SEMI E57-0299
PROVISIONAL MECHANICAL SPECIFICATION FOR KINEMATIC COUPLINGS USED TO ALIGN AND SUPPORT 300 mm WAFER CARRIERS

1. Purpose

1.1 This standard specifies the mechanical couplings used to ergonomically align and precisely support 300 mm wafer carriers (including transport cassettes, process cassettes, quartz boats, pods, lot boxes, and shipping boxes). Such a kinematic coupling can be used at several interfaces, including:

- between a box or cassette and a tool load-port or vehicle nest,
- between a transport cassette and a box, and
- between a process cassette or quartz boat and the floor of a process chamber.

2. Scope

2.1 This standard is intended to set an appropriate level of specification that places minimal limits on innovation while ensuring modularity and interchangeability at all mechanical interfaces. Only the bottom half of the kinematic coupling is specified so that suppliers can be flexible in designing wafer carriers that can mate with it.

2.2 This standard is provisional because of concerns about kinematic coupling pins causing excessive wear on carriers. Once tribology testing is done, this standard should be upgraded from provisional status.

3. Referenced Documents

3.1 *SEMI Standards*

SEMI E15 — Specification for Tool Load Port

SEMI E19 — Standard Mechanical Interface (SMIF)

SEMI E19.4 — 200 mm Standard Mechanical Interface (SMIF)

SEMI E44 — Guide for Procurement and Acceptance of Minienvironments

3.2 *ISO Document*[1]

ISO 4287 — Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters

4. Terminology

4.1 *bilateral datum plane* — A vertical plane that bisects the wafers and that is perpendicular to both the horizontal and facial datum planes.

4.2 *box* — A protective portable container for a cassette and/or substrate(s) (as defined in SEMI E44).

4.3 *cassette* — A open structure that holds one or more substrates (as defined in SEMI E44).

4.4 *facial datum plane* — A vertical plane that bisects the wafers and that is parallel to the front side of the carrier (where wafers are removed or inserted). On tool load ports, it is also parallel to the load face plane specified in SEMI E15 on the side of the tool where the carrier is loaded and unloaded.

4.5 *horizontal datum plane* — A horizontal plane from which projects the kinematic-coupling pins on which the carrier sits. On tool load ports, it is at the load height specified in SEMI E15 and might not be physically realized as a surface.

4.6 *nominal wafer center line* — The line that is defined by the intersection of the two vertical datum planes (facial and bilateral) and that passes through the nominal centers of the seated wafers (which must be horizontal when the carrier is placed on the coupling).

4.7 *pod* — A box having a Standard Mechanical Interface (SMIF) per SEMI E19 (as defined in SEMI E44).

4.8 *wafer carrier* — Any cassette, box, pod, or boat that contains wafers (as defined in SEMI E15).

5. Requirements

5.1 *Kinematic Coupling Pin Shapes* — The physical alignment interface on the bottom of the wafer carrier

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1 ISO Central Secretariat, 1, rue de Varembé, C.P. 56, CH-1211 Genève 20, Switzerland; available in the U.S. from American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036 consists of features (not specified in this standard) that mate with six pins underneath. As shown in Figure 1 and defined in Table 1, each pin is radially symmetric about the vertical center axis line and can be seen as the intersection of a cylinder of diameter *d*91 and a sphere of radius *r*93 (which might contact a flat plate). An additional rounding radius *r*95 provides contact with angled mating surfaces, and blend radii *r*94 and *r*96 smooth the resulting edges. The final roughness height of the over-all surface finish must be less than or equal to *r*97. Dimensions *r*92 and *z*91 have zero tolerance because they only give a distance to another toleranced dimension. (Dimensions in parenthesis are not part of the requirements in this standard but are intended to clarify the preparation of manufacturing instructions.)

