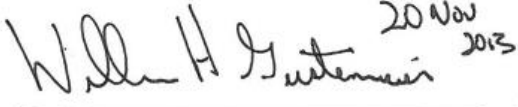# International Docking System Standard (IDSS) Interface Definition Document (IDD)

Revision C

November 20, 2013

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Concurrence

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NASA

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Revision Log

Document Revision	Effective Date	Description
IDSS IDD	09/21/2010	Initial release
Revision A	04/27/2011	Revised, rearranged, and added text to nearly all sections of document. Revised & renumbered figures. Added requirements on mechanical soft capture, soft capture sensors, HCS seals, hook stiffness, separation system, electrical bonding, environments, and materials. Added Docking Performance section, and Appendix A.
Revision B	11/15/2012	Document Hard Capture System parameter values, figure updates, separation system force addition, editorial correction and updates.
Revision C	11/20/2013	Document the narrow ring Soft Capture System (SCS) geometric parameters and update applicable figures. Added Appendix B on Magnetic Soft Capture.

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Table of Contents

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1.0 INTRODUCTION

This International Docking System Standard (IDSS) Interface Definition Document (IDD) is the result of a collaboration by the International Space Station membership to establish a standard docking interface to enable on-orbit crew rescue operations and joint collaborative endeavors utilizing different spacecraft.

This IDSS IDD details the physical geometric mating interface and design loads requirements. The physical geometric interface requirements must be strictly followed to ensure physical spacecraft mating compatibility. This includes both defined components and areas that are void of components. The IDD also identifies common design parameters as identified in section 3.0, e.g., docking initial conditions and vehicle mass properties. This information represents a recommended set of design values enveloping a broad set of design reference missions and conditions, which if accommodated in the docking system design, increases the probability of successful docking between different spacecraft.

This IDD does not address operational procedures or off-nominal situations, nor does it dictate implementation or design features behind the mating interface. It is the responsibility of the spacecraft developer to perform all hardware verification and validation, and to perform final docking analyses to ensure the needed docking performance and to develop the final certification loads for their application.

While there are many other critical requirements needed in the development of a docking system such as fault tolerance, reliability, and environments (e.g. vibration, etc.), it is not the intent of the IDSS IDD to mandate all of these requirements; these requirements must be addressed as part of the specific developer's unique program, spacecraft and mission needs. This approach allows designers the flexibility to design and build docking mechanisms to their unique program needs and requirements.

1.1   Purpose and Scope

The purpose of the IDSS IDD is to provide basic common design parameters to allow developers to independently design compatible docking systems. The IDSS is intended for uses ranging from crewed to autonomous space vehicles, and from Low Earth Orbit (LEO) to deep-space exploration missions.

This document defines docking system interface definitions supporting the following missions:

   A. International Space Station (ISS) visitation
   B. Exploration missions beyond LEO
   C. Crew rescue
   D. International cooperative missions

Vehicles using this interface may include light vehicles in the range of 5-8 tonnes, and medium vehicles in the range of 8-25 tonnes. These vehicles will dock to each other, to large space complexes in the range of 100-375 tonnes, and to large earth departure stages in the range of 33-170 tonnes. The figures and tables in this document depict the features of the docking interface that are standardized. Some docking features (e.g. sensors, separation systems) are not standardized and are left to the discretion of docking system designers, though they must follow the designated striker zone requirements. Resource umbilicals are not yet standardized and are not yet defined in this standard.

1.2   Responsibility and Change Authority

Any proposed changes to the IDSS by the participating partners of this agreement shall be brought forward to the IDSS committee for review.

Configuration control of this document is the responsibility of the International Space Station (ISS) Multilateral Control Board (MCB), which is comprised of the international partner members of the ISS. The National Aeronautics and Space Administration (NASA) will maintain the IDSS IDD under ISS Configuration Management, until an appropriate International Standards Body is identified and mutually agreed.

2.0 APPLICABLE AND REFERENCE DOCUMENTS

None.

3.0 INTERNATIONAL DOCKING SYSTEM STANDARD

3.1   General

The following subsections describe the system interfaces for the IDSS.

3.1.1   System Description

3.1.1.1 Docking

The IDSS IDD defines a 2-stage approach to docking. The first stage establishes the initial capture of the docking vehicles, and is performed by the Soft Capture System (SCS). During the capture phase, the active docking mechanism's SCS aligns with and latches to the passive docking mechanism, then stabilizes the newly joined spacecraft relative to each other. The soft capture system then pulls the docking spacecraft together in order to initiate the second stage of docking, performed by the Hard Capture System (HCS). The HCS performs structural latching and sealing at the docking

interface in order to transfer structural loads between the spacecraft and to create a transfer tunnel which can be pressurized for crew and cargo transfer for joint mission operations. The docking operation needs to be completed within a maximum time to ensure a safe docking operation.

The IDSS docking interface is fully androgynous about one axis, meaning the interface configuration is capable of mating to an identical configuration. During docking, one androgynous soft capture interface must be active (active mode), while the other androgynous soft capture interface remains retracted and locked in place, or passive (passive mode). The active interface controls the soft capture function and all sequences of docking through hard capture. *Figure 3-1: Androgynous Docking Interface – Axial View* and *Figure 3-2: Androgynous Docking Interface – Cross Sections* depict the Androgynous IDSS interface.

The androgynous SCS interface consists of a capture ring, guide petals, mechanical latches, mechanical latch strikers, sensors and sensor strikers. The term "striker" refers to the area on the passive side of the mating interface which is intended to be a contact surface for an active component on the active side of the mating interface. During docking soft capture, the guide petals are the first element to make contact; this is referred to as initial contact. The SCS then responds to correct the lateral and angular misalignment between the two opposing interfaces. Soft capture is complete when the two capture rings are in full contact and the active mechanical capture latches are fully engaged with the mechanical latch strikers on the opposing vehicle.

The SCS then aligns the two mating vehicles and retracts to bring the two hard capture interfaces into hard capture range. Fine alignment is accomplished by a combination of SCS retraction and HCS guide pins.

The HCS uses active hooks to engage opposing passive hooks to provide the structural connection and pressure seal compression. The HCS interface consists of a tunnel, 12 active/passive hook pairs on each side, dual concentric pressure seals, fine alignment guide pins and guide pin receptacles, sensors, sensor strikers, separation system, and resource umbilicals (resource umbilicals are not yet standardized).

The docking operation is complete when the mechanical hooks and resource umbilicals are fully engaged.

3.1.1.2 Berthing

Berthing spacecraft together using a mechanical robot arm has been a crucial capability for spaceflight operations. This capability has been used extensively as part of the United States Space Shuttle and ISS programs. This international docking standard interface will not preclude robotic assisted berthing by the ISS Space Station Remote Manipulator System (SSRMS) (or an equivalent system) if the total force required to enable soft capture is less than 150N. The primary method for berthing utilizes a fully functional soft capture system.

3.1.2 Engineering Units of Measure

All dimensions are in millimeters. All angular dimensions are in degrees. Unless otherwise specified, the dimensional tolerances shall be as follows:

xx implies xx ± 1 mm

xx.x implies xx.x ± 0.5 mm

xx° implies xx° ± 30'

3.1.3 Coordinate System

The IDSS utilizes a reference frame for cross reference between figures illustrated in this document. Two reference lines are a Line of Androgyny and a Line of Symmetry as shown in *Figure 3-1: Androgynous Docking Interface – Axial View*. The Axial Axis is defined as shown in *Figure 3-2: Androgynous Docking Interface – Cross Sections*.

3.2 Mating Interface Definition

An overview of the IDSS interface is shown in *Figure 3-1: Androgynous Docking Interface – Axial View*. The IDSS docking interface shall conform to the definition as shown in *Figure 3-2: Androgynous Docking Interface – Cross Sections*. The HCS Mating Plane is defined as the seal plane between two vehicles' HCS tunnels when structurally mated.

The SCS Mating plane is defined as the plane normal to the Soft Capture Ring's axis which intersects the conic outline of the Guide Petals at a diameter of 1200 mm.

The SCS mating plane is the top surface of the capture ring for both active and passive modes.

Unless otherwise stated, the dimensions and features called out in section 3.2 and its subsections shall be implemented on IDSS-compatible systems; these are requirements which must be met to ensure docking interface compatibility. Each requirement dimension is specified only once with its required value and tolerance. For increased clarity, some requirement dimensions are repeated elsewhere without tolerance, and are marked with "REF". "REF" stands for "REFERENCE", and denotes a repeated callout of a primary requirement dimension that can be found elsewhere in this document. Some dimensions in the figures are enclosed in braces, i.e. "{ }". These dimensions are not a requirement of the standard, but are dimensions from existing proven heritage systems. Deviations from these dimensions may be possible.
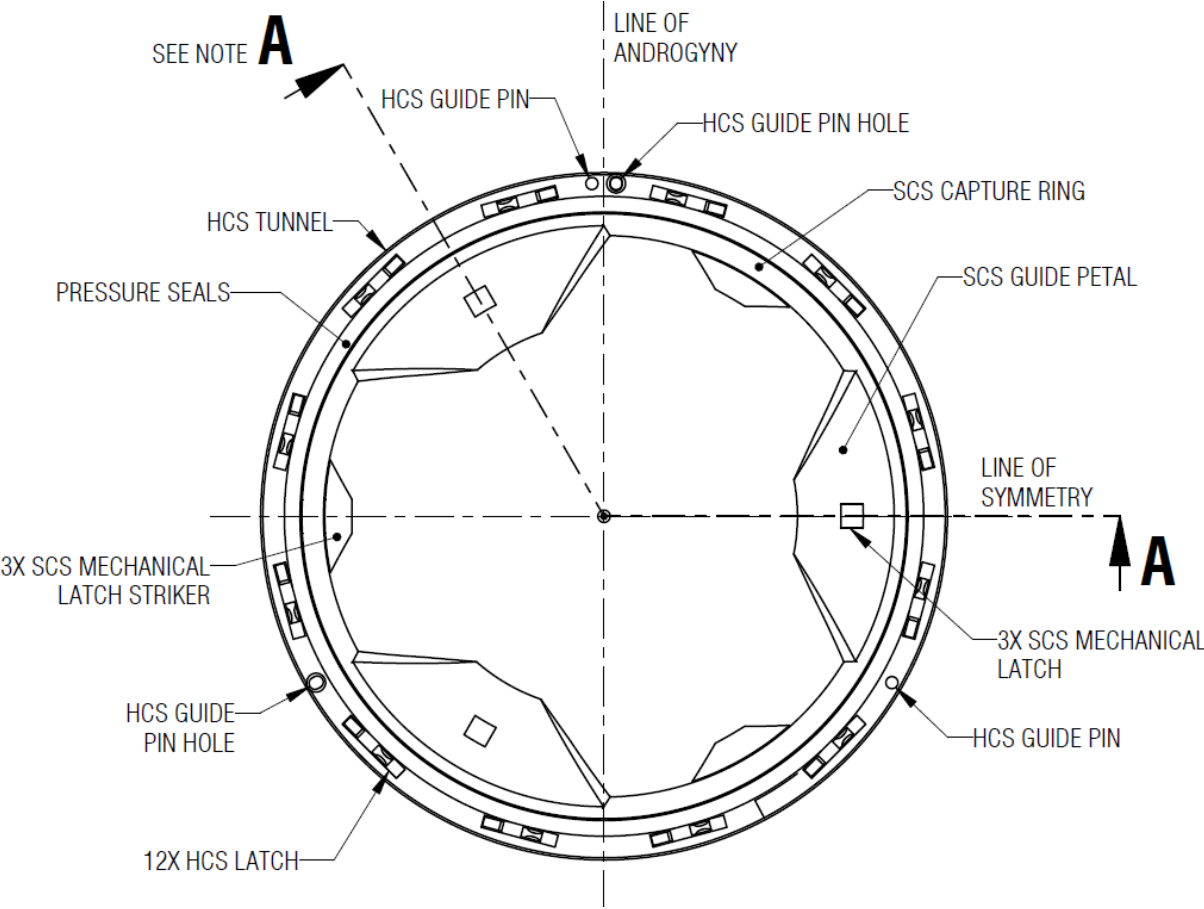
Note: Refer to Figure 3-2a for Section A-A.

