



**SDI-5330 Immersion System for
Pulse Echo Plate, Billet and
Composite Inspection**



Note: This specification is for a typical SDI-5330 Inspection System and is for information only. The details may differ significantly from those proposed for specific customer requirements. The specification provided in the Statement of Compliance and formal quotation supersedes this document.



1 INTRODUCTION

This specification details the SDI-5330 precision immersion system suitable for a variety of high performance C-scan applications. The system is widely used for the production inspection of metallic raw material, advanced composite and metal bonded components.

High speed contour following capability is available for back wall following plate inspection or PE inspection of complex laminate parts. A number of transducer assembly options are available including linear phased arrays for composites. It can be supplied with a variety of parts positioners such as turntables and rotators, and with multiple search tubes or transducer assemblies to increase the throughput.

The motion control, data acquisition and instrumentation components can be installed in a system control room, or operated from a shop floor console. It incorporates the MasterScan motion control and WinScan data acquisition packages, which are among the most powerful in the industry, together with SDI's ultra-low noise servo drive components. All components/modules used in the system are designed and manufactured in-house by SDI in their Camarillo, CA facility.

The design features a rigid aluminum heavy box section bridge, supported by a stand-alone gantry configured for the specific application. The bridge carries a number of heavy duty search tubes and gimbal assemblies. In the standard configuration all drive components are housed in a control console, together with the motion control and acquisition computers. Apart from the extremely low current ultrasonic signals, only low voltage drive voltages are present on the bridge and gantry making the system design extremely safe.

2 SYSTEM FEATURES

- Scan speed up to 24 ips.
- Linear Amplifier UT for greater defect amplitude resolution.
- Log Amplifier UT for greater dynamic range.
- Optional coordinated parameter control – instrument parameters such as gain and gate position can be built into a scan plan as additional coordinated “axes” changing at rep rate speeds.
- 130 dB dynamic range.
- 40dB Distance Amplitude Correction.
- Multi-processing allowing scans to be analyzed while they are being acquired.
- Auto-normalization and auto-teach of scan profiles.
- Complex curve following in any orientation, with 3 point part location.
- Optional full waveform capture usually used with mini-scan described below.
- Return to defect – automatic return to ROI identified by the operator.
- Mini-scan – automatic re-scan around ROI for defect analysis.
- Absolute encoding eliminating the need for frequent homing even after activation of collision switch or E-stop.



- 3D to 2D image mapping for accurate flaw sizing.
- Optional automated pen marking controlled from image analysis station.
- Linear phased array option with integrated Olympus Tomoscan.

3 MECHANICAL CONFIGURATION

The mechanical configuration is outlined in the attached concept drawing. All gantry members are welded box section. The gantry is mounted directly to the floor with a recessed or above floor sump fitted with water containment and recirculation components. The main bridge assembly is fabricated from welded aluminum tube forming an extremely rigid and stable box girder platform. Y axis carriages are mounted on ball shafts, with helical rack and pinion drive. The Z axis search tubes are designed to accept a range of interchangeable gimbal assemblies for various applications.

The axes of motion provided on the system are shown in the table below: Typical ranges are given. These will vary according to customer requirements.

Axis	Description	Range in.	Speed	Resoluti on	Accuracy
X	Primary axis along the frame. Bi Polar d.c. servo drives with resolver and high precision toothed belt transmission.	96-600	24 in/sec	.001 in.	.004 in/ft
Z1, (Z2)	Vertical column rack and pinion drives. Bi polar d.c. servo drives with resolver.	36-96	4 in/sec	.001 in.	.004 in/ft
Y1, (Y2)	High precision toothed belt drives with Bi polar d.c. drives and resolvers	60-144	12in/sec	.001 in.	.004in/ft
A1, (A2)	Gimbal in X, Y plane	+/-90deg	30 deg/sec	.01deg	0.01deg
B1, (B2)	Gimbal in Y, Z plane	+/-90deg	30 deg/sec	.01deg	0.01deg

There are a number of dual search tube options. For plate inspection, either X or Y scanning can be used. For Y axis scanning, the two search tube can be set up to scan different regions of the Y axis, with identical transducers, with or without overlap. Alternatively, one search tube can be equipped with a paintbrush transducer for an initial coarse scan, and the other with a spot focus transducer for defect evaluation. The system can be made to automatically perform a defect evaluation mini-scan, with full waveform capture, for every indication meeting the defect criteria used in the automatic cluster analysis.