5.2 *Kinematic Coupling Pin Locations* — The pins are arranged in three sets with two pins in each set. As shown in Figure 2, the outer pin in each set is designated the primary pin for use on a tool load-port or vehicle nest or inside a box, and the inner pin in each set is designated the secondary pin for use on a robotic arm that would pick up the carrier (typically from the side opposite the load face plane). The location of each pin is determined with respect to the three orthogonal datum planes defined in Section 4: the horizontal datum plane, the facial datum plane, and the bilateral datum plane. Figure 3 shows the locations of the kinematic coupling pins as viewed from above, and Table 2 defines the locations (all of which are bilaterally symmetric about the bilateral datum plane). Angle θ is shown in Figure 3 for clarity and is not part of the requirements in this standard.

5.3 *Empirical Determination of Datum Plane Locations* — Given a set of three primary or secondary kinematic coupling pins, the datum planes should be determined as follows. The two pins that are closest together are the front pins which (along with a known vertical direction) define a Cartesian coordinate system. The center axis line of each pin is defined to be the vertical line whose *x* (left-right) coordinate is the average of the maximum protrusions of the pin to the left and to the right and whose *y* (front-back) coordinate is the average of the maximum protrusions of the pin to the front and to the back. The bilateral datum plane is defined to be the vertical plane that contains the center axis line of the rear pin and that is equally distant from the center axis lines of the front pins. The facial datum plane is defined to be the vertical plane that is perpendicular to the bilateral datum plane and whose distance to the center axis line of the rear pin is 1.5 times the average of the distances to the center axis lines of the front pins. The horizontal datum plane is defined to be the horizontal plane that is 13 mm (0.51 in.) below the average of the heights of the highest and lowest pin tops. Once these datum planes have been determined, the three kinematic coupling pins can be evaluated to see if they conform to Section 5.1 and 5.2 of this specification. If they comply, the kinematic coupling pins and datum planes can be used to evaluate the compliance of carriers to standards cited in Section 6.

6. Related Documents

6.1 *SEMI Standards*

SEMI E1.9 — Provisional Mechanical Specification for Cassettes Used to Transport and Store 300-mm Wafers

SEMI E19.5 — Specification for 300-mm Bottom-Opening Standard Mechanical Interface (SMIF)

SEMI E47.1 — Provisional Mechanical Specification for Boxes and Pods Used to Transport and Store 300 mm Wafers

SEMI E62 — Provisional Specification for 300-mm Front-Opening Interface Mechanical Standard (FIMS)

SEMI E63 — Provisional Mechanical Specification for 300-mm Box Opener/Loader to Tool Standard (BOLTS-M) Interface

SEMI M31 — Provisional Mechanical Specification for Front-Opening Shipping Box Used to Transport and Ship 300-mm Wafers

6.2 *Other Documents*

Alexander H. Slocum, *Precision Machine Design*, Society of Manufacturing Engineers, Item Code 2597, 1992 (originally published by Prentice-Hall, 1992)

Table 1. Kinematic Coupling Pin Dimensions

Symbol Used	*Value Specified*	*Dimension Description*
*d*91	12 ± 0.05 mm (0.4724 ± 0.002 in.)	Diameter of pin centered on the center axis line
*r*92	6 mm (0.2362 in.)	Radial distance from the center axis line to the origin of the shoulder radius *r*95
*r*93	15 ± 0.05 mm (0.5906 ± 0.002 in.)	Radial distance from the intersection of the center axis line and *z*91 to the top of the pin
*r*94	2 ± 0.1 mm (0.0787 ± 0.004 in.)	Blend radius for the intersection of *r*93 and *r*95
*r*95	15 ± 0.05 mm (0.5906 ± 0.002 in.)	Radial distance from the intersection of the horizontal datum plane and *r*92 to the far shoulder of the pin
*r*96	2 ± 0.1 mm (0.0787 ± 0.004 in.)	Blend radius for the intersection of *r*95 and *d*91
*r*97	0.30 µm (12 µin.) maximum	Roughness (R_a) as defined in *ISO 4287*
*z*91	2 mm (0.08 in.)	Vertical distance from the horizontal datum plane to the origin of top radius *r*93