Figure 3-1: Androgynous Docking Interface – Axial View

TUNNEL ID
Ø 1255 +0.65 / −0.50

PETAL BASE
Ø 1200 +0 / −0.5

E

TRANSFER PASSAGEWAY
Ø 800 +5 / −0.3

SEE NOTE

AXIAL AXIS

HCS MATING PLANE

PETAL HEIGHT 200 REF

SCS MATING PLANE RECESSED BELOW HCS MATING PLANE

6 REF

Ø 305

GUIDE PETAL KEEP OUT ZONE
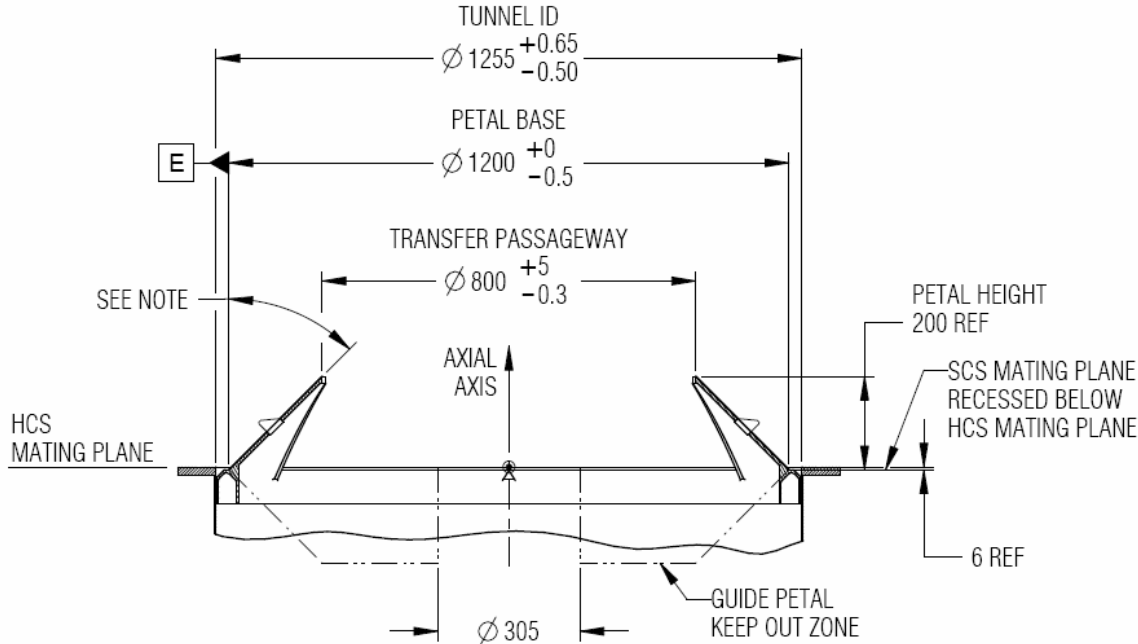
Note: Refer to Figure 3-2b for details

Figure 3-2a: Section A-A (Cross-section through mid-plane of two petals)

PETAL BASE
Ø 1200 REF

0.8

C

45° +0° 30' / −0°

B ◁—▷ C

45° +0° 5' / −0°

A ◁—▷ B

B

38 MIN

A

SCS MATING PLANE

CAPTURE RING

GUIDE PETAL

℄ CAPTURE RING
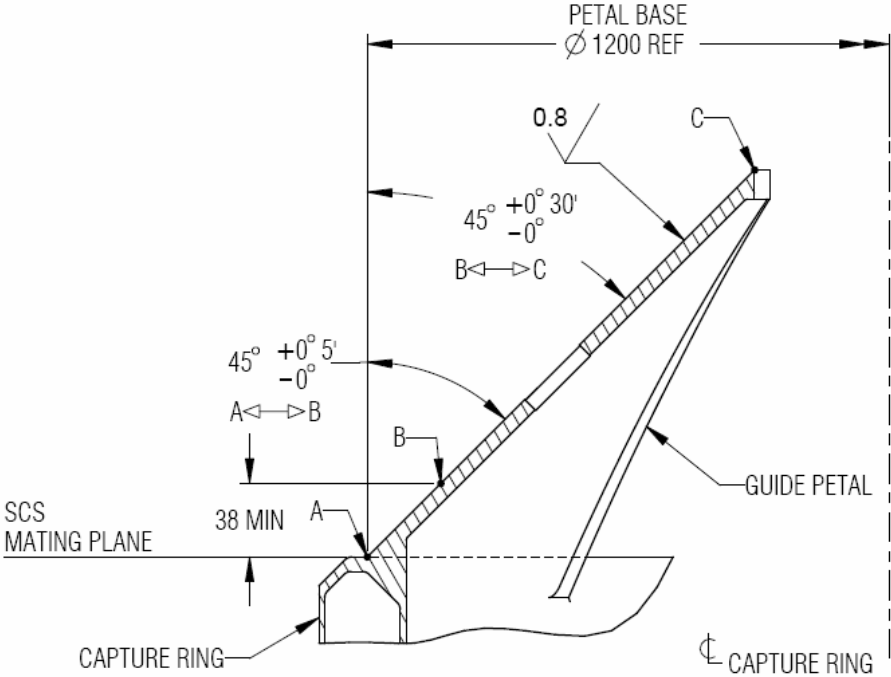
Figure 3-2b: Detailed Section of Petal

Figure 3-2: Androgynous Docking Interface – Cross Sections

3.2.1 Transfer Passageway

The docking system shall maintain the minimum transfer passageway diameter as shown in *Figure 3-2: Androgynous Docking Interface – Cross Sections.*

3.2.2 Soft Capture System

The SCS performs soft capture using mechanical capture latches with mechanical strikers. The capture system shall conform to the definition as shown in *Figure 3-3: SCS Interface - Capture System.* Soft capture is the initial mechanical mating between the docking systems. It is the first stage of attachment in the docking sequence for the purpose of soft capture system docking interface alignment, capture, arrest and stabilization of dynamic motion between the spacecraft, and finally, interface alignment prior to hard capture system engagement.

An alternative concept for a capture system based on magnetic capture - which would be compatible with mechanical latches - is described in *Appendix B.*
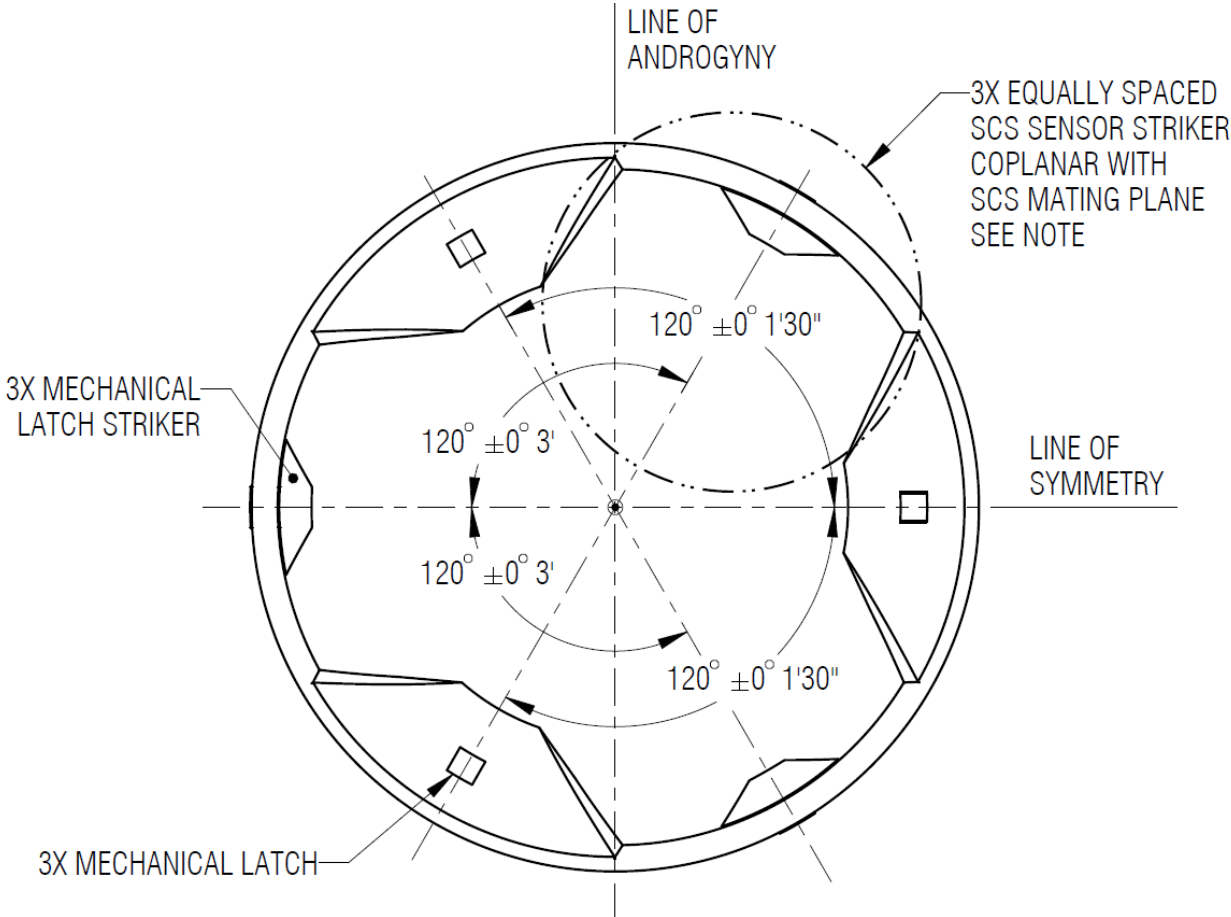
Note: Refer to Figure 3-3b for Striker Zone details

Figure 3-3a: Capture System Overview

LINE OF
ANDROGYNY

17°

17°

60° REF

SCS SENSOR STRIKER ZONE
OUTER EDGE ON TOP FACE: $\varnothing$ 1220 REF
INNER EDGE ON SLOPED FACE: $\varnothing$ 1195.8 MIN