3.1 Gantry-X Axis.

The gantry is fabricated from heavy steel box section with a high redundancy outrigger design calculated to provide the required rigidity and stability for the large accelerating mass of the bridge and search tubes. The gantry is fitted with ground tracks with leveling jack screws and guide bars. Mounted to the tracks are the linear ways and heavy duty rack and pinion drive components to provide precise positioning and encoder feedback. The gantry also carries the cable distribution components. All drives are closed loop d.c. servos with encoders/resolvers.

3.2 Bridge Y Axis

The bridge is fabricated from heavy aluminum box section with a rigid box girder construction. Mounted to it are the precision V ways for the Y-axis carriages which support the Z-axis vertical drive housings. The design incorporates methods of adjusting to orthogonality and alignment of the X, Y and Z axes.

3.3 Search Tubes Z-Axis

The search tubes incorporate several novel design features to provide the required adjustments and accuracy to maintain the alignment of two independent search tubes during high speed 3D contour following. The stainless steel cruciform construction, precision rack and pinion drive and V ways provide single search tube systems with these benefits even though the alignment requirement does not exist.

3.4 Gimbals

The gimbals are zero backlash harmonic drive servos with integral high precision resolvers. The units are housed in oil filled stainless steel enclosures. The transducer is attached to the gimbals by a UHF mount.

3.5 Parts Positioners

There is an extensive range of parts positioners available. Motorized devices include turntables, horizontal rotators, and head and tail stocks for large irregular shaped components. In addition, work support fixtures are available ranging from heavy duty supports for plate and billet to universal part fixtures for airframe components.