Table 2. Distances to the Center Axis Lines of the Coupling Pins

Symbol Used	*Value Specified*	*Datum Plane Measured from*	*Pin Center Axis Line(s) Measured to*
*r*97	0.30 µm (12 µin.) maximum	Roughness (R_a) as defined in *ISO 4287*	*r*97
*x*91	115 ± 0.05 mm (4.5276 ± 0.002 in.)	bilateral	front right and left primary
*x*92	92 ± 0.05 mm (3.6220 ± 0.002 in.)	bilateral	front right and left secondary
*y*91	80 ± 0.05 mm (3.1496 ± 0.002 in.)	facial	front right and left primary
*y*92	120 ± 0.05 mm (4.7244 ± 0.002 in.)	facial	rear primary
*y*93	64 ± 0.05 mm (2.5197 ± 0.002 in.)	facial	front right and left secondary
y94	96 ± 0.05 mm (3.7795 ± 0.002 in.)	facial	rear secondary

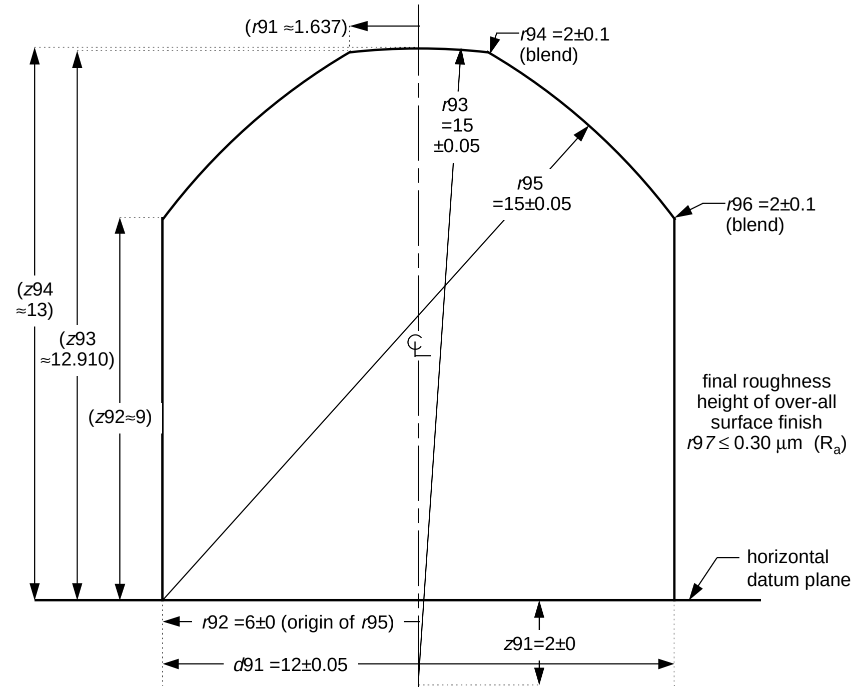

Figure 1
Kinematic Coupling Pin Shape

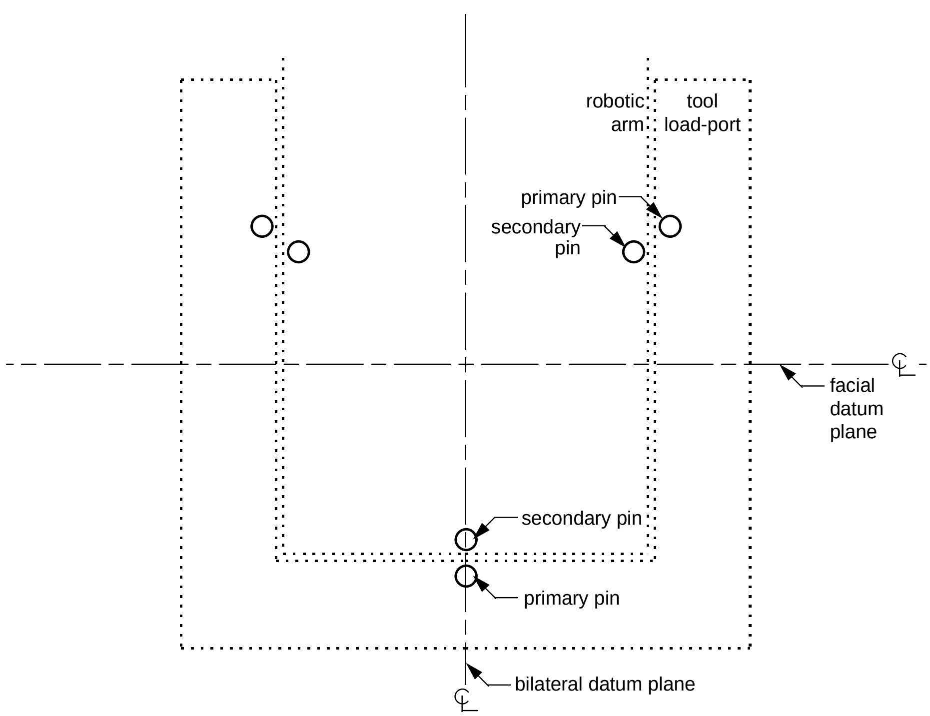

Figure 2
Primary and Secondary Kinematic Coupling Pins