LINE OF
SYMMETRY
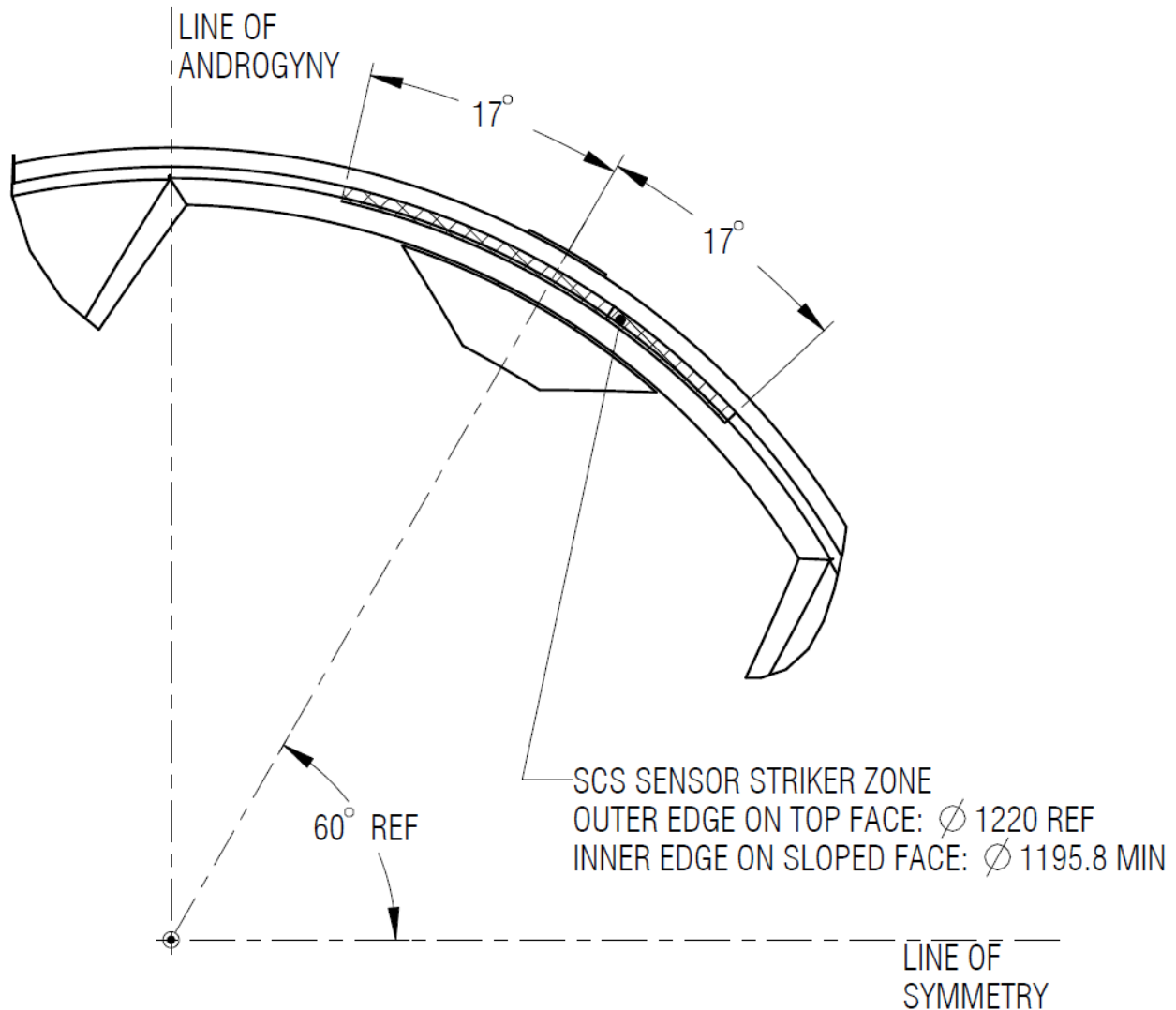
Figure 3-3b: Striker Zone Detail

Figure 3-3: SCS Interface - Capture System

3.2.2.1 Guide Petal System

IDSS compliant systems shall implement three inward pointing guide petals integrated on the soft capture ring. The petals shall be equally spaced around the circumference of the soft capture docking ring as shown in *Figure 3-4: SCS Interface – Guide Petal System Overview* Additional SCS interface details that shall be implemented are shown in *Figure 3-5: SCS Interface – Guide Petal System Details* and *Figure 3-6: SCS Interface – Capture Ring Profile*.
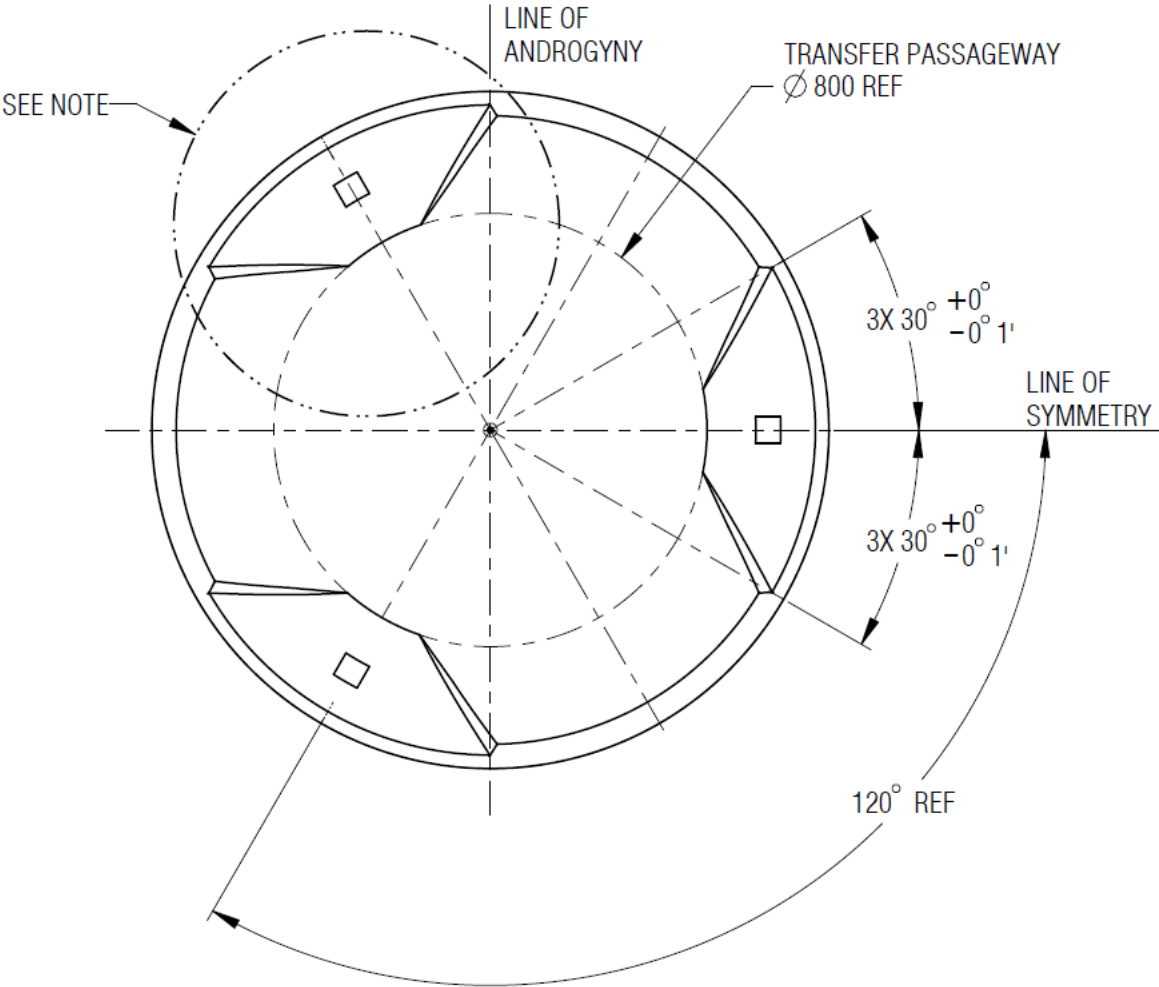
Note: Refer to Figure 3-5a and Figure 3-5b for Petal details.

Figure 3-4: SCS Interface – Guide Petal System Overview
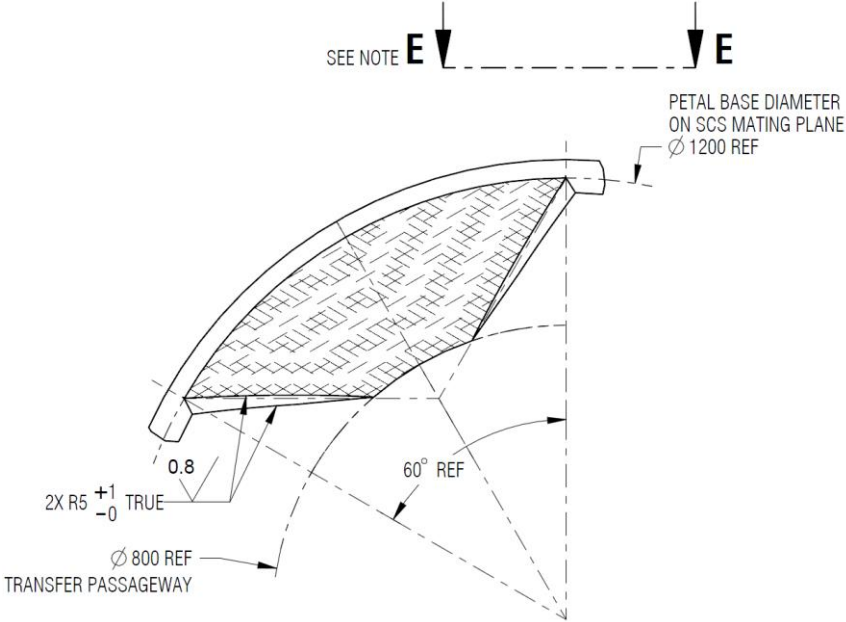
Note: Refer to Figure 3-5c for View E-E

Figure 3-5a: Petal Detail
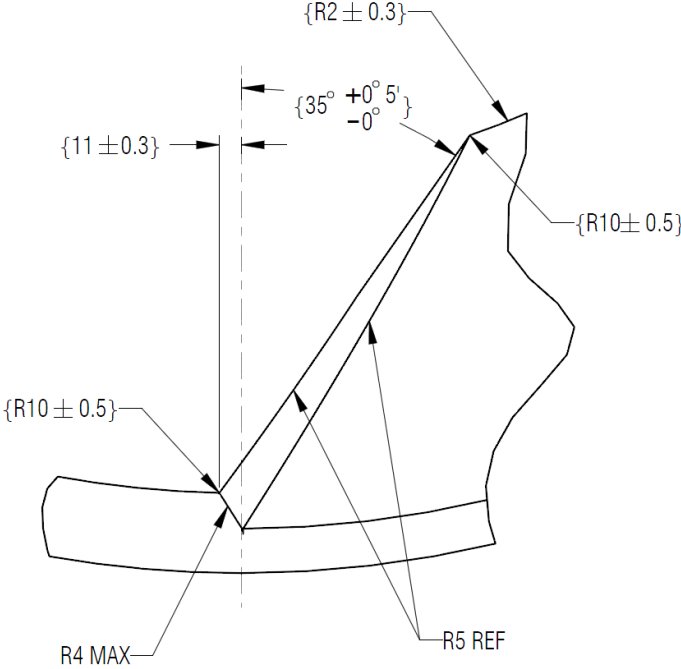
Figure 3-5b: Petal Profile Detail

