling or display readability.

The minimum total time for a Quasar test cycle is about 1.5 seconds. Some parts can be tested quickly but most parts will take significantly longer than this minimum. The Quasar test time is a function of the number of frequencies that must be swept and the specific data collection parameters. It is during the actual Quasar test when data is being collected, that minimizing parts handling noise is important, although this is the time that a material-handling system is typically moving parts. Since overlapping testing with parts movement provides the customer with the greatest throughput, Magnaflux and the material-handling vendor must work together closely to make appropriate compromises to maximize throughput while maintaining an appropriate testing environment.

Table 4 Test Cycle Elements

ELEMENT	TIME (Seconds typ.)
PCRI Test	1.0 – 20.0
Raise/Lower Part	0.1 – 0.2
Part Settling	0.1
Temperature Measurement	0.05 – 0.2
Communication	0.05 – 0.1
Total	1.5 - 8

Raising and lowering the part or the transducers is accomplished with an electric lift in most installations. The time required for this movement depends on the direction of movement, and the settings in the lift controller. The lift is set to place the part onto the transducers slowly to minimize the part bounce. Even with a restricted placement, the PCRI test is delayed after transducer contact by approximately 100 ms to assure that the part is firmly resting on the transducers and not ringing due to the impact when the Quasar transceiver initiates the part scan.

The time required to measure part temperature is generally much smaller than the time it takes the transceiver and the control computer to react to the result. Typically, the Quasar system pauses for 50 ms or more for the thermocouple to reach the part temperature. The communication delays shown in Table 4 are associated with serial communication between the transceiver, the control computer, and the Quasar system. The communications rate is typically about 10-20 Hz. Other communication delays are imposed by the response of the control computer's Windows operating system.

Figure 1 shows the relationship between the signals for various sensors, indicators, delays and testing. The part arrives and the part in place sensor(s) goes true. After a small delay for the thermocouple to reach the part temperature, and in a manual loaded environment a longer delay

for the operator to properly orient the part, the part is moved to the test position. Another short delay assures that the part is not moving when the test request is made. The transceiver requests and receives the part temperature and then starts the resonant testing. Once the test is complete, the transceiver sends the test result to the Quasar software and indicates that it is now available for another test. Once the transceiver is no longer busy, the part is returned to the load position, the part in place sensor(s) goes true, and the part is removed.

The PH Clear signal is an input to the Quasar system. There may be one of these signal lines for each test head or a single common one for all heads simultaneously. This is an optional signal that is available to maximize throughput. Without this signal the Quasar system must delay lifting the part for the maximum time it takes the material handling system end effector/gripper to move outside the vertical motion envelope of the Quasar system test head. As shown in the above graph, the signal must be false when the part is placed on the Quasar system and true for the Quasar