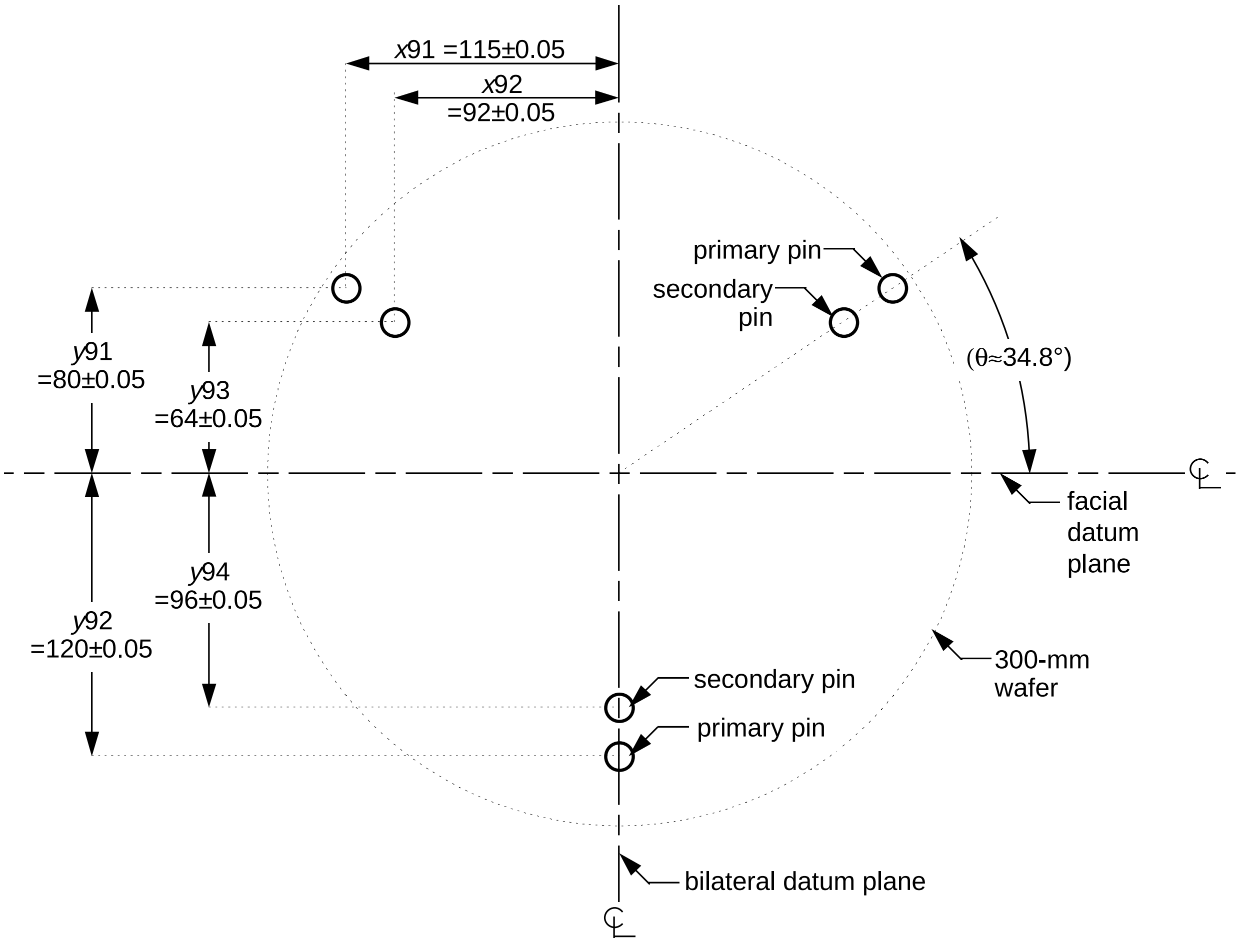

Figure 3
Kinematic Coupling Pin Locations

APPENDIX 1
APPLICATION NOTES

NOTE: This appendix was approved as an official part of SEMI E57, but the recommendations in this appendix are optional and are not required to conform to this standard.

The three features on the bottom of the wafer carrier that mate with the six pins underneath are not specified in this standard. These three features are recommended to be inverted V-shaped grooves, each of which extends along a line that is perpendicular to, and co-planar with, the nominal wafer center line (as shown in Figure 4). Such grooves are likely to work well even when shrunken or slightly misaligned (such as when they do not all line up with the nominal wafer center line). Other mating features are also possible, such as those