$32° \ 30' \ ^{+0° \ 30'}_{-0°}$

$B \triangleleft \!\!\longrightarrow\!\! \triangleright C$

0.8

C

GUIDE PETAL
TOP SURFACE

$32° \ 30' \ ^{+0° \ 5'}_{-0°}$

$A \triangleleft \!\!\longrightarrow\!\! \triangleright B$

$1 \ ^{+0.36}_{-0}$

B

SCS
MATING PLANE

38 MIN

A

℄ CAPTURE RING
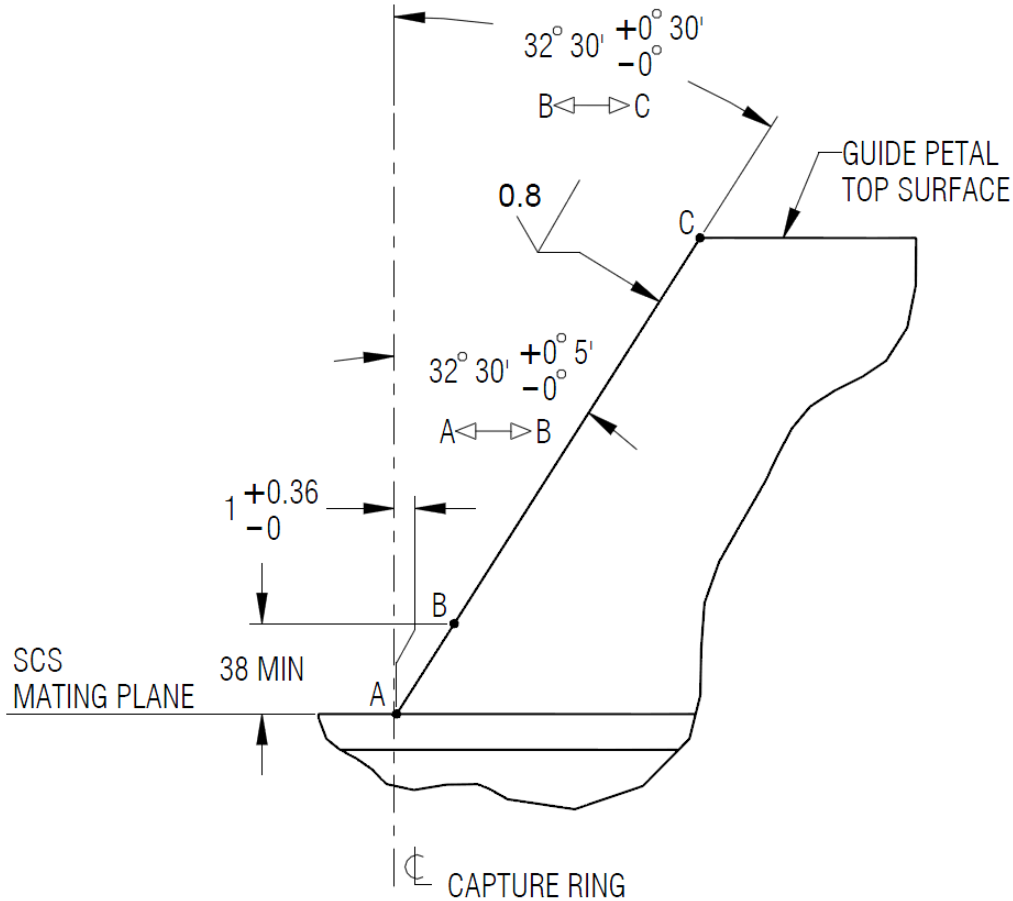
Figure 3-5c: Section E-E - Guide Petal Outline

Notes:

In Petal Detail view, dimensions projected on the SCS mating plane are shown.

Petal outline shown is on the external conic surface of the petal system.

Figure 3-5: SCS Interface – Guide Petal System Details
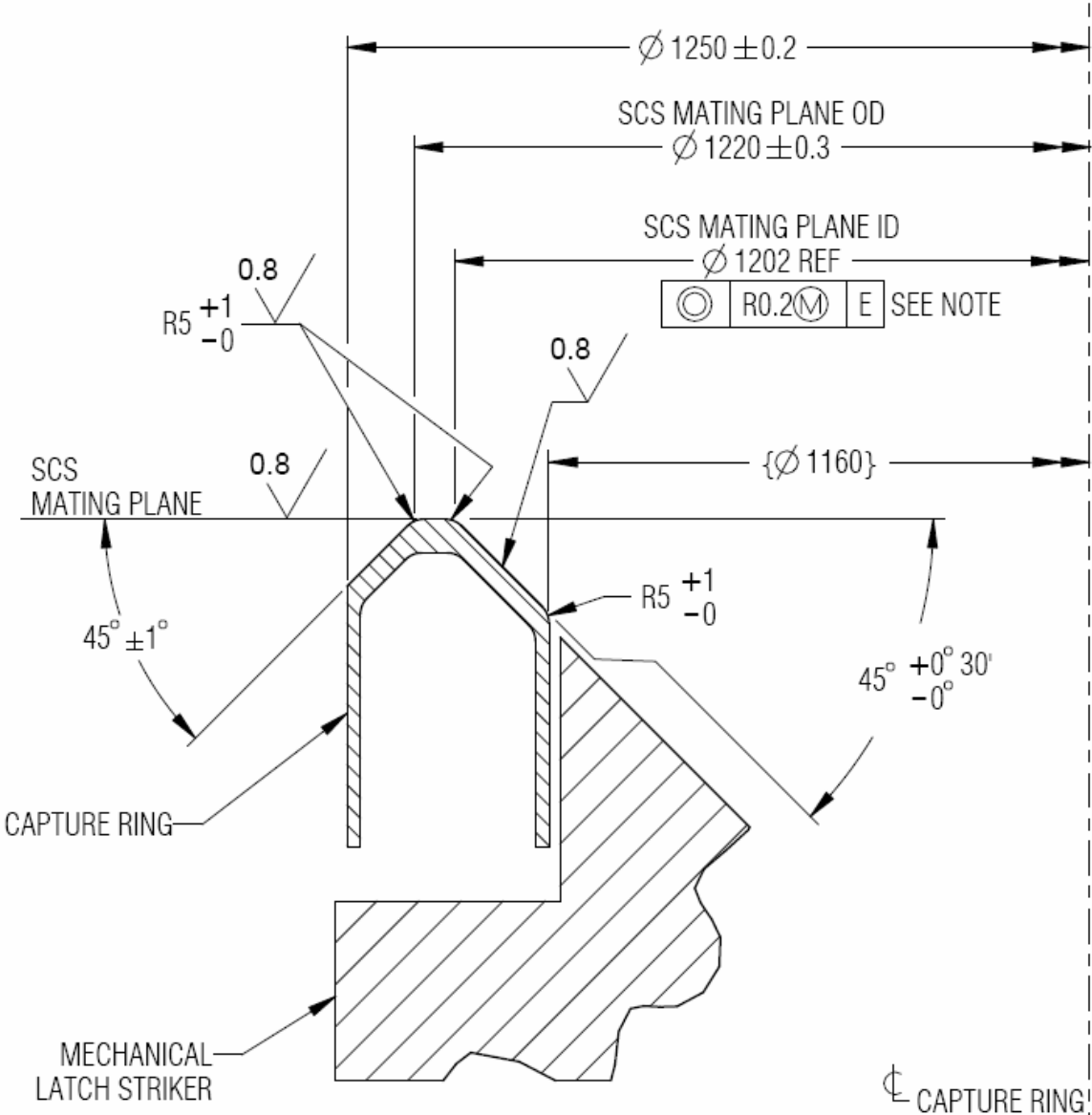
Note: Datum E is defined in Figure 3-2.

Cross Section View of Capture Ring in Passive Mode through the Striker

Figure 3-6: SCS Interface – Capture Ring Profile

3.2.2.2 Soft Capture Ring

The SCS Ring is retracted and held firmly in place below the HCS mating plane when in passive mode. In active mode, the SCS Ring is actuated above the HCS mating plane to perform soft capture.

3.2.2.3 (Deleted)

Figure 3-7: (Deleted)

3.2.2.4 Mechanical Capture Latch System

The IDSS SCS interface includes three mechanical latch strikers to accommodate mechanical latching systems as shown in *Figure 3-3: SCS Interface - Capture System*. The mechanical Latches and strikers shall conform to the definition shown in *Figure 3-8: Latch Striker for Mechanical Systems*, and *Figure 3-9: Active Mechanical Soft Capture Latch Interface*.
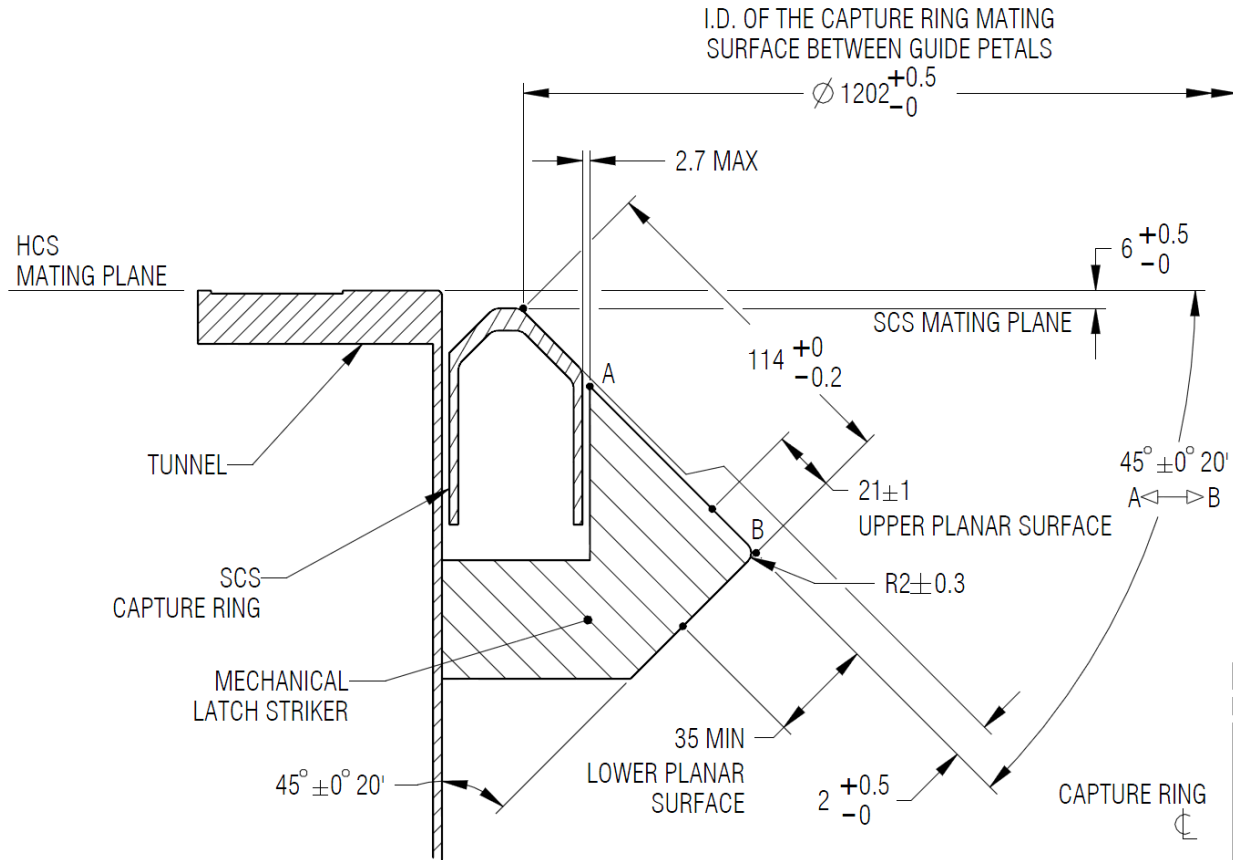
Figure 3-8a: Cross Sectional View through Centerline of Mechanical Latch Striker

