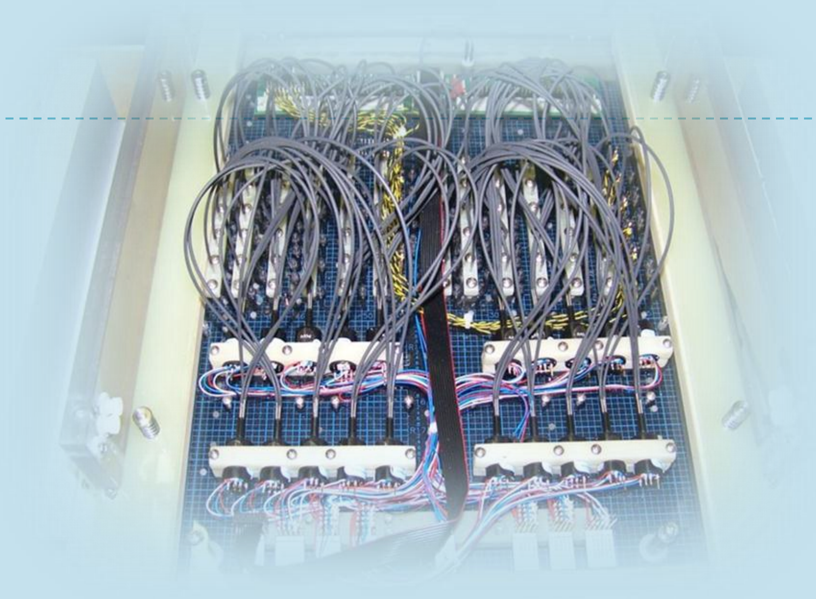


Test Fixture Design Presentation

ICT & FCT Test Fixtures

IPC Presentation

Introduction

- **Quality Control is essential in production processes. In the PCB Assembly process there are several Quality Control steps or options. The most popular tests are the electrical (In-Circuit or ICT) and the function (functional or FCT/FVT) test.**
  ICT test fixtures are standardized and there are several major test platforms available which are industry standards.
  For FCT applications there are many more variations possible due to the vast number of testers and interface approaches unique to each customer; also due to an endless list of applications which fall under the category of Functional Test (RF, High Current, LED test, Leak test etc.)

- Test Probes are a very important part in ICT as well as in FCT applications. If the wrong test probe (type, spring force, tip style etc.) is used, the test fixture will not work as intended. In addition the test probe must be installed correctly in order to work properly.

- **This presentation will show general information and some guidelines for a proper Test Fixture design to assure the most efficient production.**

- In-circuit Test for High Volume Production is nowadays **almost** 100% located in cheap-labor countries like China and Mexico. Only a few products are still made in the US and most times it is only Low Volume Production with a few exceptions.
  However, Functional Test has a larger market share in the US than ICT has. Some EMS Companies have their ICT equipment build in the USA and transferred to the appropriate manufacturing site located in Asia, Mexico etc.
  With this fact in mind, the existing ICT demand in the US market needs to be served professionally and in highest possible quality and cost efficiency.
  In the past 2 or 3 years FCT demand increased about 50% and at RNS the shares is about 65 : 35 (FCT : ICT).

  Functional applications are more time consuming and can be even higher in cost if more special components are involved like certain Electronic equipment or highly complex mechanical features. In the application sector FCT or FVT (Functional Verification Test) we include HiPot, RF (High Frequency), High Current, Leak Test, ISP Programming, Test Rack, Interconnect Solutions (Connector blocks …) etc., everything which is not 100% ICT falls under the category FCT/FVT.

- **There is no clear answer if ICT or FCT is higher in cost. The most important fact is to rather spend some more dollars on a high quality test equipment for highest efficiency in PCB-Manufacturing than to just go with the cheapest price and have then a lot of down-times on the production line because of not proper working test equipment.**

Agenda

1. Introduction
2. Test Probes Basics – Terminology
3. The most common Tip Styles
4. Test Probes Life Expectancy
5. Bead Probe Technology
6. Aggressive Tip Styles
7. Passive Tip Styles
8. Common Question
9. Fixture Overview
10. Fixture Types
11. ICT vs. FCT
12. Hold Down Mechanism
13. Difficulties in Fixture Manufacturing vs. Board Design

The most common Tip Styles!

Standard Test Probes

- * For Grid >25mil
- * More than 50 different tip styles
- * Over 15.000 variations in the individual series
- * Interface Probes for Test Systems
- * exclusive: e-type Probes (for ICT)

Switching Probes (SKS)

Grids > 100 mil

Reed-Probes (with Magnet)

Rotating and Non-Rotating Test Probes

Grids > 50 mil

Threaded Test Probes

Grids >50 mil

Pneumatic Probes (PKS)

Grids > 75 mil

Stroke up to 20 mm

High Current Probes (HSS)

Grids > 100 mil

Currents up to 400 A

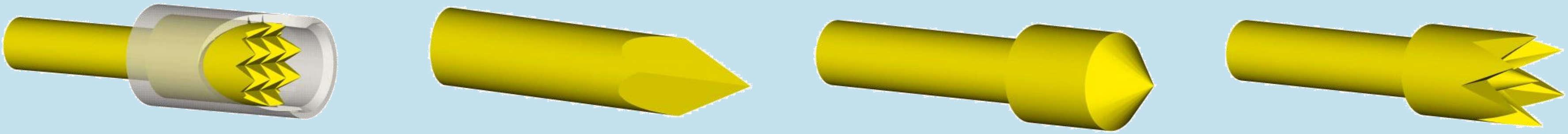
High Frequency Probes (HFS)

Grids > 100 mil

Range up to 6 GHz.

Impedance 50 or 75 Ω

e.g. Tip Styles



Bead Probe Technology

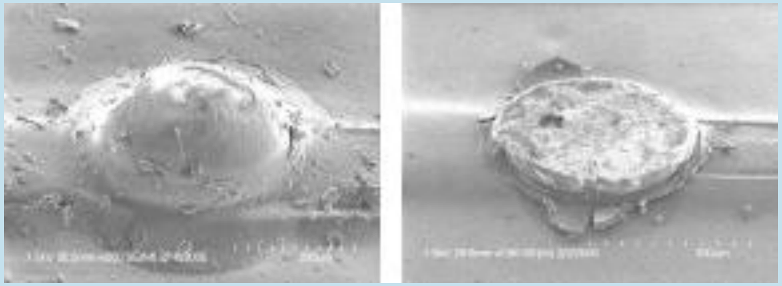
Bead Probe Technology was invented by Agilent on demand of more and more density in Board Manufacturing. Solder beads are placed directly on traces (only on top layer traces possible) where the original test pad or point cannot be reached due to high density or component interference.

In regards to test fixture manufacturing, nothing has to change because Bead Probes are handled just like regular ICT test probes.

The biggest advantages are:

- Larger test coverage
- Lower fixture costs because of less smaller probe sizes (25, 40 and 50 mil)
- Fixture Manufacturing does not require additional processes
- Same receptacles as used for Standard Probes (GKS)

Ingun has developed special tip-styles in close cooperation with global customers to be able to provide the ideal solution for the applicable Bead.



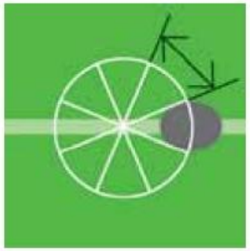
Left: un-probed Bead

Right: probed Bead

Tip Style 79		Series		
		050	075	100
Tip-Ø	Ø 0,50 mm	x		
	Ø 0,64 mm		x	x
	Ø 0,90 mm			x

ingun® innovation

Good matching up of contacting area and length of Bead

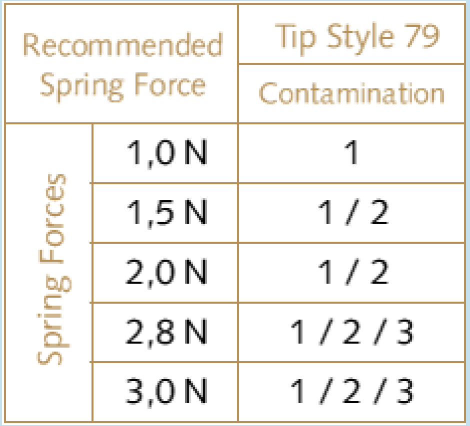


Poor matching up of contacting area and angle of knife-edges too large for length of Bead.

Bead Probe Technology

The choice of the ideal spring-Force in combination with the tip-style, which has already been chosen depending on the composition of the Beads (i.e. contamination / solder hardness) and the intended deformation of the Bead. spring forces from 1.0N (3.6 oz.) to 3.0N (10.8 oz.) are available.