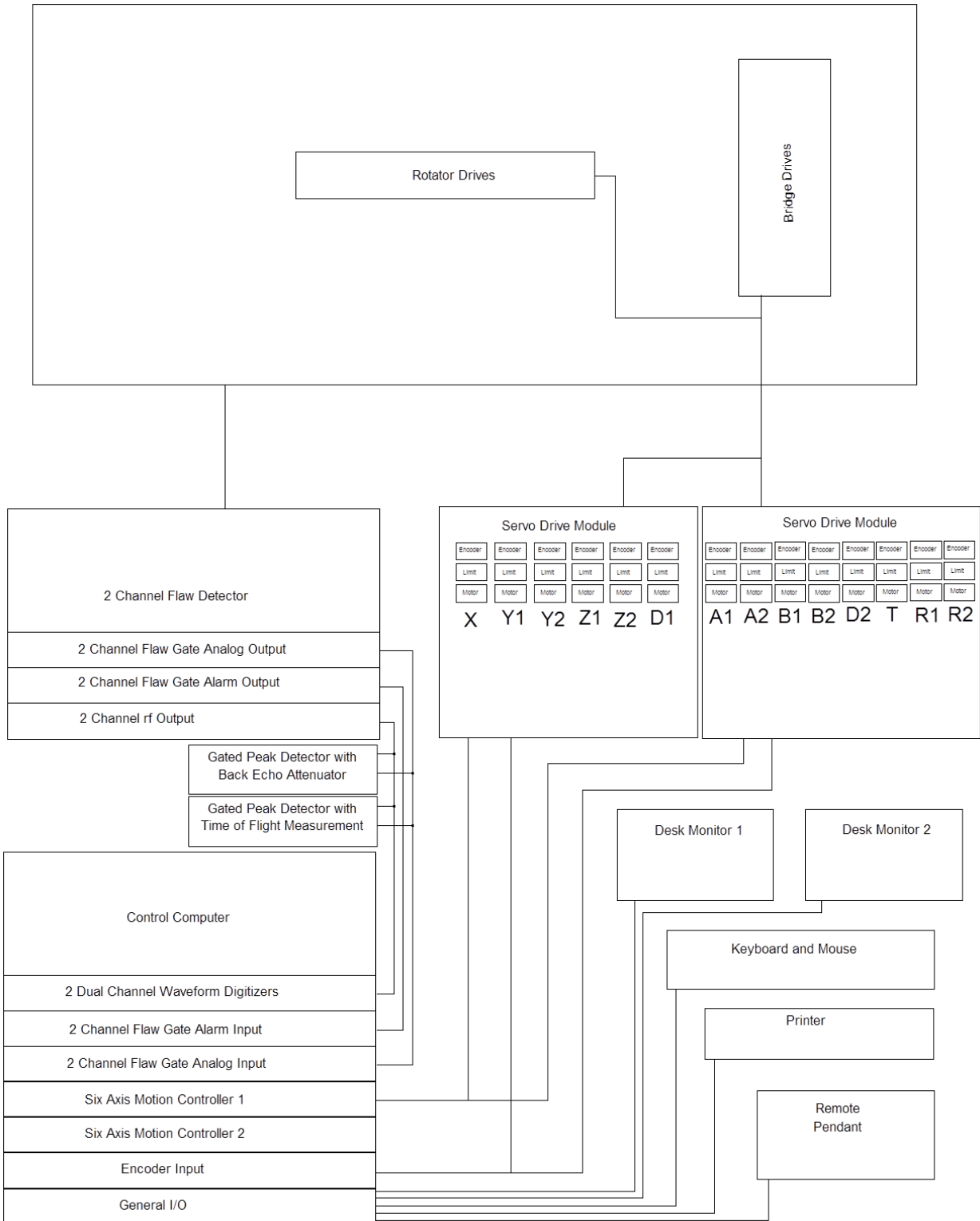


4 ELECTRICAL CONFIGURATION

The electrical configuration describes the components and interconnections for the motion control, drive, instrumentation and data acquisition sub systems. The majority of the components are housed in the system console. All system components meet applicable US and International safety codes. Apart from the very low current ultrasonic signals, no voltages greater than 70 volts are present anywhere on the system outside the control console.

Control Console. The mobile control console can be positioned anywhere within reasonable distance from the system. Current SDI systems have similar remote consoles up to 80 ft. from the scanner. It is fitted with two 21 inch monitors linked in the Windows operating environment to allow windows to be dragged from one screen to the next, or expanded over two screens. The console requires a single 110V 60 Amp single phase supply. SDI will install the necessary transformers to achieve this from the customer's supply. The console houses all the computing, drive and instrumentation components required to operate the system. The enclosure includes a filtration and refrigeration unit.