14
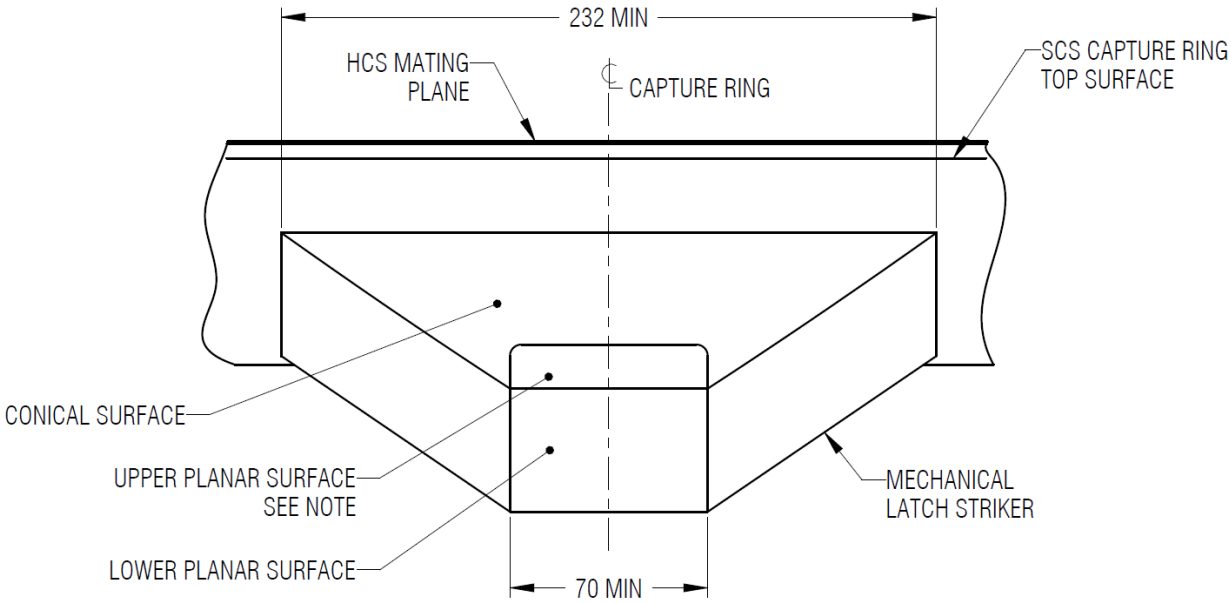
Note: Two orthogonal planar surfaces are required to form a straight edge at nose. The upper planar surface transitions into the Striker conical surface as required in such a way that the upper planar surface is either flush or slightly recessed below the conical surface. This will ensure there is no obstruction on the striker during SCS capture.

Figure 3-8b: Radial View
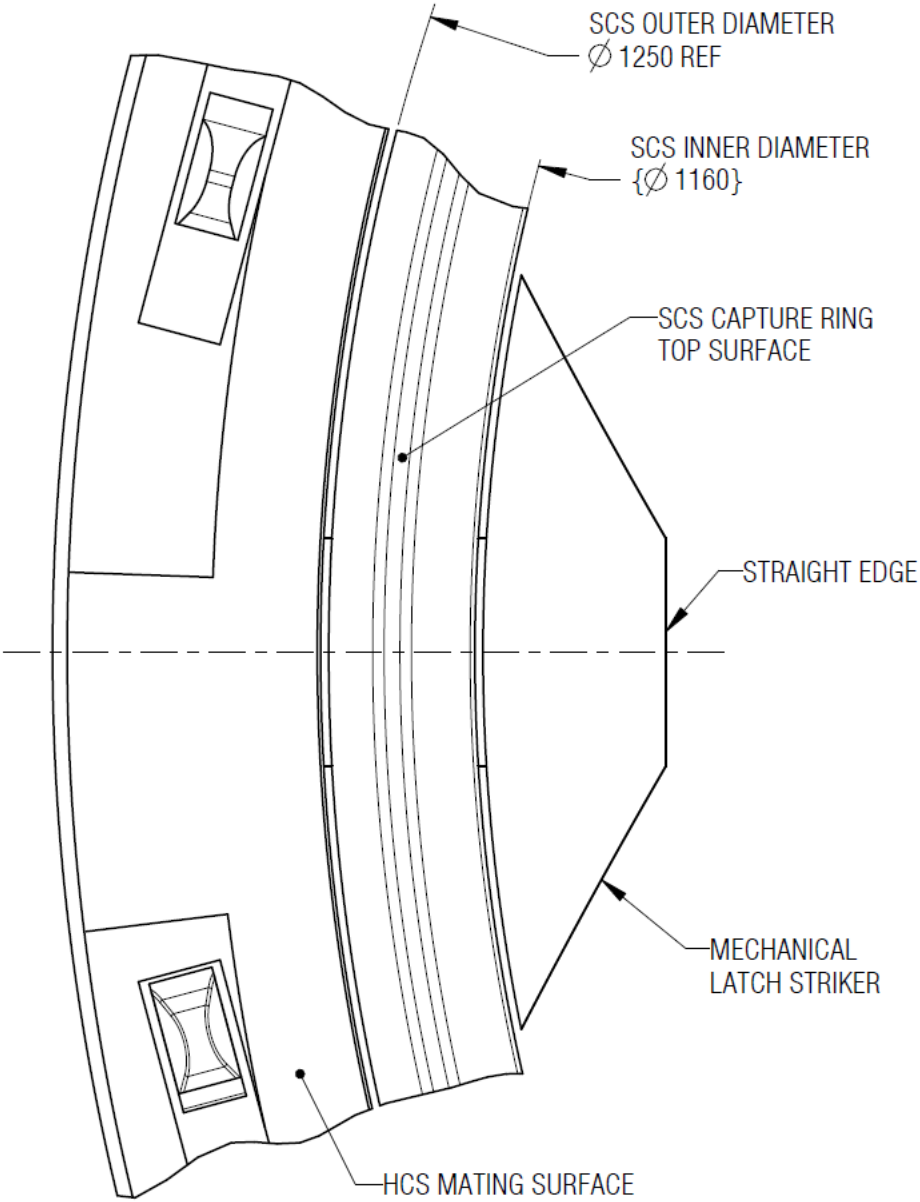
Figure 3-8c: Top View

Figure 3-8: Latch Striker for Mechanical Systems
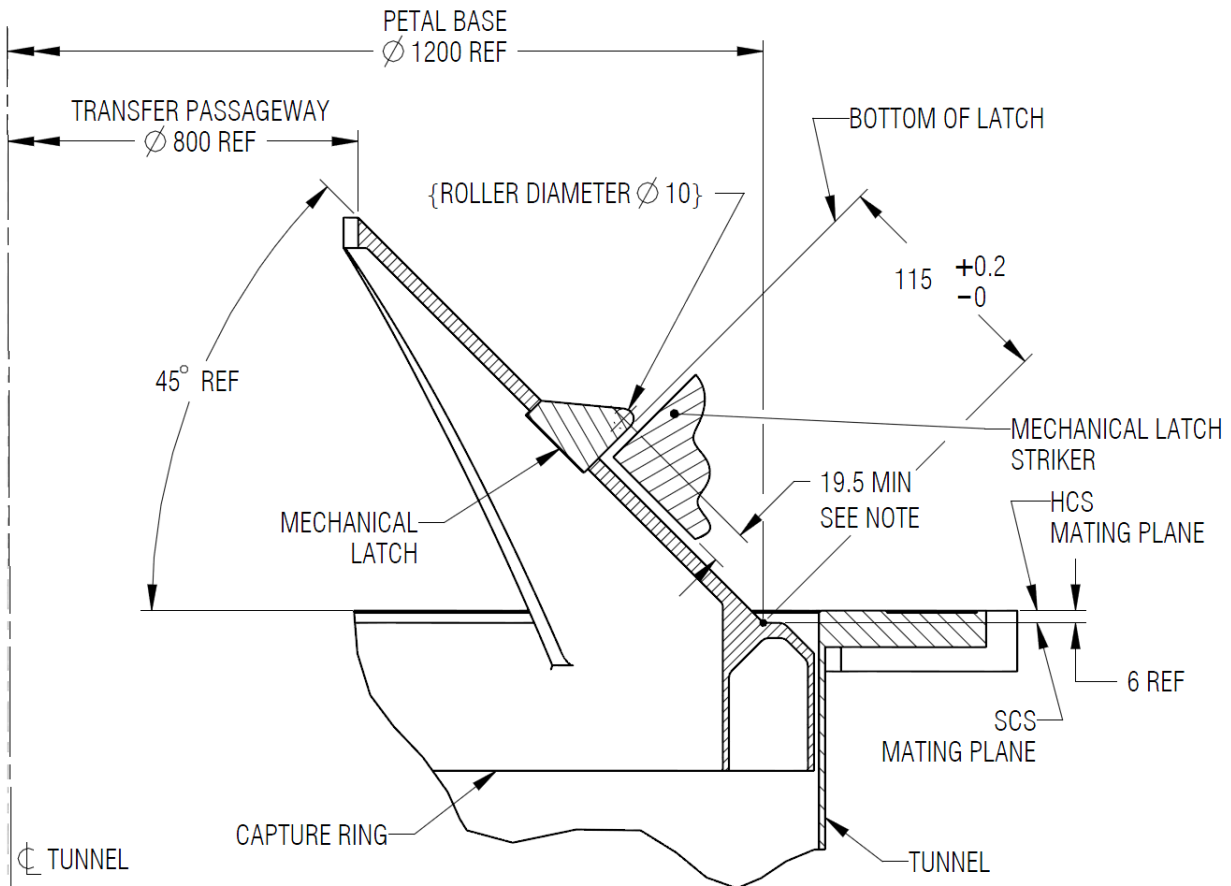
Note: Nominal minimum latch engagement.

Figure 3-9: Active Mechanical Soft Capture Latch Interface

3.2.2.5 Soft Capture Sensor Actuation

To ensure successful soft capture performed by various active docking systems that may utilize different technologies, a limit on the total resistance force produced by a passive SCS, including force to simultaneously actuate all SCS sensors (Example: Capture sensors), is to be defined as follows:

The total actuation force due to all SCS sensors shall be ≤ 50N.