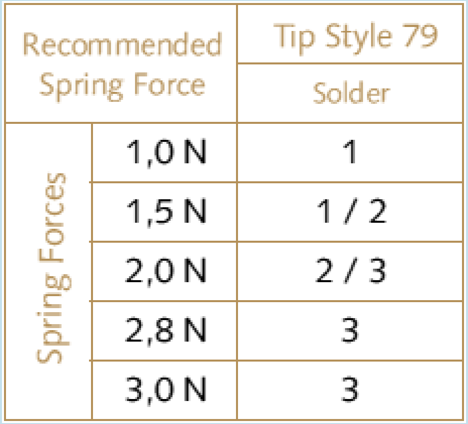
choice of Spring-force depending on the type of contamination and flux-deposits:



Recommended Spring Force		Tip Style 79
		Contamination
Spring Forces	1,0 N	1
	1,5 N	1 / 2
	2,0 N	1 / 2
	2,8 N	1 / 2 / 3
	3,0 N	1 / 2 / 3

Examples:
No Contamination / Flux-deposits:
Contamination 1 (good)
Soft, fluid-type Flux-deposits:
Contamination 2 (middle)
Hard, wax-type Flux-deposits:
Contamination 3 (bad)

choice of Spring-force depending on the hardness of the Solder:



Recommended Spring Force		Tip Style 79
		Solder
Spring Forces	1,0 N	1
	1,5 N	1 / 2
	2,0 N	2 / 3
	2,8 N	3
	3,0 N	3

Examples:
SN 63 = 12.8 HV: Hardness 1 (soft)
SAC 305 = 17.7 HV: Hardness 2 (middle)
Innolot = 33.6 HV: Hardness 3 (hard)

Aggressive Tip Styles (91 - Dagger)

Tip Style 91 (Dagger)

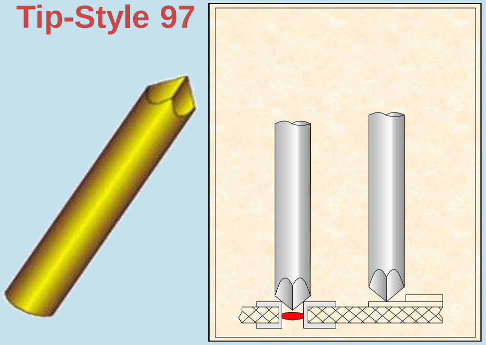
The solution to most contacting problems
- aggressive Steel Tip
- ground edges
- high life-expectancy
- similar alternatives available, see tip-styles 77 & 97

For every application, the matching tip-style

Tip-Style 91

Dagger, aggressive,
2 contacting edges:
- for highly contaminated PCB‘s

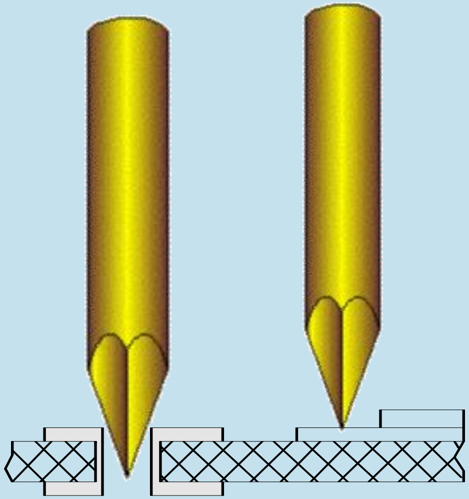
Tip-Style 97



Dagger, more passive, but also more robust. 2 contacting edges:
- for closed/sealed via (i.e. lacquer) -see above!
- for less-contaminated PCB‘s

Tip-Style 77

Dagger, aggressive,
more robust:
3 contacting edges,
- for demanding high-volume production



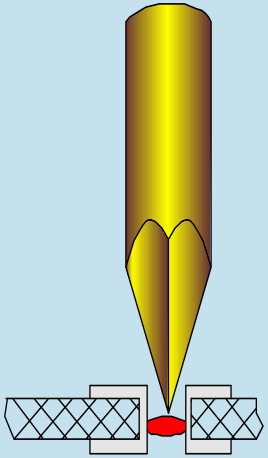
Area of Usage:
- highly contaminated PCB‘s
- for open or closed/sealed vias
- universal usage possible

Alternative to 91

Alternatives to Tip Style 91

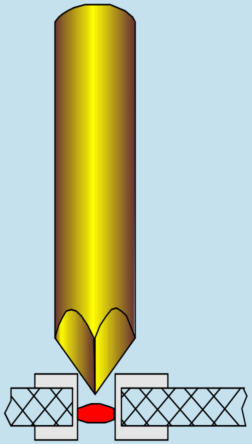
➥ Sealing Lacquer prevents good contact of the flanks of the tips 77 and 91, i.e. the tip digs into the Lacquer

➥ Possibility that the Sealing Lacquer is punctured



Tip Angle 40°

Tip Style 97



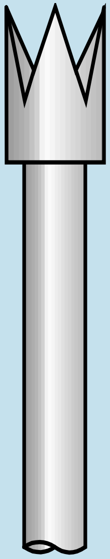
Tip Angle 90°

Tip Style 98

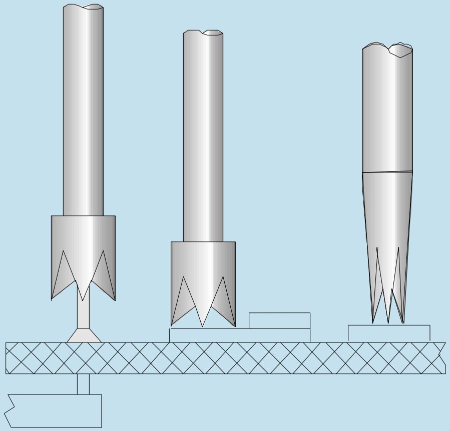
- Tip Angle ~ 150°
- Equivalent to QA tip-style 61 (Blade)

Aggressive Tip 14 & 09

Tip Style 14

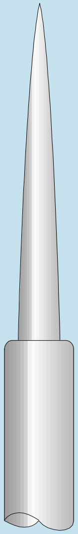


4-point crown
self-cleaning

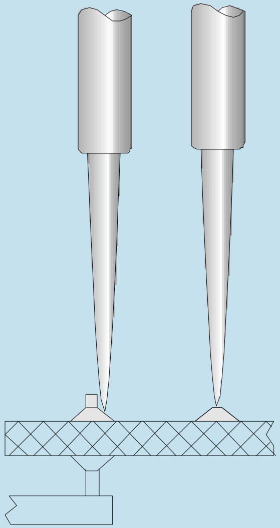


- very aggressive
- for component pins

Tip Style 09



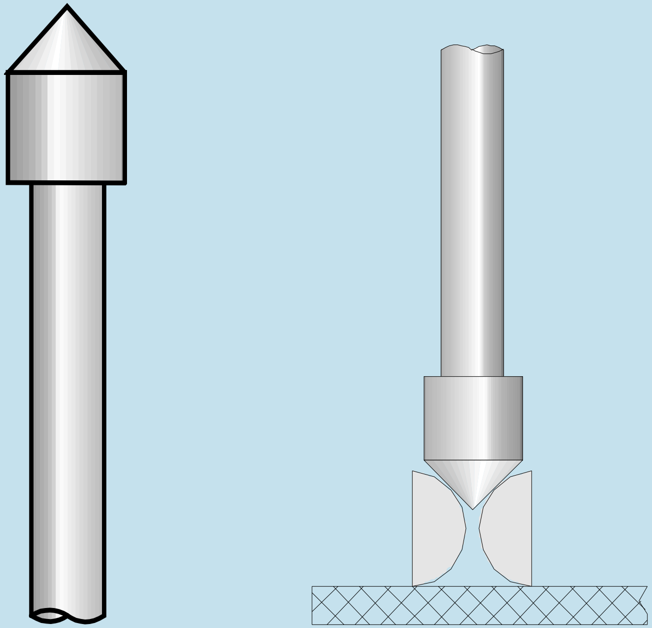
Flexible Needle



- high Stability and Flexibility

Passive Tip 08 & 06

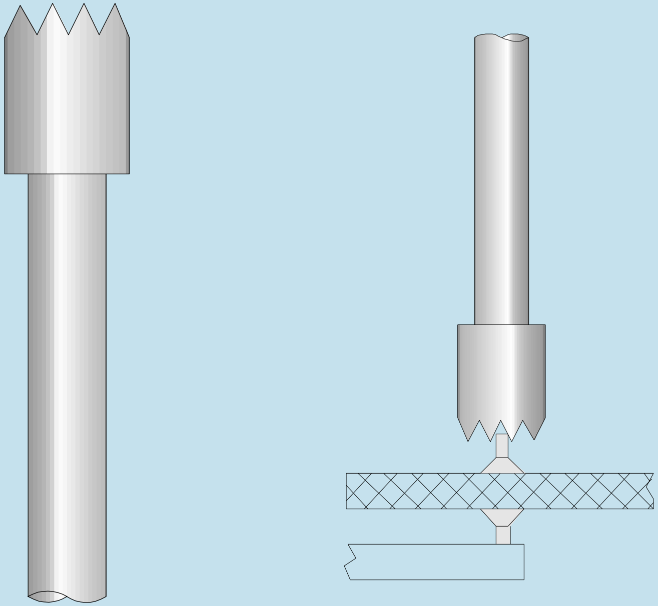
Tip Style 08



90 º Conical Tip

- for less-critical applications (i.e. Connectors)

Tip Style 06



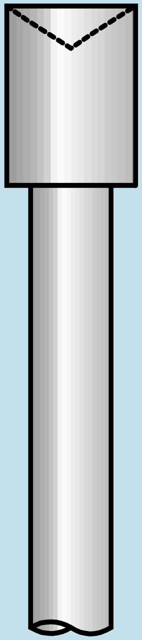
Serrated Tip

- universal applications, but prone to contamination

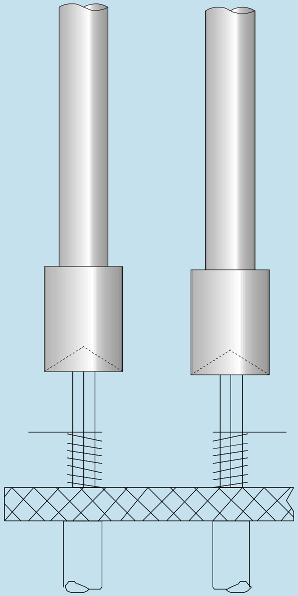
Passive Tip 03 & 05

Tip Style 03

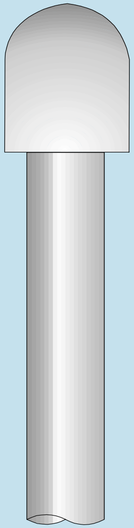
Tip Style 05



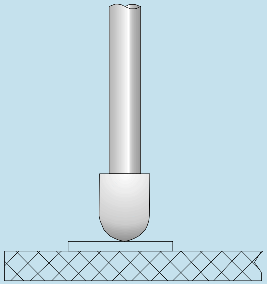
90° Inverse Cone



- self-registration
- for Connector Pins
- tends to contaminate



Bullet-nose Tip



- very passive
- for less-critical applications

Common Question

Question:

What are the guidelines for the probe hole size?