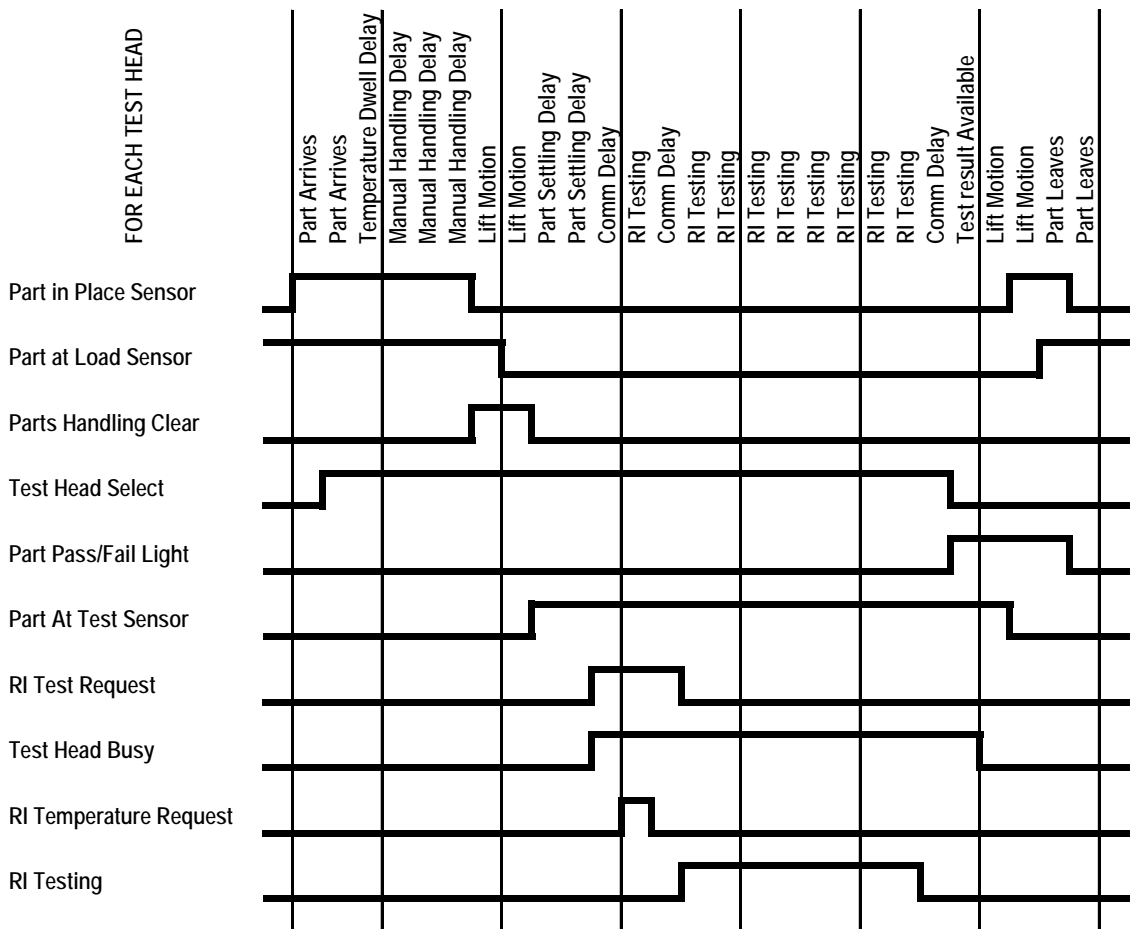


Figure 1 PCRI System I/O Timing

system to lift the part to the test position. At any other time this signal is ignored. Since this is an option, the connection to this signal must be expressly setup for each particular system.

K. Throughput

The throughput of the Quasar PCRI system alone, independent of the material-handling system, is shown in Figure 2 below. This throughput is for a dual test head system with a single transceiver. The performance shown does not include any external delays such as would be required when interfacing to a material-handling system. For the shorter sorting times and higher throughput values, any test messages to the operator such as test results would not be on the production display long enough for the operator to read them. Any point in the green or green-striped area is a safe operating region. The area below the blue line is essentially a “no risk” throughput performance region. The green striped area is the maximum practical performance. The red is an area of high risk; any external delays will decrease the throughput below the values shown. The top of the red is the absolute maximum performance of the Quasar system without any limiting external factors.

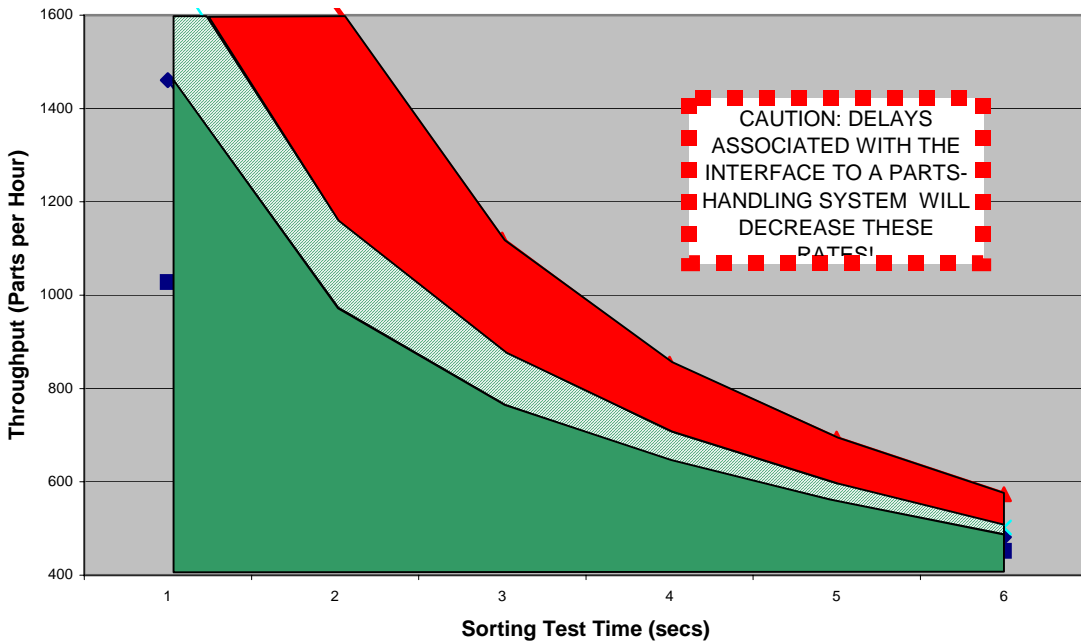


Figure 2 Quasar PCRI systems Throughput.