3.2.2.6 Soft Capture Sensor Strikers

Designated areas for striker zones used by all SCS sensors from the opposing docking system are defined as shown in *Figure 3-3: SCS Interface - Capture System*. Active system shall place their sensors such that they will strike the passive IDSS interface within these zones. Passive system shall provide a smooth striking surface within these zones to accommodate active system sensors.

3.2.3 Hard-Capture System

The Hard Capture System (HCS) performs the final structural mating between the two vehicles, establishing a connection capable of withstanding atmospheric pressure combined with the loads from planned mated operations of the two spacecraft.

The HCS interface shall conform to the definition as shown in *Figure 3-10: HCS Interface - Axial View* and *Figure 3-11: HCS Interface - Sensor Striker Zone*. HCS components that are not critical for transferring mated loads or maintaining pressurization are intentionally omitted from these figures for clarity. Designated striker regions are identified for participants to configure peripheral hardware (e.g. separation system and sensors).
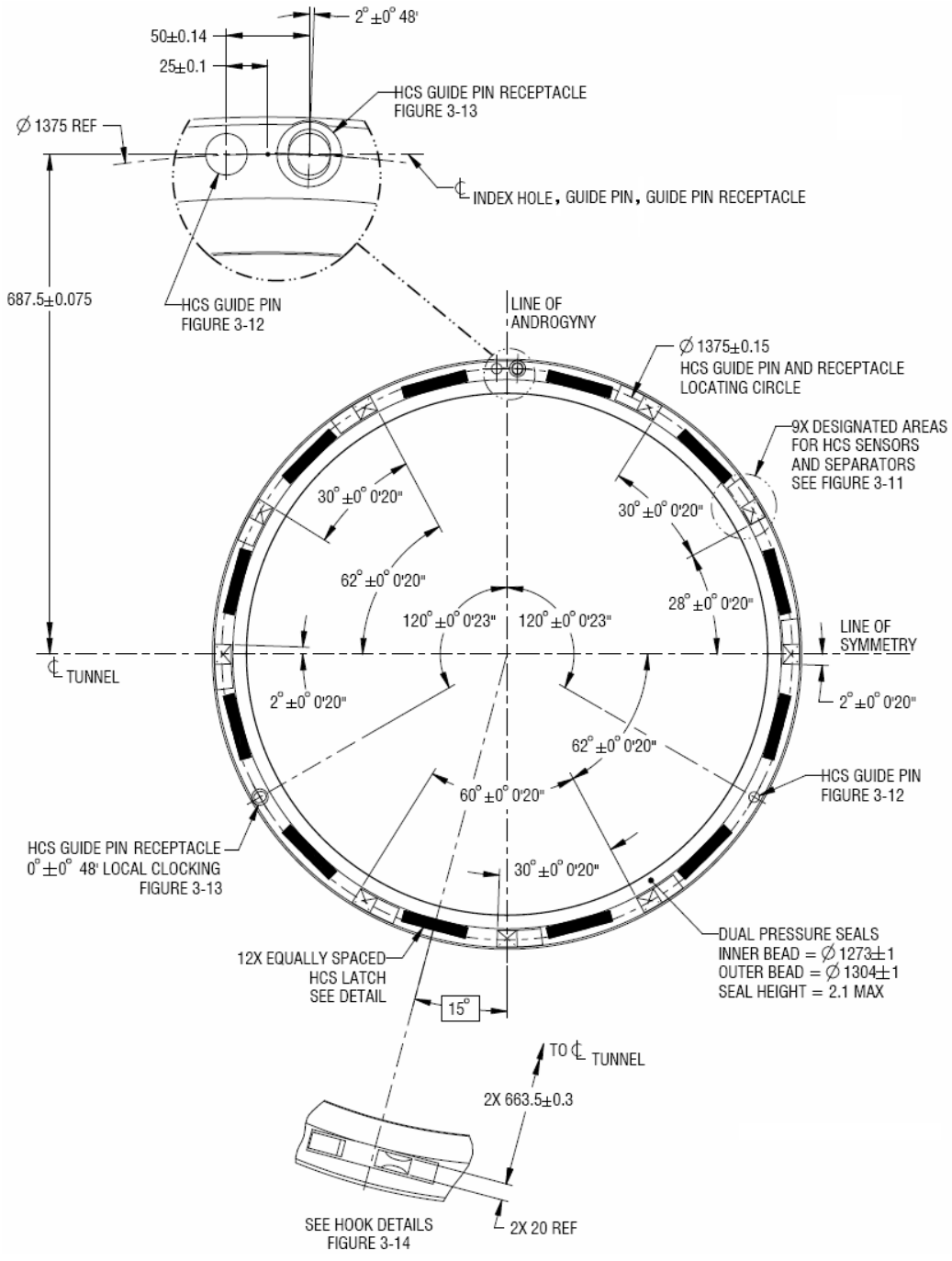
Notes:

1. Boxed angular dimensions are shown as Basic Dimensions that illustrate the theoretical construction lines.

   No dimensional tolerances are to be applied to the Basic Dimensions.

2. Separation systems shall be retracted below the HCS mating plane prior to closure of HCS interface.

Figure 3-10: HCS Interface - Axial View

19
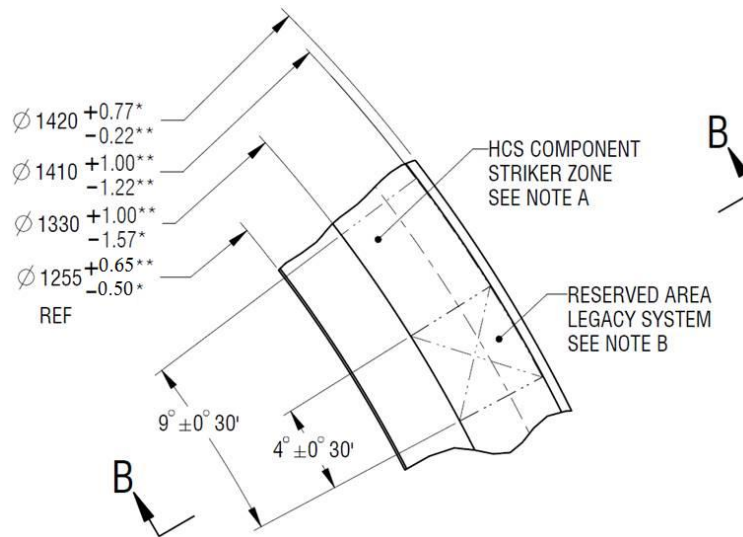
Sensor Striker Zone
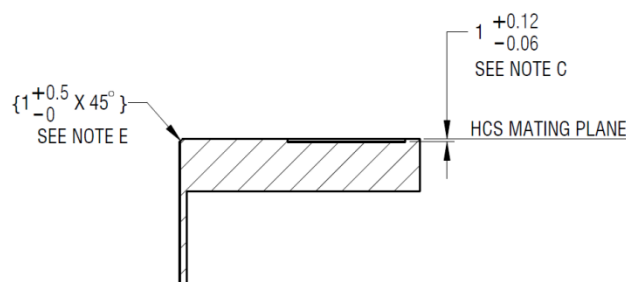
Section B-B

Notes:

  * To accommodate NDS legacy

  ** To accommodate APAS legacy

a) "HCS Component Striker Zone" is to depict the area for any international partner's components to strike. This zone provides the area for HCS sensors and separation mechanisms to contact.

b) "Reserved Area" is the area inside the "HCS Component Striker Zone" for legacy HCS components and strikers. Refer to Appendix A for details.

c) "HCS Component Striker Zone" and "Reserved Area" are recessed from HCS mating plane as shown in Section B-B.

d) HCS Component Striker Zone may contain features that require accommodation. See Appendix A for details.

e) A chamfer is shown as a required minimum clearance cutout all around the circumference. The cutout may have a different form and size as long as it meets the above minimum material removal requirement.

Figure 3-11: HCS Interface - Sensor Striker Zone

3.2.3.1 Tunnel

The tunnel is the main housing of the docking system that includes the interface flange for structural mating.

3.2.3.2 Seal

The HCS shall implement two concentric pressure seals that accommodate seal-on-seal mating. For seal diametral dimensions, refer to *Figure 3-10: HCS Interface - Axial View*. The pressure seals are located internally with respect to the tangential hook location. Seal parameters shall be as defined below. Also see *Table 3-6: HCS Maximum Mated Loads* for seal closure (compression) force.

> Total seal adhesion force for both concentric seals   ≤ 900 N
>
> Seal protrusion height in a free state above the HCS mating plane ≤ 2.1 mm
>
> "Seal adhesion force" is defined as the force that is required to pull the docking pressure seals apart after they have been pressed together.

3.2.3.3 Guide Pins and Receptacles

The HCS shall implement two guide pins and two guide pin receptacles, as shown in *Figure 3-12: Guide Pin Details* and *Figure 3-13: Guide Pin Receptacle Details* for final alignment features of the hard-mate interface. The dimensions shown are for the final interface contour surfaces of the docking system assembly, disregarding any specific design of the insert.
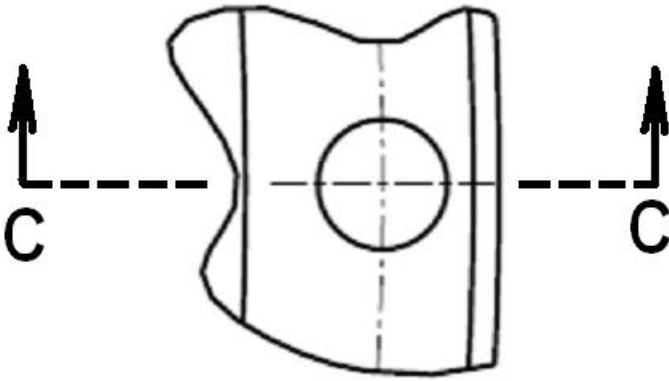
Figure 3-12a: Guide Pin
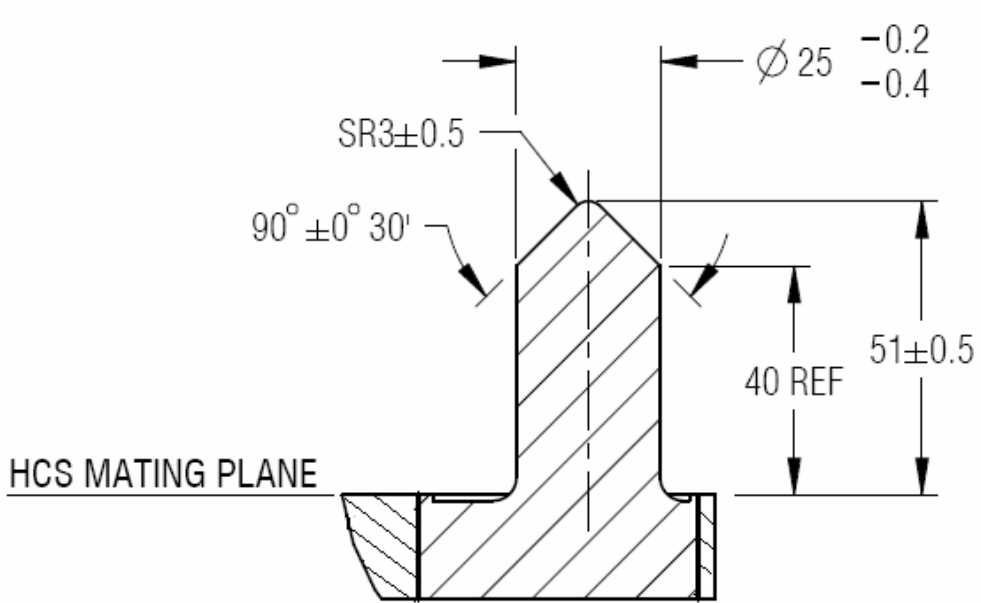
Figure 3-12b: Section C-C