Answer:

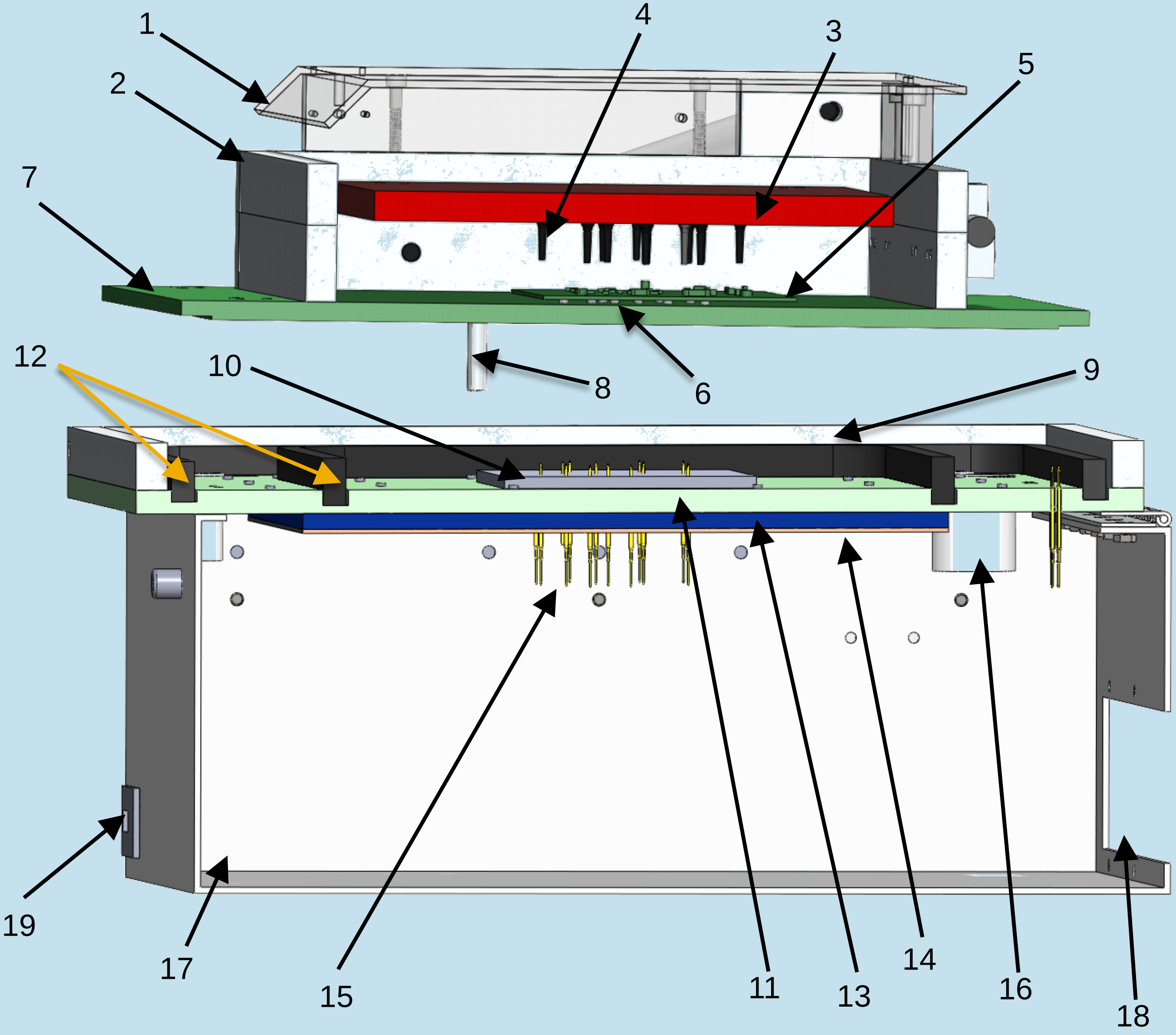
The Hole-ø and Drill-ø depends on:

- Probe Plate Material (e.g. CEM1, FR4, Delrin etc.)
- Feed of drill
- Speed of drill
- Grid (smaller holes are critical)
- Quality of the Drilling Machine
- Quality of the drill bit

For standard series INGUN have laid down drilling parameters for CEM1 und FR4 materials, however, sample drilling is unavoidable!

At RNS specific drill procedures and state-of-the-art CNC drill equipment assures highest accuracy even on 50, 40 and 25 Mil test probes.

Fixture Overview



ID	Component Name
1	Cover
2	Backer Gate Frame
3	Push Plate
4	Push Tees
5	PCB (UUT)
6	Standoff (Board Stop)
7	Top Plate
8	Registration Pin
9	Probe Plate Rail
10	Probe Support Plate
11	Probe Plate
12	Vacuum Dam
13	Support Plate
14	Ground Plane
15	Test Probes / Receptacles
16	Vacuum Port
17	Fixture Pan
18	Interface cutout
19	Counter

Fixture Types

- **The industry uses several standard tester platforms**
- HP307x, GenRad 227x, Zenthel, Spectrum …

Most common Fixture actuations

  - **Vacuum:** In ICT application Vacuum actuation is the most used technic
  - **Pneumatic:** For fixtures with a very large amount of probes pneumatic actuation is used.
  - **Mechanical:** Mostly used in Functional applications.
- **Most common hold-down mechanisms or Fixture Types are**
  - **Backer Gate**
  - **Vacuum Cover (Box)**
  - **ZSK – Clamshell**
  - **Mechanical/Linear Fixture**
- **Wired and Wireless (no wires) Fixtures**
  - Traditional ICT Fixtures are wired from Test Probes to the Interface Panel.
  - Sometimes a ICT Fixture is required in Wireless-Technology which means no wires are involved for transferring signals from the test points to the Tester. In this case there are double-ended test probes utilized in conjunction with a Transfer Board or Translator Board. The fixture stack-up is different to a traditionally wired fixture. There is no fixture pan involved like with a wired fixture.

ICT vs. FCT

- **ICT is board level test (component placement and value)**
  - Lot of test probes
  - Most board failures can be repaired
  - In-circuit Test detects:
    - Missing components
    - Disorientation of components
    - Improper value

- **FCT is a functional test (performance test)**
  - Less test probes
  - After board assembly is completed
  - If performed without ICT, board failures can result in loss of complete assembly

Hold-Down Mechanism

Backer Gate

Mechanical hold-down but with vacuum actuation. Only for bottom test points. In some events it is possible to have test probes contacting on the top side of the PCB (this has to be carefully determined). UUT can be accessed during test.


[redacted]

Vacuum Cover (Box)

Bottom and top side of PCB is enclosed in vacuum. No UUT access during test.

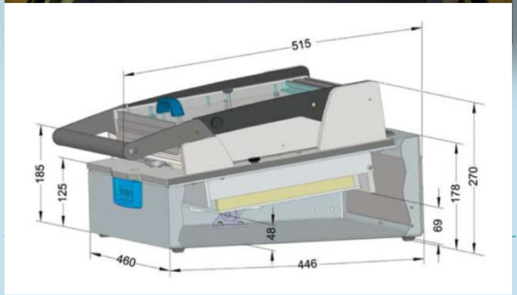

[redacted]

ZSK - Clamshell

The same as a Vacuum Box Fixture but with probes contacting top & bottom side test points. No access to the UUT during test.

Mechanical / Linear Fixture

The same type as the Backer Gate but with linear motion and actuation is 100% manual.
Number of test probes allowed to use is depending on spring force of test probes.



Difficulties in Fixture Manufacturing vs. Board Design

The most challenging part for a fixture manufacturer is to provide a reliable and good contact at all time. Several factors are playing a role to achieve this goal. If testability is already taken into account when the board is in design stage often several obstacles can be avoided or eliminated.

In order to provide a reliable test for board production a board design needs:

1. As close as possible 100% accessibility to test points
   a) Test point covered by component, bracket, heat sink, cover etc.
2. Enough test point clearance to components to assure guided probe technology.
   a) Some components require milling into the top plate
   b)

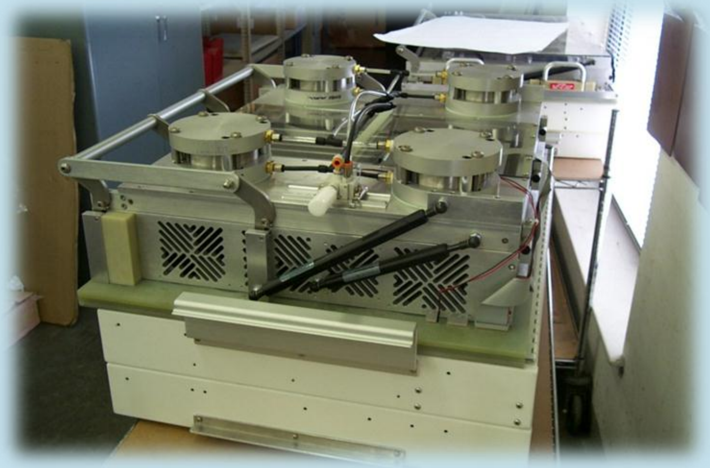
Probe Series (spacing)	Distances (inch)
040 Mil	0.035
050 Mil	0.035
075 Mil	0.045
100 Mil	0.055

3. Test pads as large as possible
4. Enough space on board to place board standoffs (board stops) on top plate
5. Enough space on board to place push tees/rods on top side of the board
6. Contact issues (test points) can occur because of:
   a) Test Probe not guided (Guide holes can be eliminated through extensive routing for components)
   b) Solder flux, Dirty environment