shown in Figure 5 where one pin is contacted on the top. Front-opening boxes may need to contact the pins on the side to provide pressure against a front mechanical interface. Such options are why the top and sides of the pins are toleranced so tightly. When designing the mating features on the bottom of the wafer carrier, it is suggested that designers follow the recommendations given in the book (listed in Section 6) by Dr. Alexander H. Slocum.

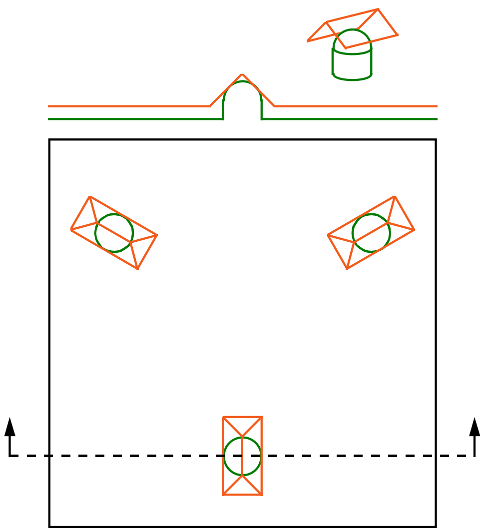

Figure 4
Recommended Mating Features

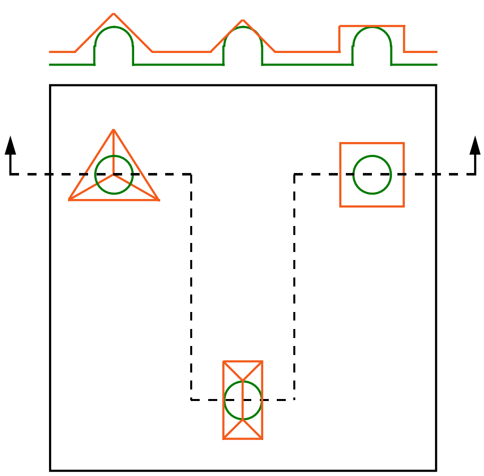

Figure 5
Alternative Mating Features

All of the dimensions for the kinematic coupling pin surfaces and locations are given as ranges so that any roundness, cylindricity, perpendicularity, bending, or misalignment of the pins must be contained within the limits given.