The electrical layout is shown below





5 INSTRUMENTATION

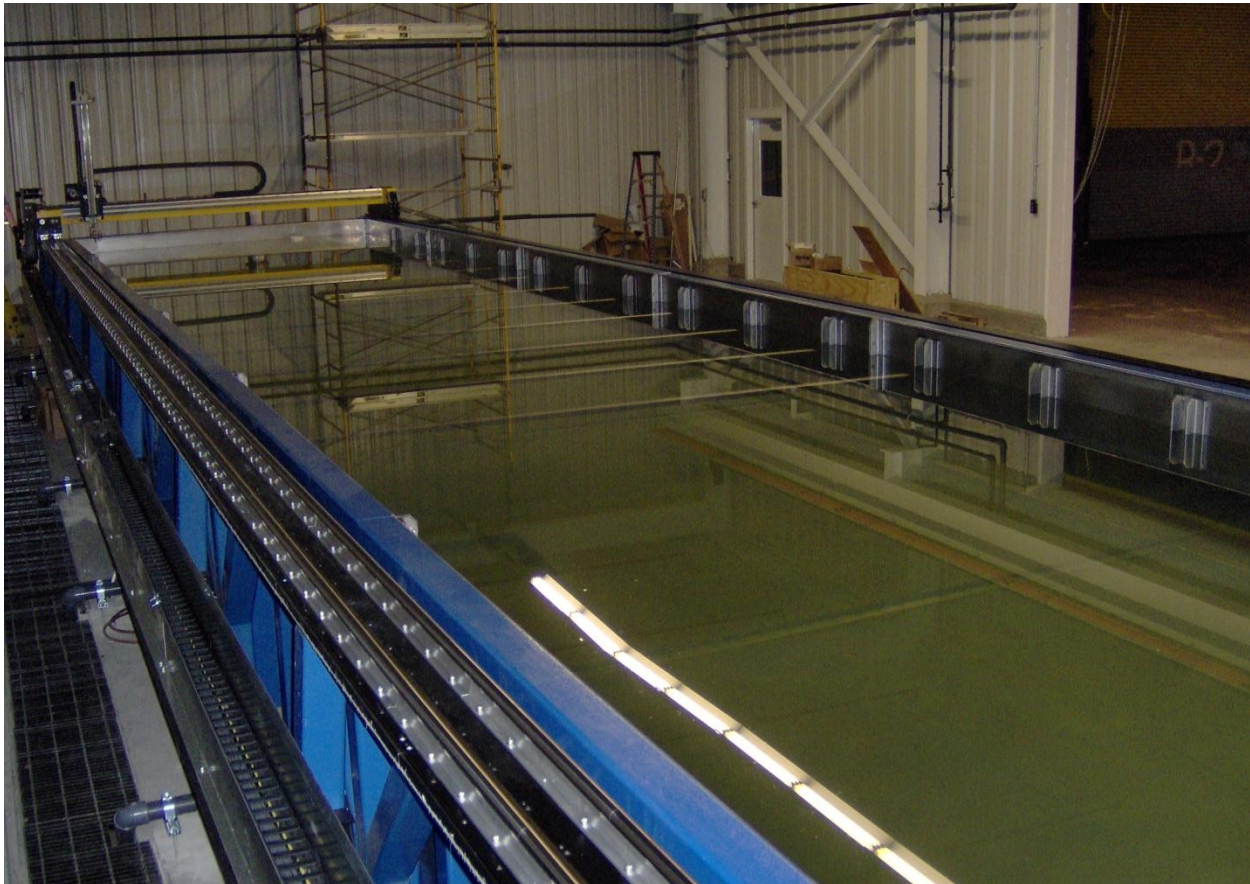
The system can be supplied with any third party systems instrument such as the Socomate USPC3100-2, two channel unit. When installed with the SDI sequencer unit, the system can be configured to be able to provide simultaneous pulse echo from each side together with two through transmission tests, resulting in the acquisition of four channels of data in a single scan. A range of auxiliary instrumentation can be provided to aid in the inspection of the more complex highly attenuative lay-ups. This will include log amplifiers, pre-amplifiers, tone burst pulsers and air transmission modules. With the SDI dual frequency transducers, scans can be performed at two frequencies simultaneously.

Linear phased array systems are available with the Olympus phased array hardware and software fully integrated with SDI system control.

6 MOTION CONTROL

The motion control is provided by the SDI-1830 MasterScan advanced controller. Designed specifically for ultrasonic applications, it features ultrasonic functional axes and scripted scan plans. This means that complex motion control and acquisition activities unique to ultrasonic inspection techniques are available to the operator through simple commands using ultrasonic terminology. The operator can construct complex scans by chaining together individual motion commands, scan plans and instrument set-ups. Full details of MasterScan are given in the data sheet. Some of the key features are:-

- Functional axes using standard UT terminology
- Import/Export of scan plans to CAD programs
- Automated normalization
- Auto teach of scan plans
- Integrated instrument control coordinated with the motion along a scan trajectory.
- Scripted scan plans
- Chained scans
- Dual independent search tubes performing different scans simultaneously.
- Stop on defect
- Return to defect
- Display of scan progress and time to finish.
- 3 point relocation to allow rapid scan setup from previously taught scan plans.