Figure 3-12: Guide Pin Details

30.2 $^{+0.34}_{-0}$

D

D

R20.5±0.3

25.2 $^{+0.14}_{-0}$

2X R

Ø 39±0.3
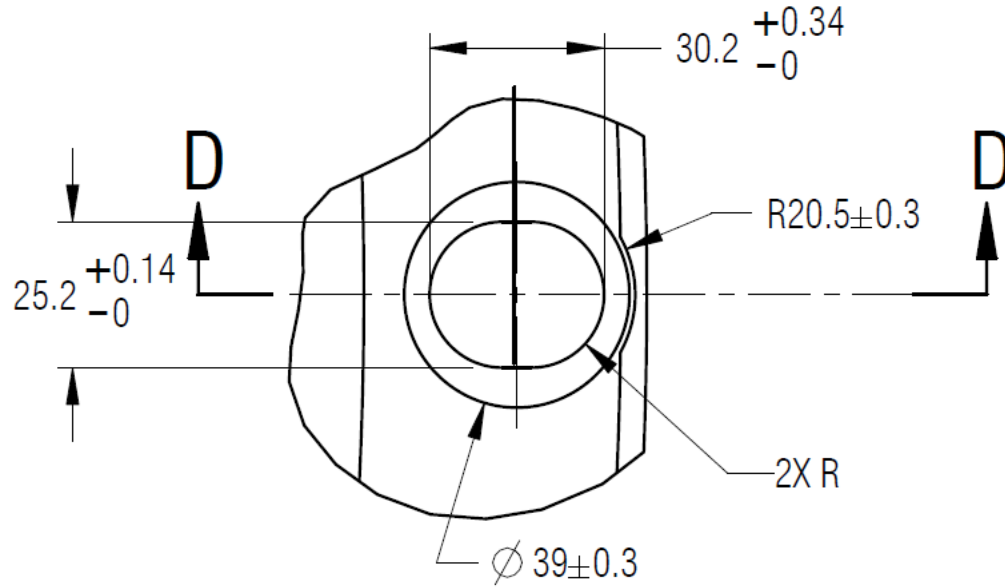
Figure 3-13a: Guide Pin Receptacle

90° ±0° 30'

1±0.5*

HCS MATING PLANE

12±0.5
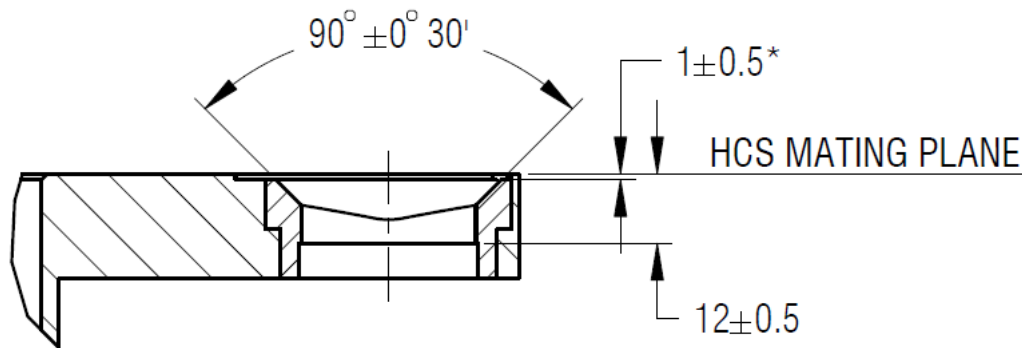
*Note: As the Guide Pin Receptacle is located in a recessed area, this dimension depicts the distance from the HCS Mating Plane to the start of the hole chamfer.

Figure 3-13b: Section D-D

Figure 3-13: Guide Pin Receptacle Details

3.2.3.4 Hard Capture Hooks

The HCS shall incorporate 12 pairs of active and passive hooks, located as shown in Figure 3-10: HCS Interface - Axial View. To carry nominal loads, 12 active hooks on one docking system shall engage 12 passive hooks on an opposing docking system interface. On a fully androgynous system, the 12 active hooks on each side of the interface may be engaged with the 12 passive hooks on the opposing interface for a total of 24 active hook engagements. Although engaging 24 hooks is not a requirement,

this capability can be used to carry additional mated interface loads.   The HCS implements a passively compliant passive hook. The hooks shall conform to the definition as shown in *Figure 3-14: HCS Hooks - Side Views*, *Figure 3-15: HCS Active Hook*, and *Figure 3-16: HCS Passive Hook*. The motion of the active hook shall be bounded by the envelope shown in *Figure 3-17: HCS Active Hook Motion Envelope*.
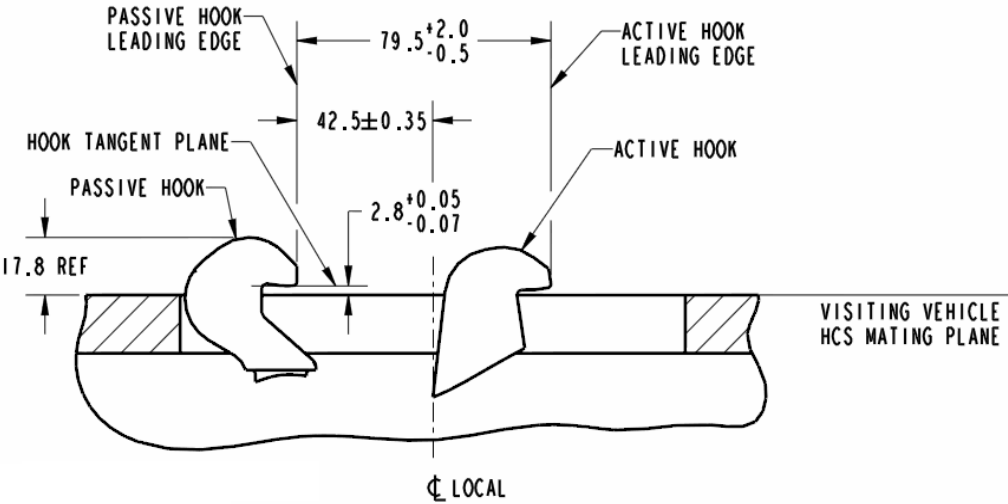
Figure 3-14a: Ready to Dock Configuration
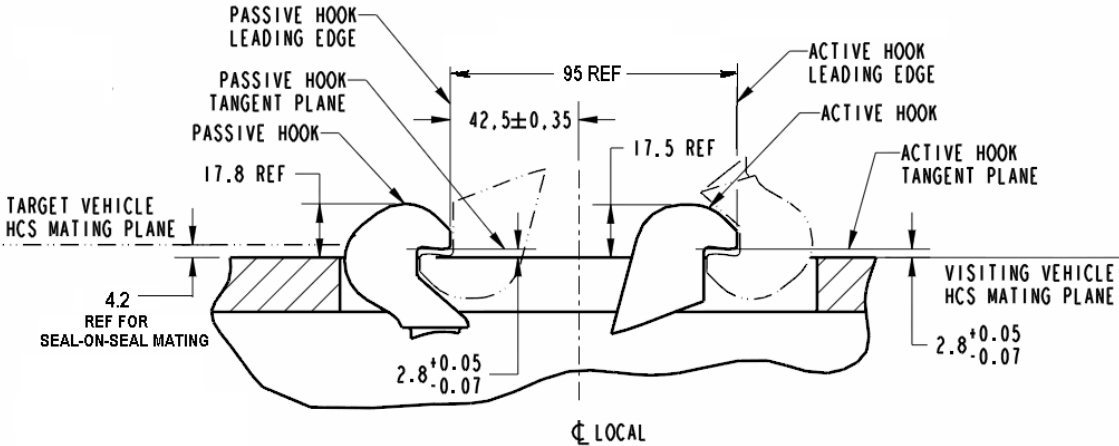
Figure 3-14b: Ready to Hook Configuration
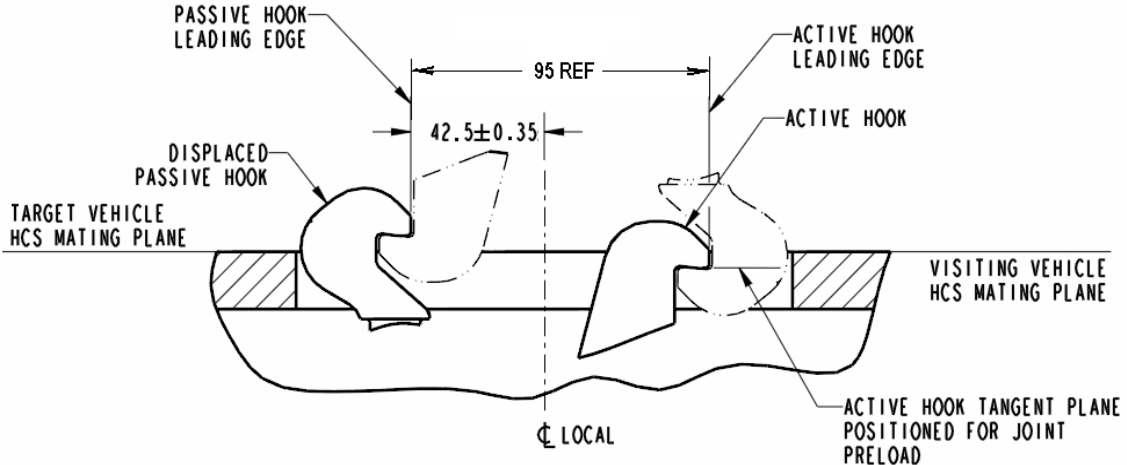
Figure 3-14c: Fully Mated Configuration