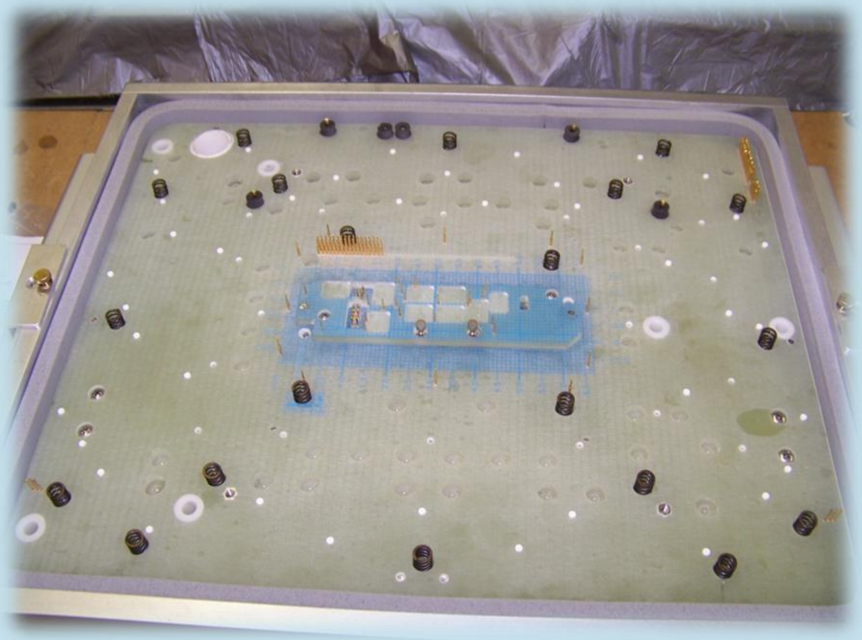
ICT Test Fixtures

ICT Test Fixtures

Test Points	Fixture Kit Size	
Total: 4417 100 Mil: 2306 075 Mil: 1076 050 Mil: 1035 040 Mil: 32	28 x 30 x 6 inch Single Well Turn Time: 14 – 18 days	GenRad ICT Pneumatic



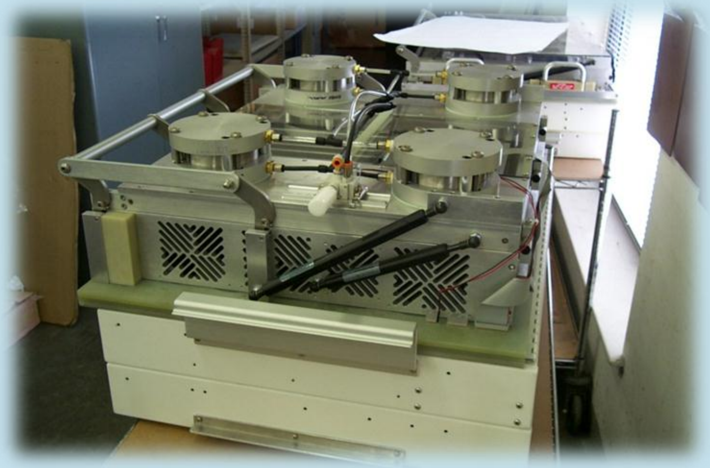
ICT Test Fixtures



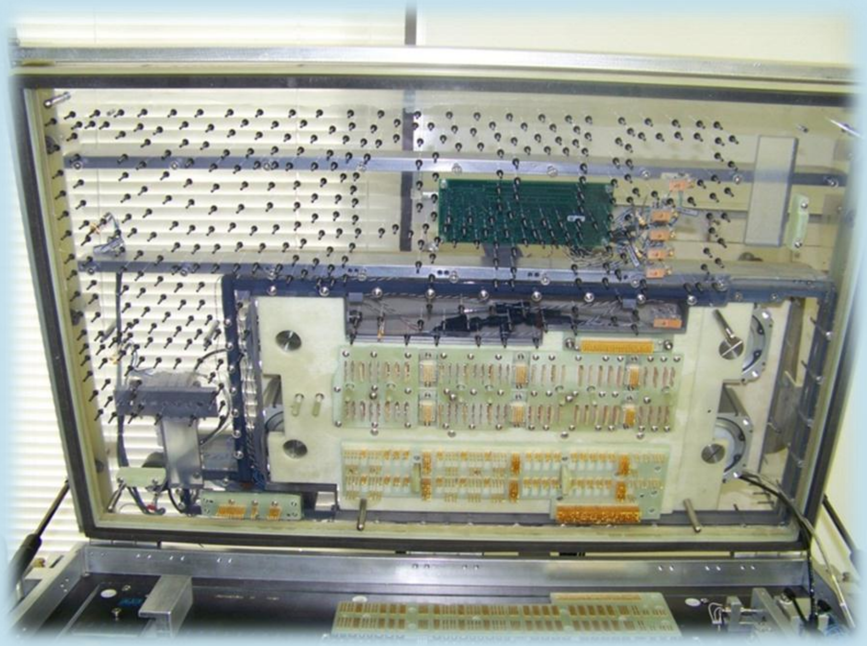
Test Points	Features	
Total: 718 100 Mil: 168 075 Mil: 159 050 Mil: 285 040 Mil: 48 025 Mil: 58	Top and Bottom Test With ZSK-Clamshell	Genrad ICT 20 x 16 x 3.5” Turn Time: 8 – 10 days

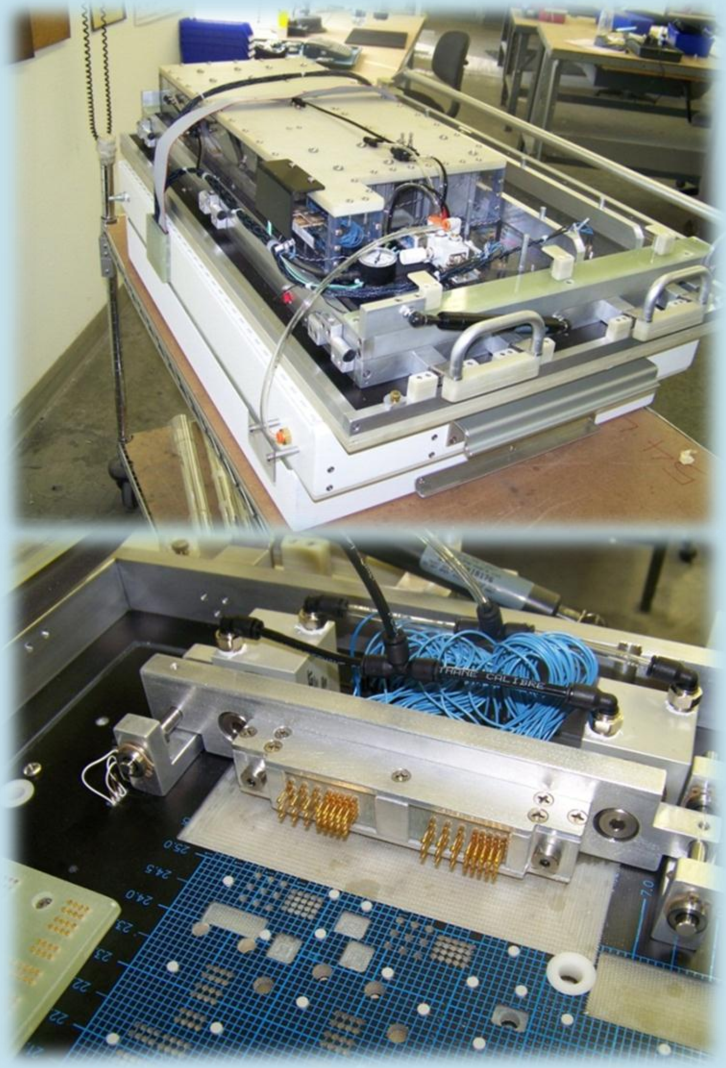
ICT Test Fixtures

Test Points	Fixture Kit Size	
Total: 4417 100 Mil: 2306 075 Mil: 1076 050 Mil: 1035 040 Mil: 32	28 x 30 x 6 inch Single Well Turn Time: 14 – 18 days	GenRad ICT Pneumatic