7 ACQUISITION/ANALYSIS

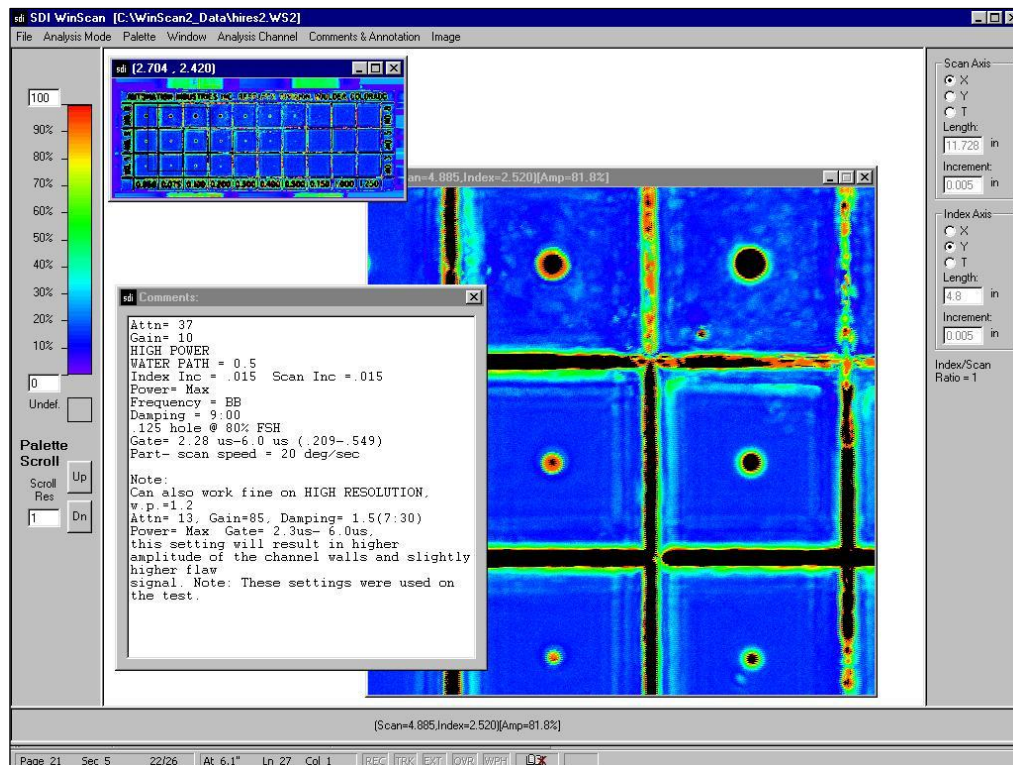
The system is supplied with the latest SDI-WinScan multi-tasking acquisition and analysis package designed for high throughput production applications. A technical description of the features and benefits of this high performance industrial package is attached. Some of the key features are :-