L. Ladder Description

The ladder consists of a main program and several subroutines. A flowchart for the main program and the Quasar system test head operations subroutine are available on request. The flowcharts provide a simplified view of the decisions made by the ladder and how they affect the testing process. A flowchart is not provided for the remaining subroutines which are relatively short, simple, and self-explanatory. Only the startup and Quasar system operations subroutines are called conditionally. The remaining subroutines are scanned during every ladder scan. This structure limits testing to when the Quasar system hardware and the control computer software are ready while assuring that the communication links and temperature measurements are as up to date as possible. As shipped, the ladder scan time is on the order of two milliseconds.

M. I/O List

The Quasar system design simplifies the interface to a material-handling system. All testing operations are divided into two elements: those directly associated with testing the part and those associated with getting the part to and from the test head. The ladder controls all the tasks directly associated with Quasar testing the part. The material-handling PLC is only required to control the parts loading and removal tasks.

The DeviceNet network is organized as follows:

Node 1	Scanner
Node 6	DeviceNet to Ethernet Bridge (Used in Commissioning only)
Node 11	16 input, 16 output Armorblock 24VDC module
Node 13	Quasar Head Identification Dongle
Node 15	2 input TC/mv input module

The network also includes five 16 input/16 output modules at nodes 31 through 35. These modules are not populated in the hardware but the nodes are available for use by the material handler if they chose to use the Allen-Bradley MicroLogix 1500 to control the material handling system.

In a dual head system there are two of the above networks with identical network addresses. The only difference between the two is one scanner is on slot 1 and one scanner is on slot 2 on the PLC backplane.

Only a very few of the PLC bits are required for operation of the Quasar automatic mode. Table 5 lists the inputs to and outputs from the Quasar system available in the MicroLogix processor on the DeviceNet. The table assumes a dual test head Quasar system. For a single test head Quasar system, the second set of the numbered variables is not available. Each bit is discussed in the following paragraphs. The inputs and outputs are relative to the Quasar system, that is, an input listed in the table is an input to the Quasar system.

When the power up process is complete, the Master System Ready bit is set true. At this point the Quasar PCRI system is capable of running in either a manual or semi-automatic mode. No activity will occur however, until a part-in-place (PIP) proximity sensor goes true. This happens when a part is placed on the test head tooling.

Table 5 PCRI Quasar PCRI System Inputs and Outputs.

DATA TAG NAME	INPUT/OUTPUT
Material-Handling System Ready (PH_PLC_Rdy)	Input
Material Handling System Clear (Matl_Hndlg_Clr)	Input
Material-Handling System PassThrough	Input
Master System Ready (Master_Sys_Rdy)	Output
Test Head 1 at Load (Nst_1_At_Load)	Output
Test Head 1 Part in Place (Nst_1_PIP)	Output
Test Head 1 New Result (N1_New_Result)	Output
Test Head 1 Part Pass (N1_Part_Pass)	Output
Test Head 1 Part Fail (N1_Part_Fail)	Output
Test Head 2 at Load (Nst_2_At_Load)	Output
Test Head 2 Part in Place (Nst_2_PIP)	Output
Test Head 2 New Result (N2_New_Result)	Output
Test Head 2 Part Pass (N2_Part_Pass)	Output

Test Head 2 Part Fail (N2_Part_Fail)	Output
Material Handling System Clear Head One	Input
Material Handling System Clear Head Two	Input
Hardware Verification Request/Test	Input/Output
Quasar PCRI System Fault	Output

Where a DeviceNet network is not available at the external material-handling PLC, the bits shown in Table 6 can be brought out to hard-wired digital I/O points for interface to a material-handling controller. This simplified material-handling system interface is provided on an ILME connector on the side of the work station. The Quasar system utilizes nominal 24 VDC signaling logic. Unless otherwise indicated, all signals are TRUE when HIGH or near 24 VDC. The input and output designations are relative to the Quasar system PLC, i.e., an input in the table is an input to the Quasar system PLC.