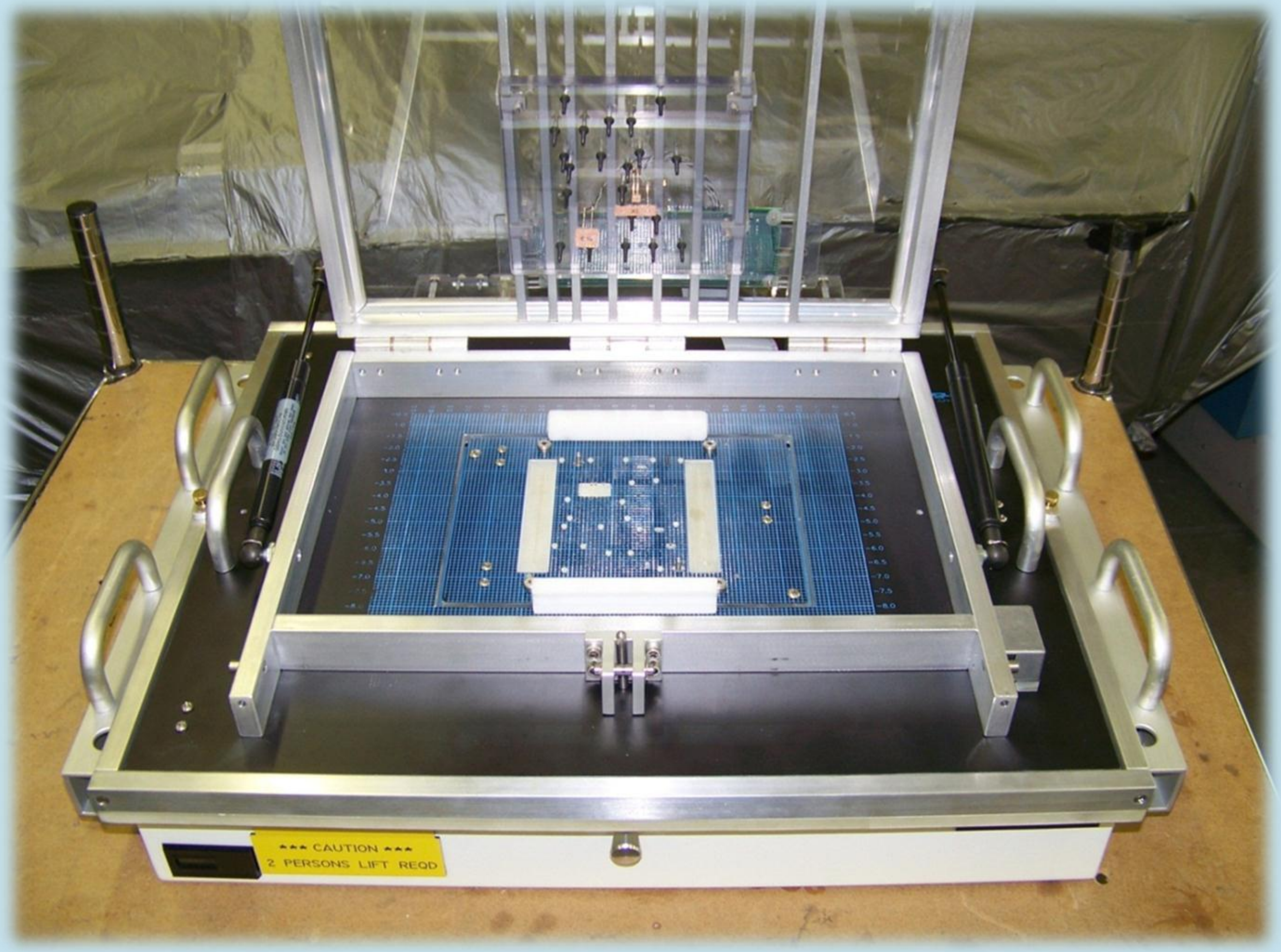
ICT Test Fixtures





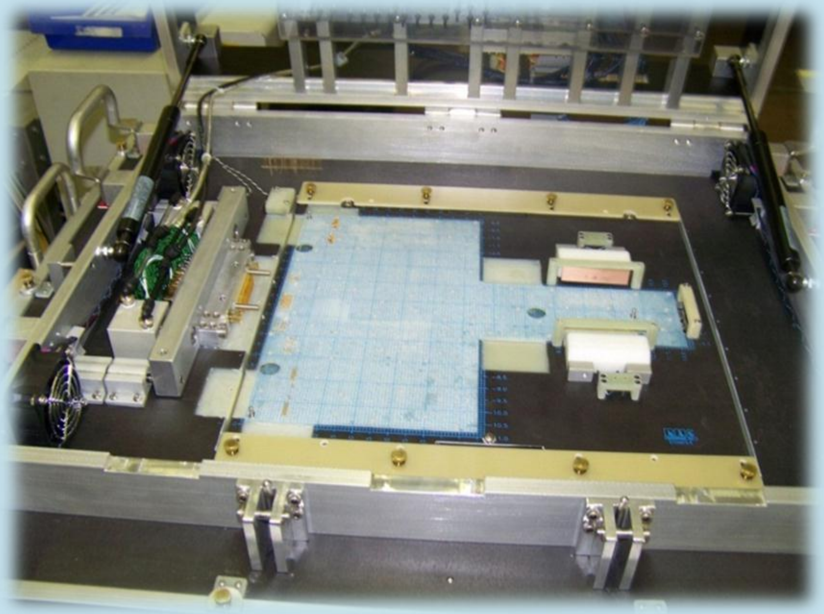
Test Points	Features	
Total: 1456 100 Mil: 1006 075 Mil: 450 050 Mil:	Pneumatic Top Access Unit Pneumatic Side Access Unit	GenRad ICT 24 x 30 Vacuum Cover Turn Time: 15 – 17 days

ICT Test Fixtures

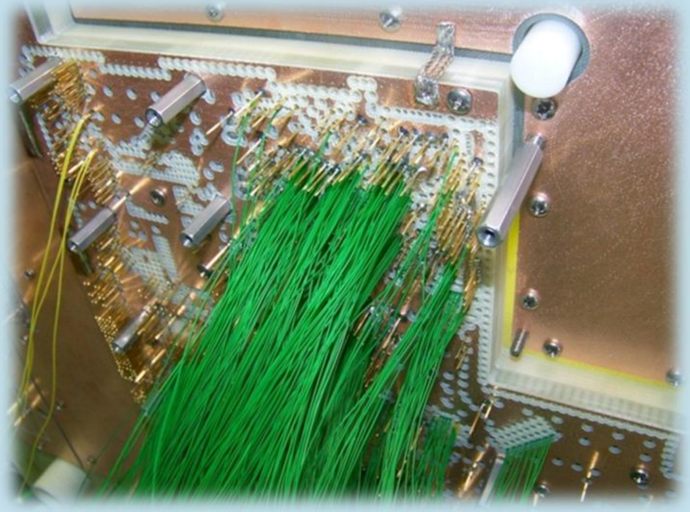


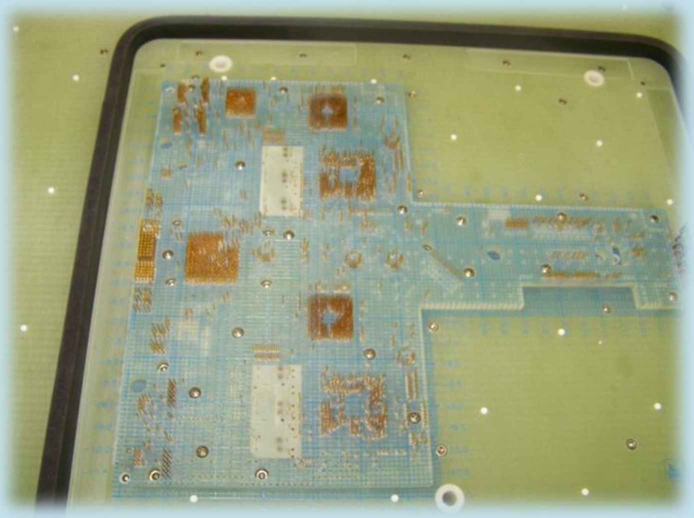
20 x 16 GenRad Fixture with Backer Gate

ICT Test Fixtures

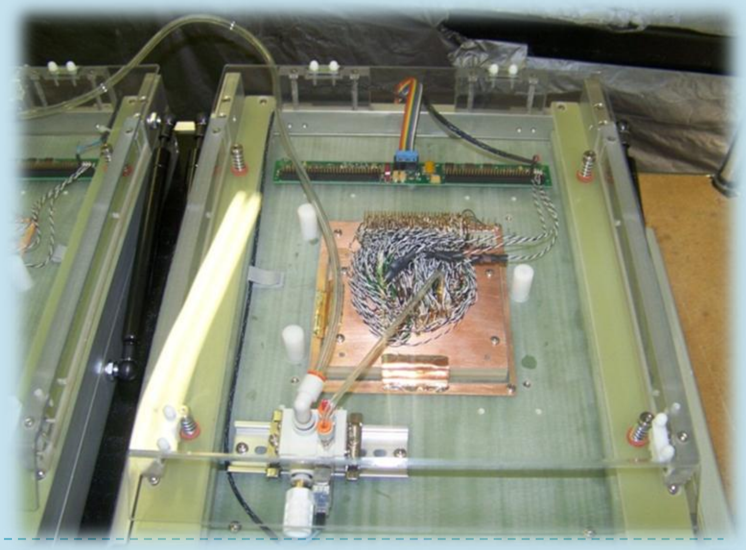


Test Points	Features	
Total: 3658 100 Mil: 134 075 Mil: 379 050 Mil: 1141 040 Mil: 1305 025 Mil: 174	(1) Pneumatic SAU (2) Mechanical SAU (9) Cooling Fans (7) LED Sensors (5) Super Conn FEA Board Stress Strain Gauge	Genrad ICT 24x30 Backer Gate Turn Time: 20 – 25 days



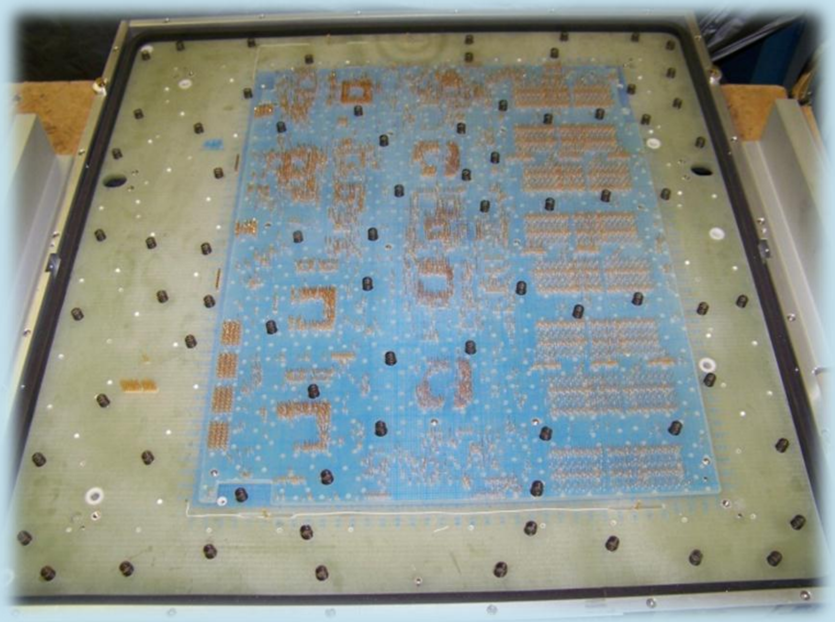


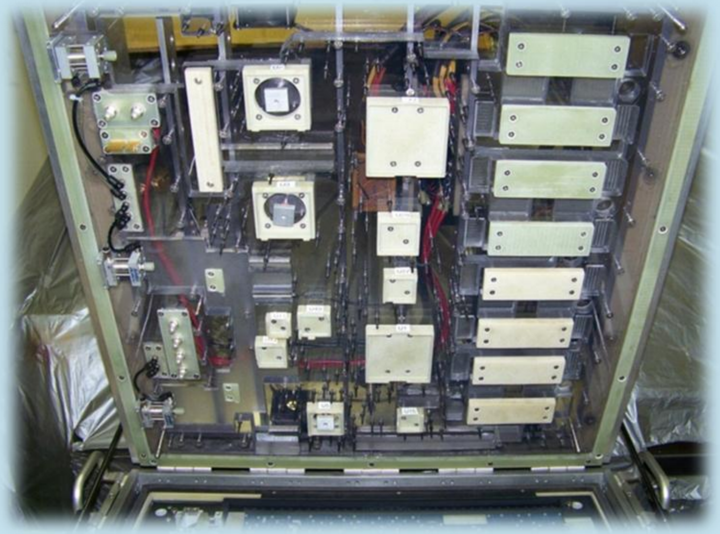
ICT Test Fixtures



Test Points	Features	
Total: 800 100 Mil: 66 075 Mil: 106 050 Mil: 612	Top and Bottom Test (3) OFM Pneumatic Probes	Genrad 227X L 20x30 ICT ZSK Clamshell Turn Time: 9 – 11 days