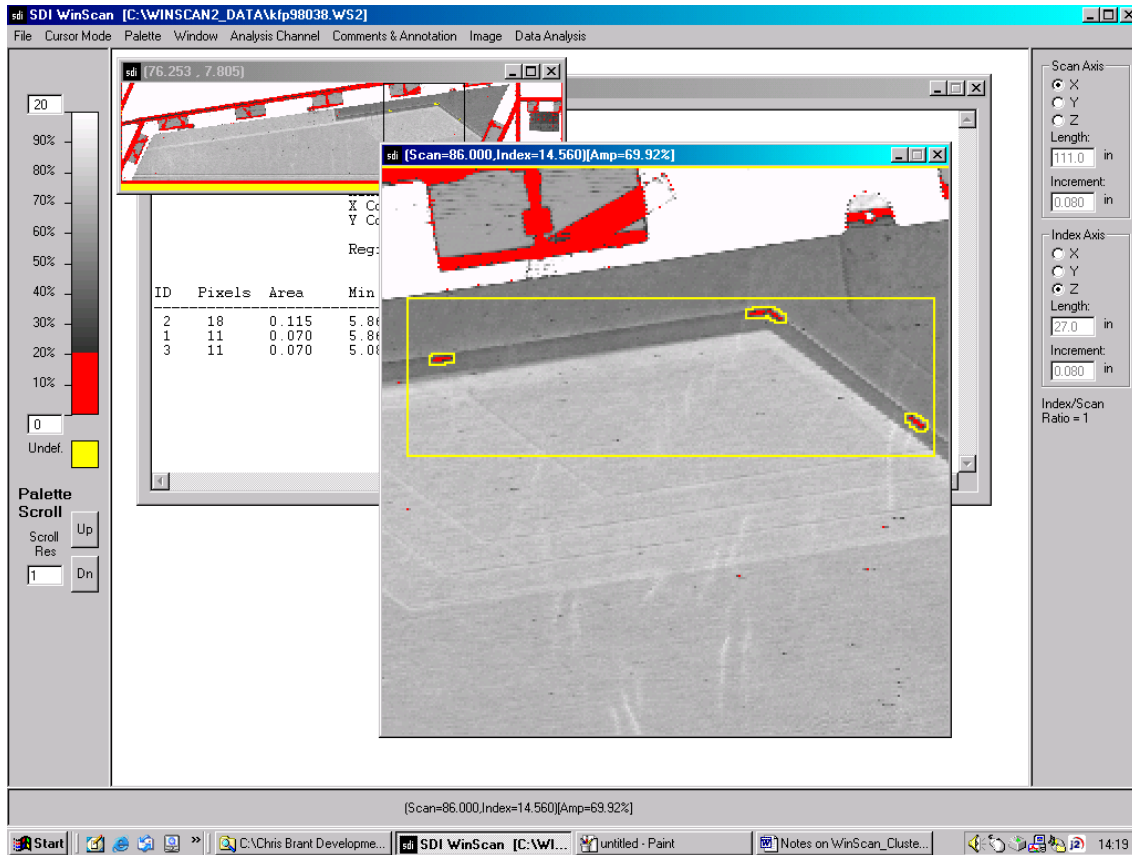
- High-speed pan and zoom through entire data file
- High speed, high quality 1:1 plotting of all or selected areas of the data file.
- Scan comments stored with the data file.
- Multi-channel operation.



- True multi-tasking to allow scanning, plotting and viewing of stored files to be performed simultaneously without a reduction in speed.
- Numerous analysis features such as histograms, in dB and linear scales, cluster analysis providing automatic defect identification, image smoothing and filtering with operator defined kernels.
- Full Waveform Capture with B-Scan

Another time saving feature of the fully integrated motion control and data acquisition package is the ability to perform mini-scans. Areas of interest can be tagged on the data file and the system will automatically drive back to them and re-scan the area using selected defect evaluation scan parameters such as full waveform capture.





8 . INSTALLATION

The system will be fully assembled and made operational at the SDI facility in Camarillo for customer buy off. The Acceptance Test Procedure (ATP) will be carried out using the test samples supplied by the customer. SDI will address any items requiring rectification prior to authorization for shipment by the customer representative. Upon receiving approval, SDI will dismantle, crate and ship the system. SDI will carry out site preparation prior to the arrival of the system. The system will then be assembled and made operational on site. The ATP will then be repeated. The system timeline is attached.

9 . TRAINING

SDI provide a comprehensive training program including 5 days training of personnel in the operation and routine maintenance of this equipment. This training will take place either at the SDI facility or at the customer site after installation.



10 . CUSTOMER SUPPORT

10.1 . Customer Support Department

SDI can offer 24-hour response to all product support requirements to ensure minimal equipment downtime.