As shown in Figure 6, these couplings can also be used to support 200 mm pods as an addition to the requirements given in SEMI E19.4. However, concurrent implementations for both 200 and 300 mm wafer carriers may be covered by patent claims.

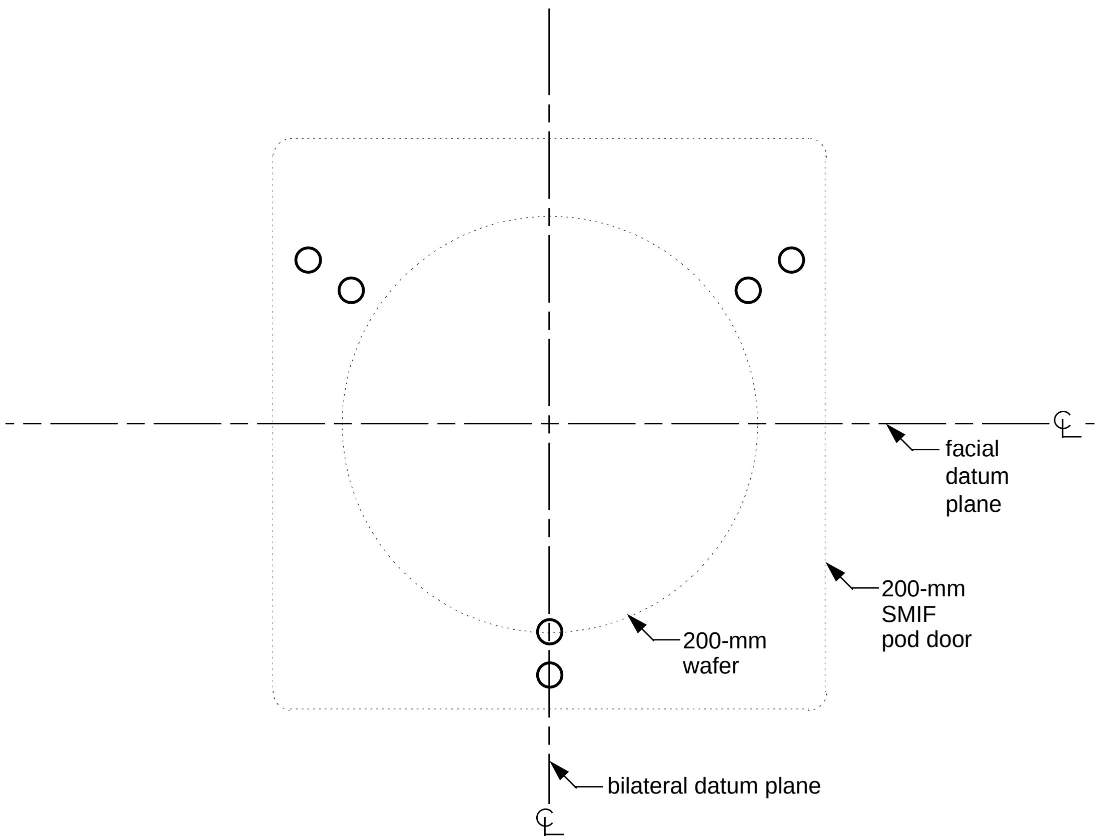

Figure 6
Application to 200 mm Pods

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RELATED INFORMATION 1

NOTE: This related information is not an official part of SEMI E57 and is not intended to modify or supercede the official standard. This information was inserted by the North America Physical Interfaces and Carriers Committee to alert the readers to potential changes to this provisional standard.

A revision ballot will be submitted to loosen the pin surface roughness (*r*97) to 0.4 µm.