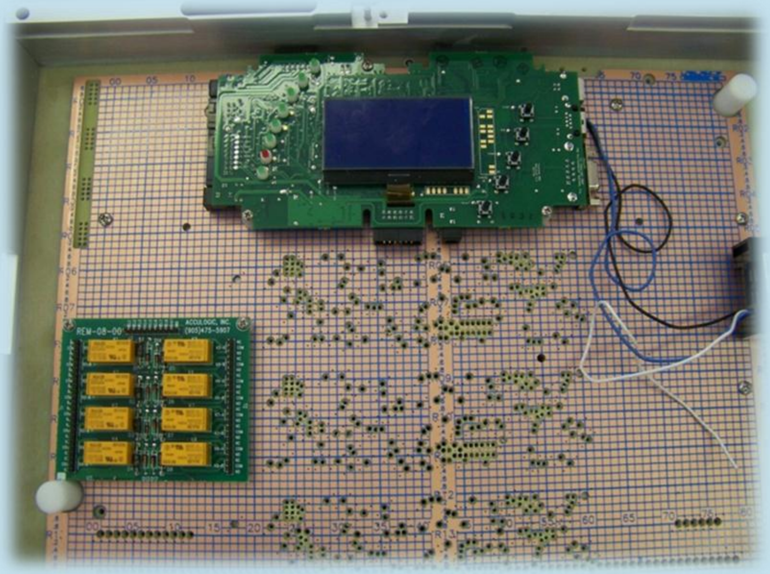
ICT Test Fixtures





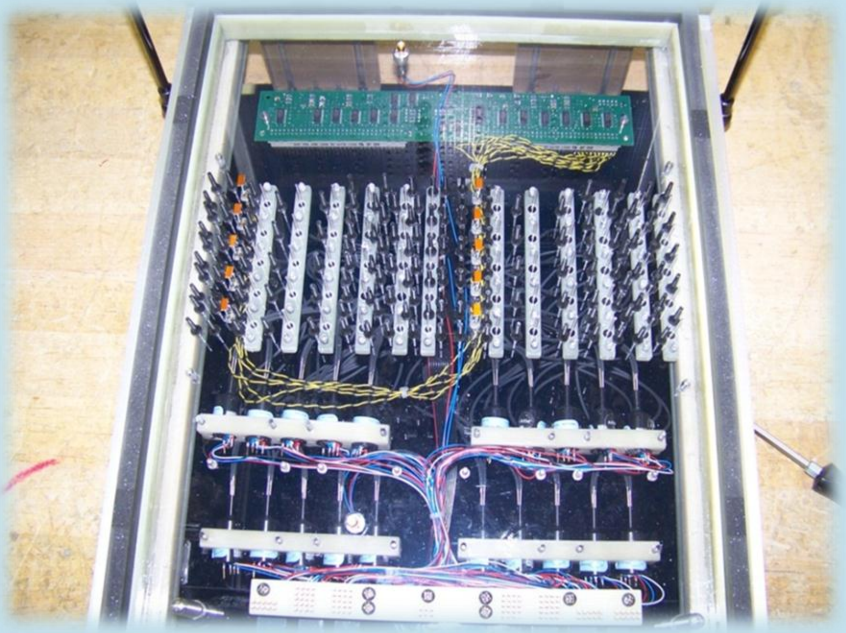
Test Points	Fixture Kit Size	**Board Size:** 18 x 23” (457.20 x 584.20 mm)
Total: 9162 100 Mil: 1979 075 Mil: 3504 050 Mil: 3074 040 Mil: 605	Wireless 24 x 30 Pneumatic Side Access BGA Cage Blocks Cooling Fans Power Supply	GenRad ICT Vacuum Cover Turn Time: 15 – 17 days

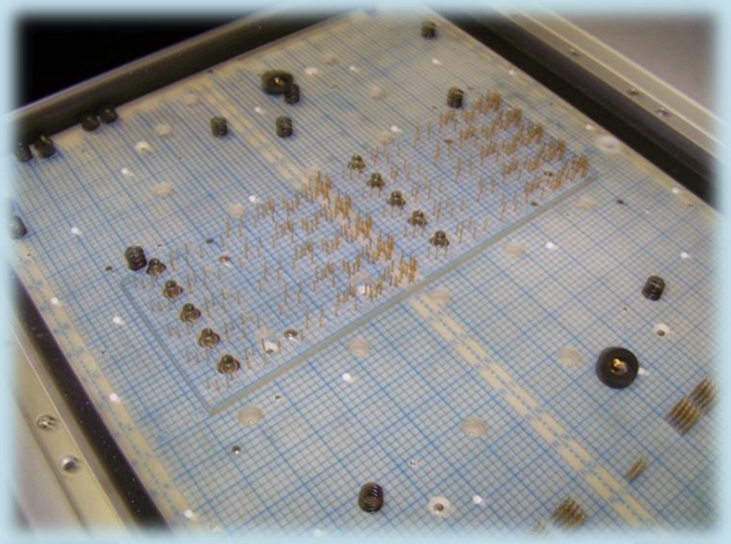
ICT Test Fixtures

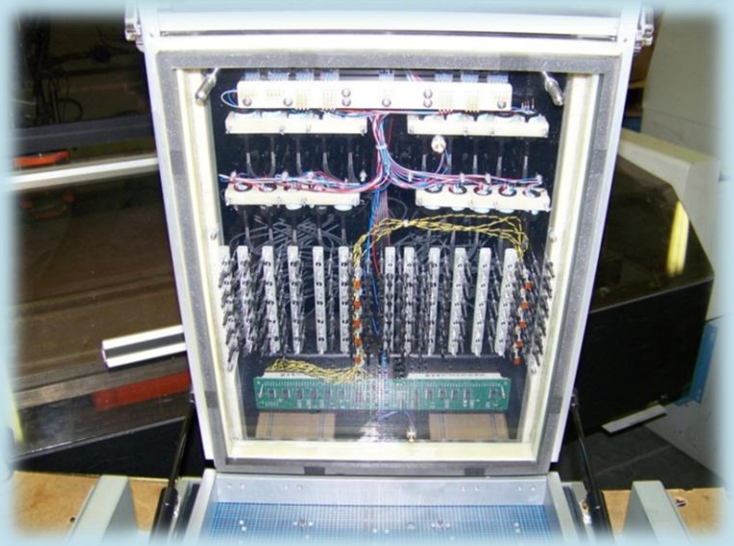


Test Points	Fixture Kit Size	
Total: 740 100 Mil: 740 075 Mil: 050 Mil: 040 Mil:	HP Small Personality 800 Board Marker (5) ISP Programmer (1)	HP307X ICT Vacuum Cover Turn Time: 7 – 9 days