10.2 . Field Service Organization

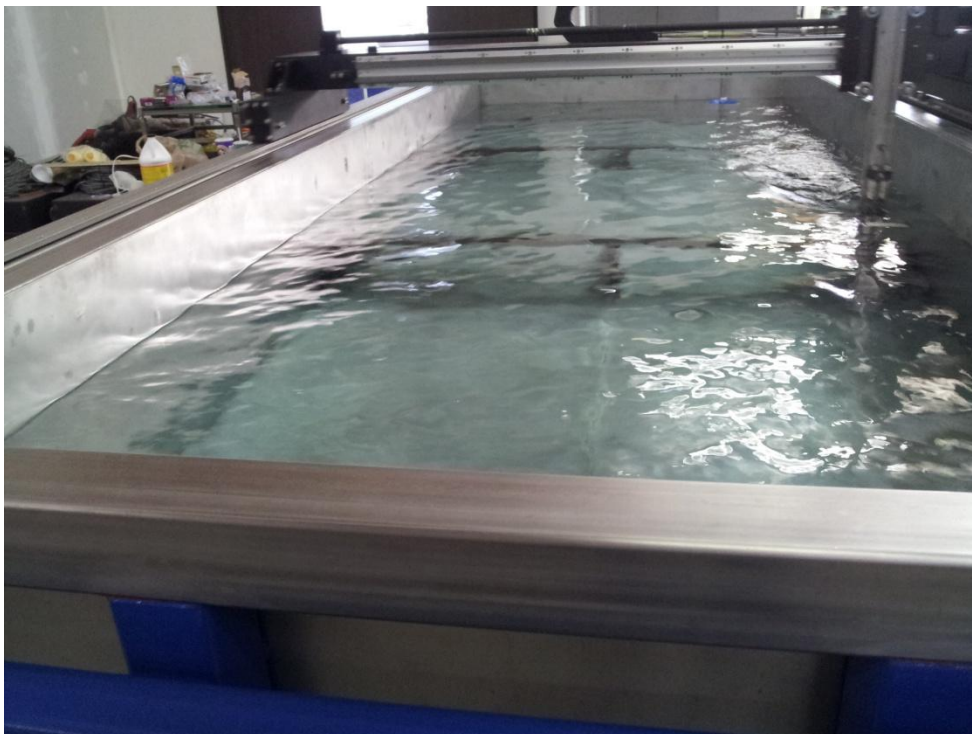
SDI has a domestic and overseas field service organization to provide post installation service and maintenance on installed systems

10.3 . Spare Parts

A recommended spare parts list will be provided with the system. Replacement of these recommended spares will be covered in the maintenance training given with the system.

10.4 . Technical Support

Technical support and engineering staff at the SDI facility a available for telephone support as required. All customers are offered free consultation via phone or fax.





Summary Of Features

ITEM	FEATURE	DESCRIPTION
Part Teaching		
1	Auto-normalization	Automatic maximization of the pulse echo signal from the part surface at a position selected by the operator
2	Auto-Teach	An automatic sequence of repeated auto-normalization and point recording at specified spacing over the part. Scan can be set to start automatically after the auto-teach is complete.
3	3 Point Correction	Scan plans can be stored with 3 reference points. If subsequent scans of similar parts need to be performed at different locations in the scan volume, it is only necessary to teach the three reference points and the stored scan plan will be re-oriented to the new location.
4	Point Reversal	For occasions where it is beneficial to teach profile in one direction and scan in another, it is possible to reverse the order of taught points, and reverse order of profiles
5	3D display of current taught points and surface	A 3D display of the part surface and gimbal positions is generated as the part is taught.
6	XYZ file Import/export.	The part shape can be exported as an XYZ file of the surface coordinate points. In addition, CAD files converted to XYZ can be imported to aid in part teaching.
Motion Control		
7	Functional Axes	Calculated functional moves, tangential A, tangential B, rotation about pivot point, water path, can be moved as a single axis through jog pad or screen jog.
8	Zonal Speed.	The scan can be split up into 10 zones each with a different scan speed.
9	Absolute Encoders,	Maintain position of up to 16 axes at all times. Allows