Once the startup functions above are complete (a delay of a fraction of a second), automatic testing using the simplified interface with a material-handling system is as follows:

To load a part, the material-handling system waits until Head “n” ready to load signal is true. Once the part is placed on the locator tooling, the Quasar system Part in Place sensor will go true. There is a slight delay (approximately 50 ms) while the temperature of the part is taken. The material-handling gripper must be completely clear of the part and the test head fixturing at the end of the temperature delay. If the material handling end effector is clear (Material handling system clear = True) then the Quasar system will move the part to the test position.

To pick up a part, the material-handling system waits until the head “n” ready to pick up signal is true. Prior to the part pick up, the material-handling system should note the head “n” part test result for use in disposition of the part. This is because the part result is maintained only while the part is on the capture plate. Once the part is removed the Quasar system Test Result bits will go false. Setting the material-handling pass through bit allows parts to move through the Quasar system without testing.

This part delivery and pickup sequence occurs in two different ways on dual test head Quasar systems. The Quasar PCRI system operates in either a sequential or overlapped manner. The system manager selects which manner in the PCRI configuration control software. When the sequential function is selected, all test head activity occurs only on one test head at a time. For the overlapped case, all test head activity except the PCRI test itself can overlap. The latter, overlapped case, provides the maximum testing throughput. If the material-handling system does not operate as fast as the Quasar PCRI system, sequential operation should be selected.

N. Environmental Requirements

The PCRI System environmental requirements are easily met as evidenced by the fact that Quasar systems are currently operating in forging, powdered metal and casting production environments in North America and in Europe. However some care is necessary in placing the systems in these environments relative to other systems. The Quasar system requirements are summarized in Table 6 below.

Table 6 Environmental Requirements

SYSTEM	REQUIREMENT
Acoustics	Quasar PCRI testing is an acoustic process. The Quasar system includes shock isolation effective in most production environments. The material-handling system must not generate noise that has a transmission path to the part during the PCRI test.
Compressed Air	Dry filtered air at 60-90 PSI, with minimal volume. (Not required on all systems. Check the Systems Design Requirements Document for each system.)
Condensed water	The PCRI System must not be stored or operated in a water-condensing environment.
Dry Parts	The PCRI System is designed to test dry parts. More than a film of any kind of fluid on the parts changes their response in the PCRI system and may adversely affect test results and component life.
Electrical Noise	The PCRI System must not be powered from the same circuit as noisy high current devices such as fractional horsepower or greater electric motors.
Fluids	The transducers and electrical equipment must not come in contact with cutting oils, lubricants, rust inhibitors, solvents, etc.
Electric & Magnetic Fields	Electric & magnetic fields from magnetic particle test equipment, induction furnaces or other high current devices can interfere with the PCRI System electronics and cause distortion in the PCRI video displays. Choose a PCRI System location so that exposure to electric and/or magnetic fields is minimized.
Power (to cabinet)	The customer will provide conditioned power at 110/220 VAC, 50 - 60Hz, Single Phase, 15 amp service unless otherwise specified.
Temperature	The operating temperature range is 40° to 120°F (5° to 50°C). The storage temperature range is 32° to 140°F (0° to 63°C) non-condensing.

O. Magnaflux Responsibilities

Where the customer or a third party contractor is responsible for the material-handling system, Magnaflux will provide support of the PCRI System during the development of the material-handling system and during the installation and checkout in the ultimate customer's factory. Generally this will require phone support and possibly a limited time on site.

Magnaflux can provide additional, more intense support as listed in the following table. This support must be specified in the contract with Magnaflux prior to initiation of the project.

Table 7 Additional Magnaflux Support Tasks (must be stipulated)

1	Technicians to support the packing and unpacking process at the material-handling contractor site.
2	Technicians to install the PCRI system at the material-handling system contractor site.
3	Application engineers to assist in the physical integration of the Quasar system with the material-handling system at the material-handling contractor site.
4	Technicians to support the packing and unpacking process at the ultimate customer's site.
5	Technicians to install the integrated system at the ultimate customer's site.
6	Application engineers to assist in the physical integration of the PCRI with the material-handling system at the ultimate customer's site.
7	Application engineers to assist in checkout of the integrated system at the ultimate customer site.

P. Documentation

The material-handling contractor must provide to Magnaflux contact information for resources and documentation for equipment used in their system such that Magnaflux can support the resolution of any integration or operational issues that may arise. At a minimum this will include:

- All customer requirements including operating constraints, number of operators, throughput, input and output constraints.
- All customer facility constraints such as power limitations, air availability, total system footprint limitations, access limitations.
- Initial interface specifications.
- Integration plans & schedules.
- Final material-handling system documentation including system drawings, schematics, and operating manuals.
- The PLC ladder or other control programs as appropriate.

– END –