ICT Test Fixtures

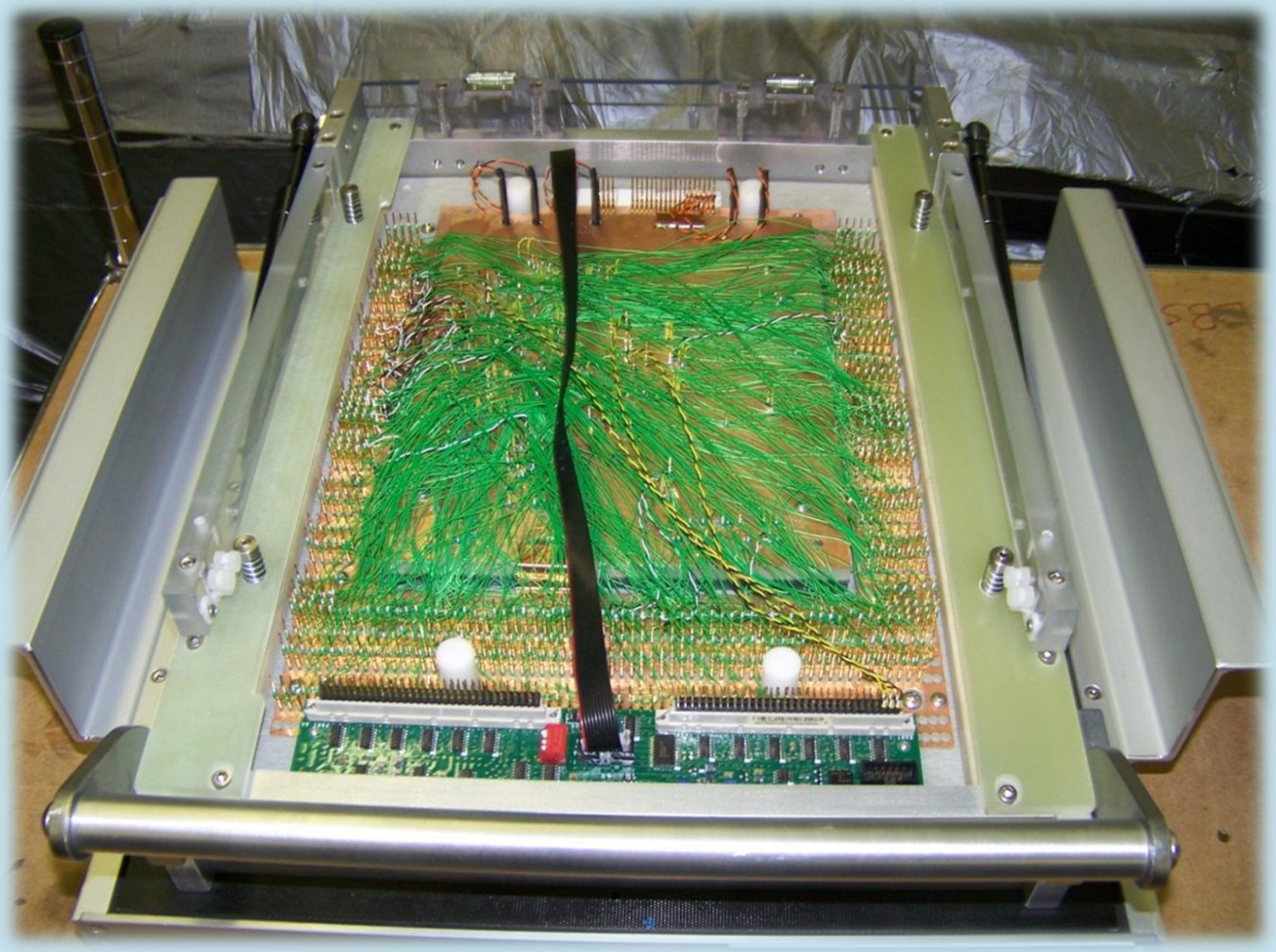




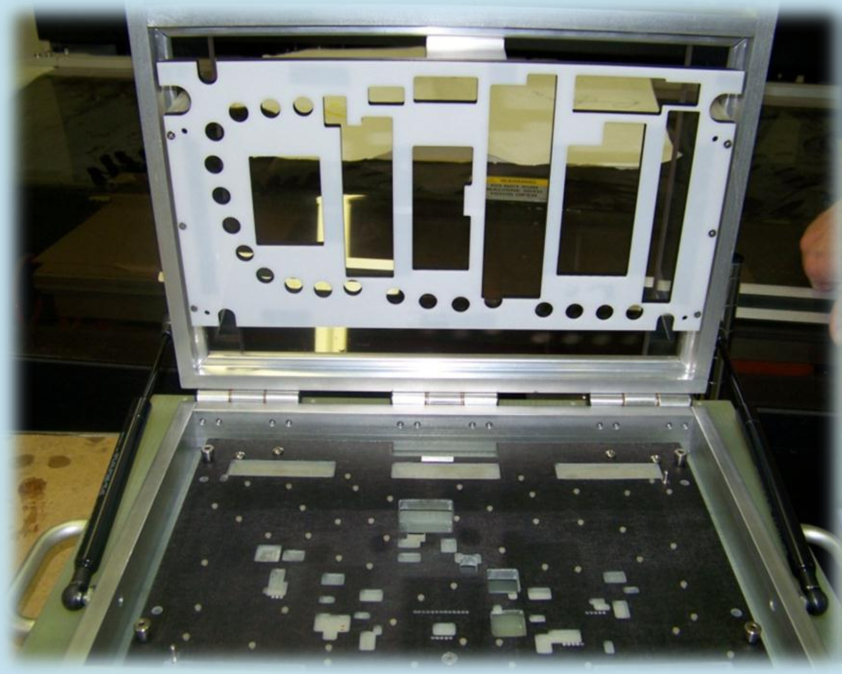


Test Points	Fixture Kit Size	
Total: 580 100 Mil: 460 075 Mil: 100 050 Mil: 20 040 Mil:	HP Small Personality 600 Board Marker (10) Trident LED Sensors (20) for (60) LEDs TestJet (10) Infrared Sensor (2)	HP307X ICT Vacuum Cover Turn Time: 7 – 9 days

ICT Test Fixtures



FCT - Functional Test Fixtures

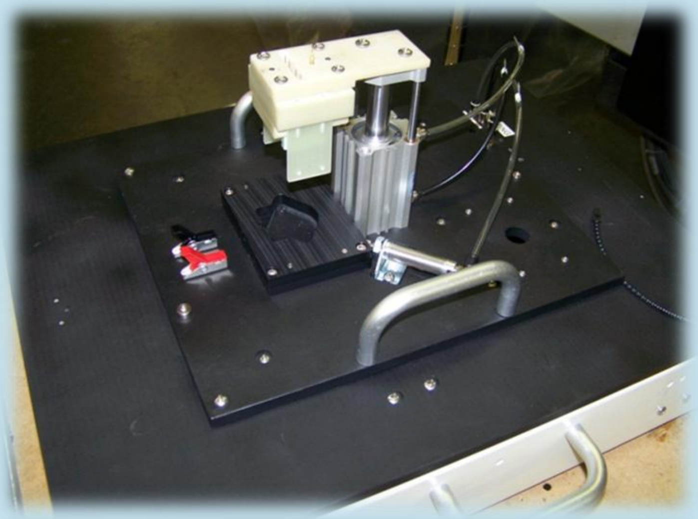


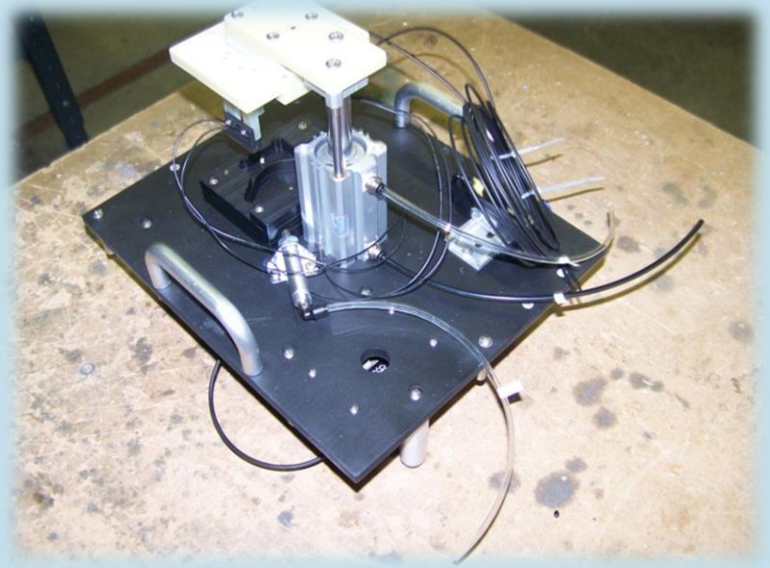
FCT- Test Rack (for Cognex camera system) showing the opened Test Fixture for the LED Board.
Challenge here is to provide a reliable and save hold-down solution without covering any LED.
Each LED has to be detected by the Vision System (Camera) on the top.

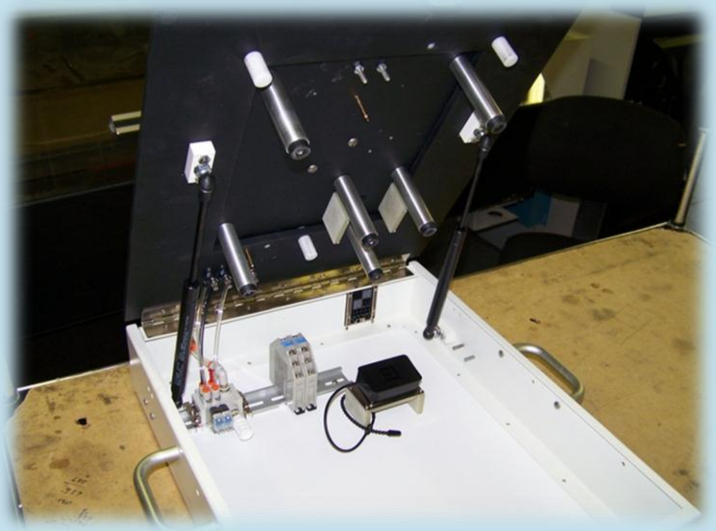
Solution is having a “push tee” across the entire board (DUT) and is accommodated with Delrin and G10 plate with proper cut-outs for LEDs and other components.

Functional Test Rack incl. Camera Stand (for Cognex Camera System) and Virginia Panel G2 Receiver		
Project: Automotive	**Application:** LED Test of Rear Light Left and Right	(1) Test Stand (Rack) (2) Debug Fixture (2) Production Fixture **Turn Time:** 7 – 9 days

FCT - Functional Test Fixtures

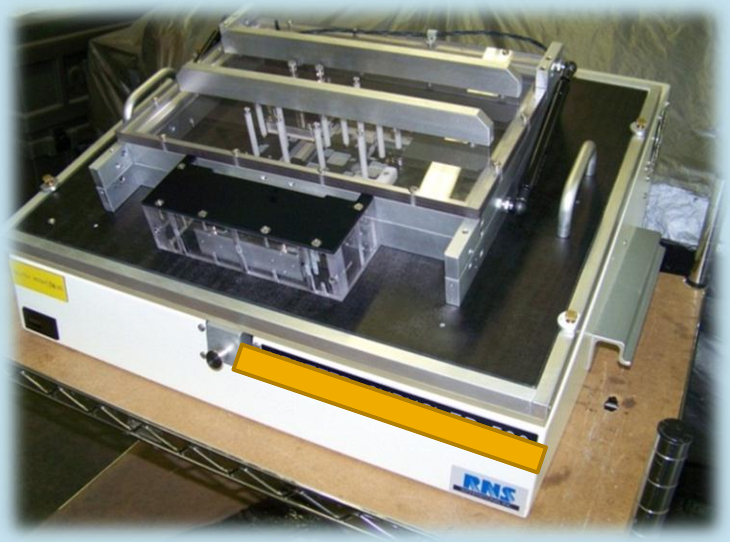


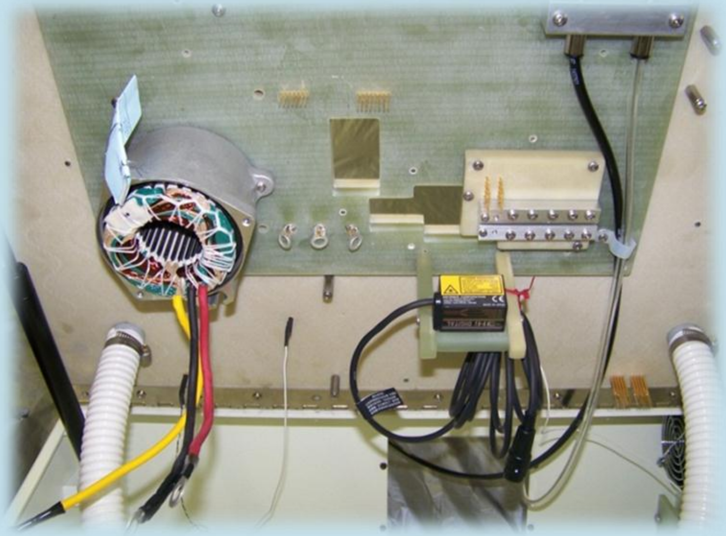




Functional Test Fixture with interchangeable nest		
Project: Automotive	Application: High Current Measurement Pneumatic actuation	(1) Production Fixture (2) Interchangeable Nest (3) Reject Chute for test rack Turn Time: 10 – 15 days