ITEM	FEATURE	DESCRIPTION
		rapid resume after E stop with no homing requirement.
10	Scripting	A sequence of previously stored scan plans can be executed automatically
11	Nesting	A taught scan plan can be executed a number of times with offsets for an array of parts mounted in the same fixture.
12	Instrument Integration	Instrument parameters such as gate position, gate width, gain etc can be integrated into a scan plan as a virtual coordinated axes. i.e. gain or gate position can vary along a scan line.
Data Acquisition		
13	A, B and C scans.	A, B and C scans can be captured and stored. (B scan only when full wave form capture option is installed).
14	Full Waveform Capture	A 200MHz waveform digitizer is used to acquire the entire waveform over a specified area. Although it is possible to acquire over the entire part, this feature is usually used with the miniscan feature described below.
15	Sampling Options	Standard data sampling for amplitude and thickness is performed at 12 bit resolution. Sampling can be selected as pulse on position (POP) or over-sampling. Over-sampling provides enhanced data fidelity by sampling multiple times for each data point and then allowing the highest, lowest or median to be stored for that point.
16	Scan Re-Start	Scans can be restarted after power outage, E stop, collision etc and continued from any point on the scan plan specified by the operator. The data collected so far is overwritten if the operator chooses to restart in an area previously scanned. This feature can also be used if the operator wishes to perform a scan of a smaller area of a previously stored scan plan.
17	Data Swathing with Multiple Transducers	For components with little or no curvature multiple squirters can be added to the search tubes. The additional squirters are offset in the X and Y directions a whole number of sample points. The motion control and acquisition will then perform a sequence of swaths which



ITEM	FEATURE	DESCRIPTION
		are reconstructed into a single data file.
18	Double Indexing with Averaging	Several users have the requirement to perform double indexing. This is where the scan increment is, say .040, but the index is .080. The SDI software has the ability to insert an averaged scan line between the actual scan lines, thus all data pixels remain as .040 x .040.
Data Analysis		
19	Log or Linear	Data can be analyzed as log or linear data. A full range of standard palette manipulation features is included.
20	Data Annotation	A wide range of data annotation options are included. The annotation is stored along with the data file without overwriting data.
21	Return to defect	The squirter can be sent back to any location marked on the data file. The curvature of any component is followed
22	Mini-scan.	An automatic mini-scan can be performed with selectable size centered on an indication identified in the data file. The scan parameter can be different to the original scan and also include such options as full waveform capture.
23	3D data display	The data for a curved part can be displayed as a colored overlay on the shape of the part.
24	Scaled Plots	Accurate scaled plots: 1;1, 1:2, 1:4 1: 8,2:1, 4:1, 8:1 on any windows printer including HP inkjet plotters
25	Data Exporting	Data can be exported as 256 level TIFF files or .CSV files for export to a spread sheet.
26	Histograms	Histograms with extensive data measurements can be produced.
27	Cluster Analysis	Automatic analysis of the data can be performed by specifying defect amplitude, area and proximity to other indications.
28	Collision switches	Collision switches are installed to eliminate part damage. Recovery from limit switch activation employs the re-



ITEM	FEATURE	DESCRIPTION
		start feature.
29	Pendant Teach and E stop.	A rugged pendant is provided with key functions required for part teaching.
Automatic Operation		
30	Auto Air/Water on/off	Automatic control of the air and water can be built into the scan plans.
31	Automatic paint marker.	Auto Paint marker allows ROIs identified in the data file to be marked on the part surface
32	Light Curtain	Laser light curtain for automatic shutoff in case the light curtain is tripped.
Ultrasonic (Uses Any Third Party or SDI Flaw Detector)		
33	High Power Spike pulser 1000v	
34	High resolution spike pulser 300v	
35	High power (800v p-p) sine wave tone burst pulser	
36	Square wave pulser	
37	Log Amp	
38	Instrument Control,	SDI, Krautkramer , Olympus , Socomate
39	Linear Arrays	Integrates with third party linear array systems - Olympus Omniscan, Tomoscan, Bercli M2M arrays, Diagnostic Sonar. Providing full data transfer for analysis and display on SDI WinScan software.