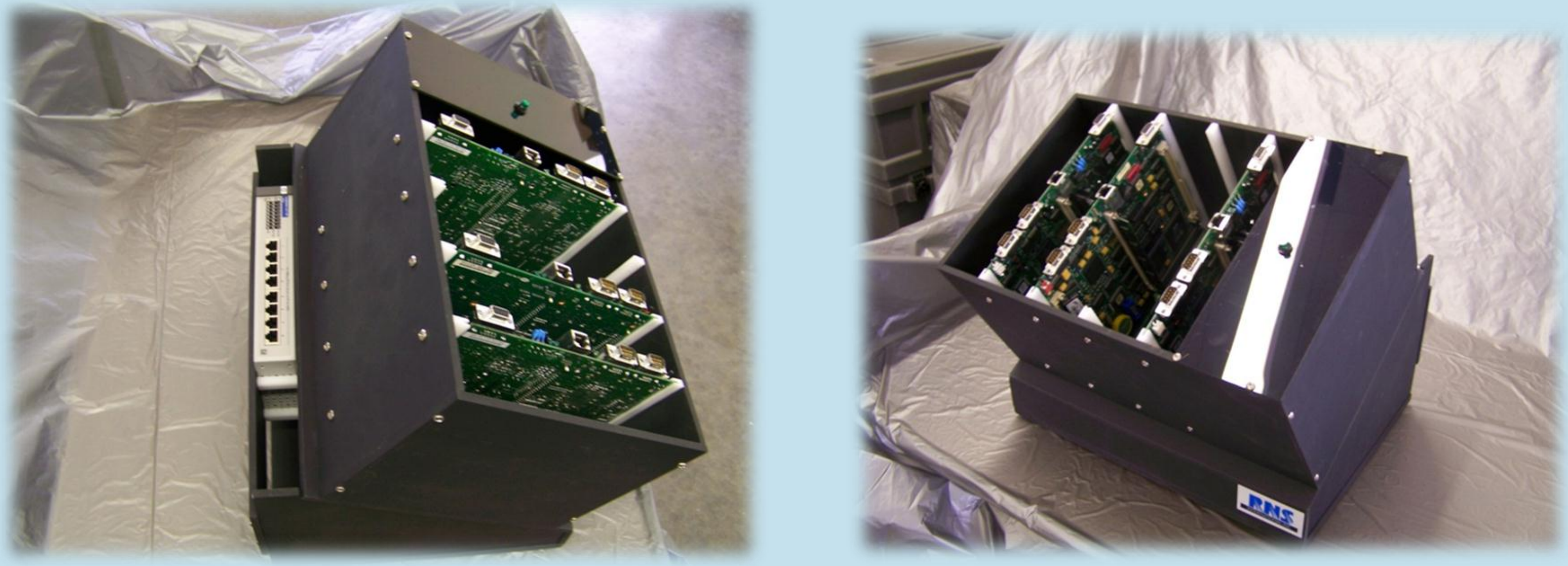
FCT - Functional Test Fixtures





Functional Test Fixture		
Project: Automotive	Automatic Gate	Turn Time: 7 – 12 days

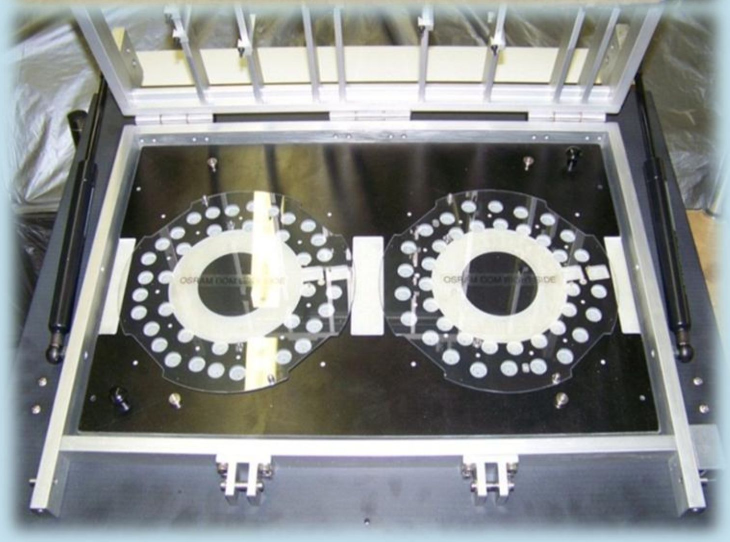
FCT - Functional Test Fixtures



Functional Test Fixtures with Linear Mechanical Gate		
Project: Agilent Card Cages	Application: Back panel Multiple Test	(2) Card Cages Turn Time: 7– 9 days

FCT - Functional Test Fixtures

Honeywell (top)		
Project: Honeywell	**Application:** PXI Receiver	Turn Time: 7– 10 days
OSRAM (bottom right)		
Project: Osram LED	**Application:** FCT (Functional Test) for LED Illumination Product	Turn Time: 7– 10 days



Vocabulary

Term	Description
Fixture Kit	A complete kit consists a fixture pan, probe plate, support plate, top plate, hold-down unit, gas shocks, handles, cycle counter
Fixture Pan	Is the base of a fixture and holds the interface and wires. Also additional test instruments are usually placed inside the fixture pan as well as the Fixture label which shows the BOM for Test Probes, Serial Number and Date of completion.
Top Plate	Here the stand offs are placed and the tooling pins to key the UUT to the fixture. Usually a X,Y grid is silkscreened for easy nail number location. The Top Plate is always ESD safe. It has a “Guided Hole” for test probes which assures the accuracy for targeting.
Guide Plate	This plate will help with guiding the test probe reliably to the target (test point etc.)
Probe Plate	Here all the receptacles are installed which are holding the test probes. Today 100, 75, 50, 40 and 25 Mil spacing is common.
Support Plate	This plate helps to make the fixture more sturdy and prevents it from bowing.
Push Plate	Push Tees are installed in this plate. They help to keep the UUT flat under test.
Test Probes	These are spring-loaded pins which contact the test points on the UUT.
Marker Probe	When a board passes or fails test then sometimes a marker probe is used to mark the Board-Assembly with a circle.
Interface Panel	The interconnection between the Test Fixture and the Tester
OFM, Test Jet, FrameScan	Test Feature for Polarity Check or Existence
Mux Card	Circuit Board to transfer the OFM / TestJet / Framescan signals to the interface
Backer Gate	Mechanical Hold-Down Unit
Vacuum Cover	Vacuum Hold-Down Unit

Vocabulary

Term	Description
Standoff	Board stops where the UUT rests on. 0.050, 0.060 and 0.080 inch height
Gasket	Seals up the vacuum area in the fixture
Registration Pin	Mates together with the Bushing to make sure that all plates in a fixture are ligned up to each other.
Tooling Pin	The tooling Pin (most times 3) register the UUT to the fixture.
Personality Pin	These Pins are used in HP3070 Fixtures as transfer pins for the probe signals
Transfer Pin	These are solid gold-plated pins which transfers signals, most times from the top to the bottom.
Gerber Files	PCB design package. These files are needed for fixture design
Drill File	This is the file which makes sure that every single test probe will hit the right test point on the UUT, if 100, 75, 50, 40 or 25 Mil
Wire File	The Wiring department of course needs appropriate instructions to wire the test probes to the correct interface location. On FCT fixtures wiring is more versatile and not that much automated as on ICT applications.
UUT, DUT	UUT= Unit Under Test / DUT= Device Under Test
Loaded Board	PCB which is assembled, also called Board Assembly
ZSK	Vacuum Hold-Down for top side testing
Pneumatic actuation	Fixture actuated with air cylinder
Bushing	Bushing for the Registration Pin
Push Tees	Installed in Push Plate (Backer Gate), VAC Plate (Vacuum Cover), Guide Plate (ZSK). They are responsible to keep the UUT flat under test.

Vocabulary

Term	Description
FEA	Finite Element Analysis. CAD based Stress analysis which shows spots where large stress is created on the UUT under test.
Strain Gauge	This is the physical stress measurement where a board assembly will be used.
SAU	Side Access Unit. Used for contacting connectors etc. from the side
TAU	Top Access Unit. Same as SAU only coming from the top. From the Bottom it would be BAU.
Translator board	Is used on Wireless fixtures to transfer the signals through double-ended probes to the Tester. Is also called Interface board.
Aluma Lift	Very common brand for Fixture handles, which are standard in the ATE Industry
ICT	In-circuit Test
FCT or FVT	Functional Test or Functional Verification Test

More Information

- Also see Fixture References for example projects (see CD)
- www.rns-usa.com/cms
- For Technical questions and Support please contact:
  Greg Dorsey: greg.dorsey@rns-usa.com
  Sven F. Nocher: sven.nocher@rns-usa.com

Test Equipment ICT/FCT • Test Probes • Interconnect Solutions
ISP Programming • LED Digital Analyzer • Color Sensors
Test Plugs • Engineering Services
Precision CNC Machining • Assembly Services

RNS International, Inc.
5001 Sirus Lane
Charlotte, NC 28208
www.rns-usa.com

Ph (704) 329 0444
Fax (704) 329 0404

sales@rns-usa.com
sven.nocher@rns-usa.com