Figure 3-14: HCS Hooks - Side Views
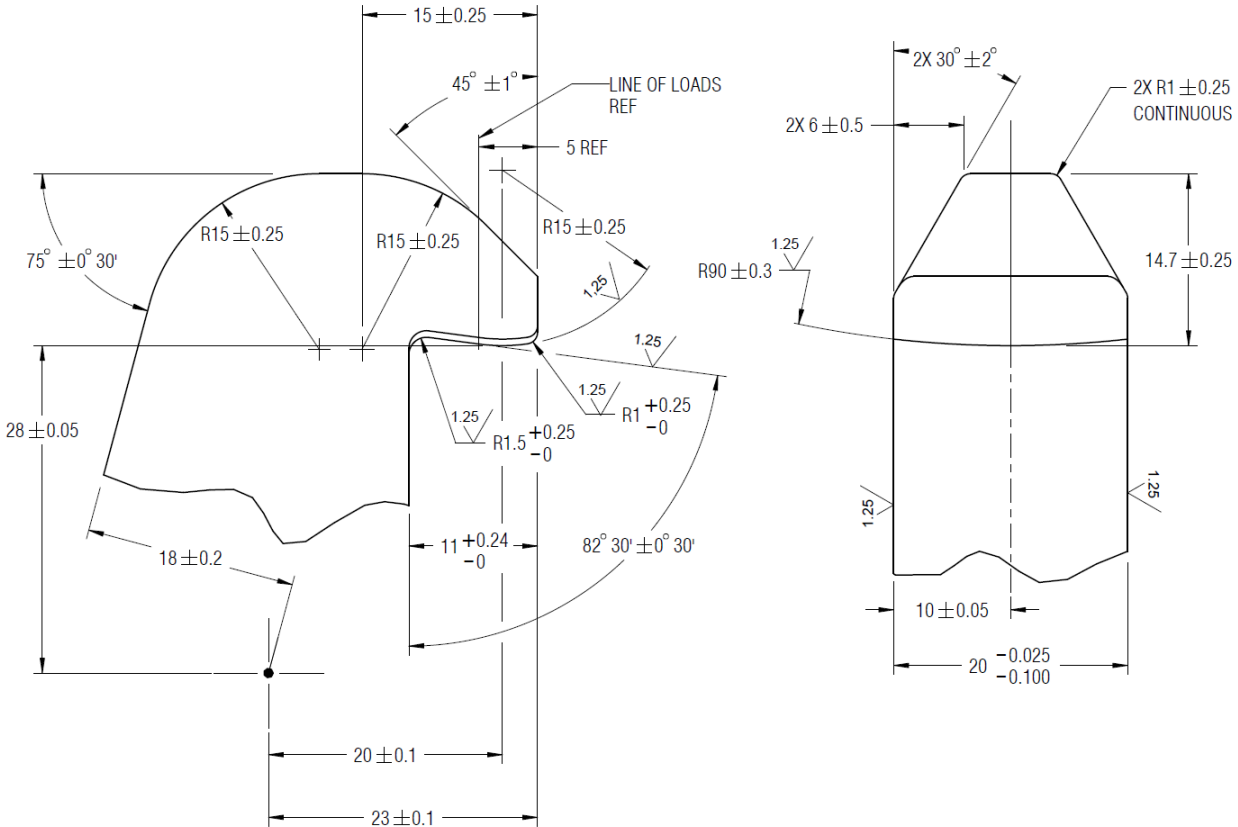
Figure 3-15: HCS Active Hook
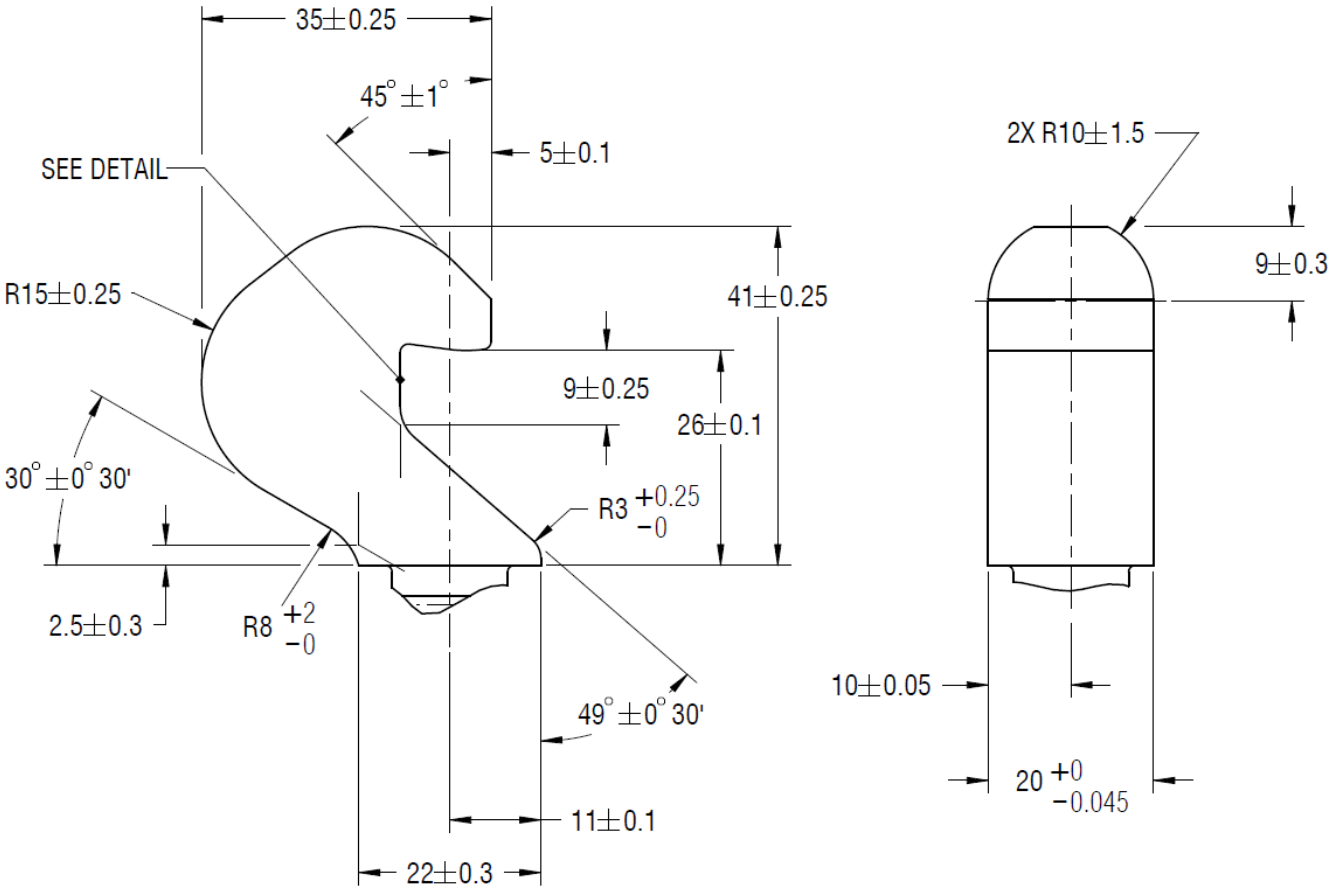
Figure 3-16a: Passive Hook
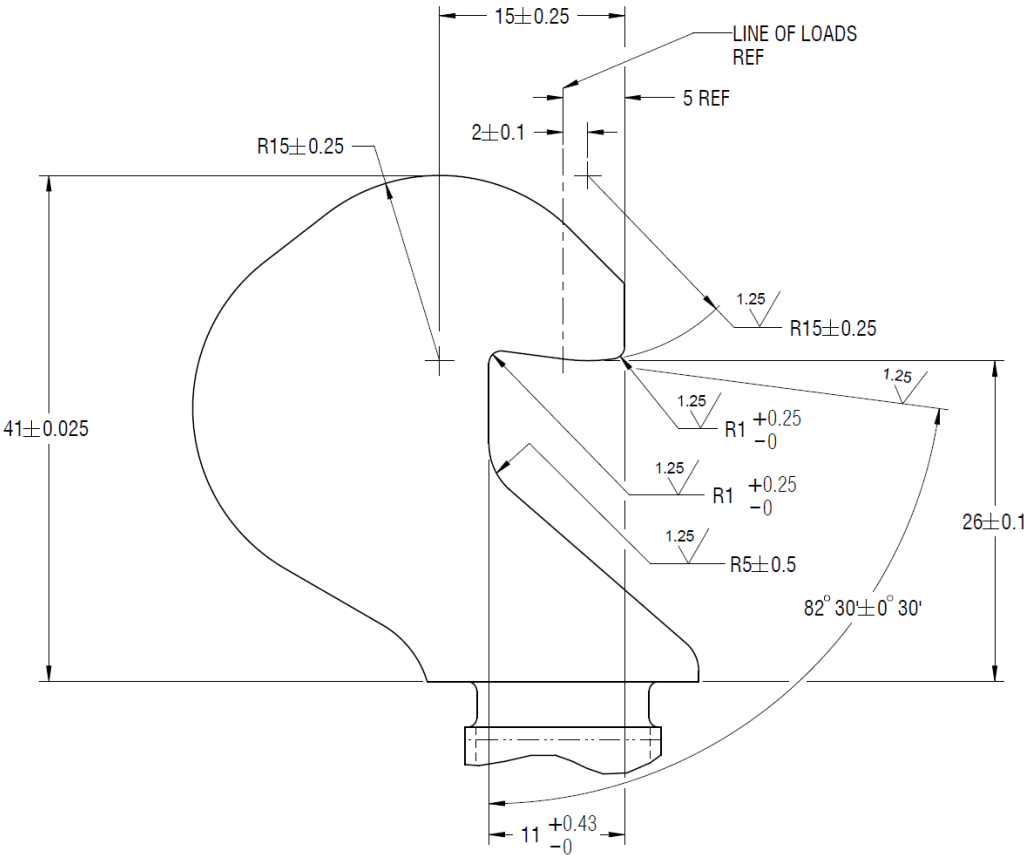
Figure 3-16b: Passive Hook Detail View

Figure 3-16: HCS Passive Hook
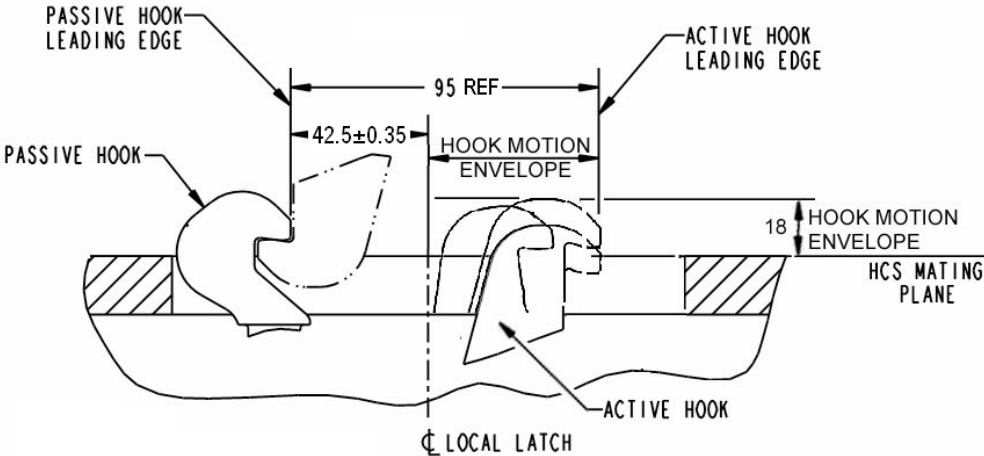
Figure 3-17: HCS Active Hook Motion Envelope

The Hook System is defined as the serial combination of the Active Hook Mechanism, Passive Hook Mechanism and the structural elements that are in compression.

a) The Preload of the Hook System after locking shall be between the following values:

Minimum Preload of Hook System after locking = 31 300 N

Maximum Preload of Hook System after locking = 44 340 N

b) The Design Limit Capability of the Active and Passive Hook element shall be = 50 000 N

c) The load response (stiffness) of the Active Hard Capture Hook Mechanism shall be between the upper and lower curves as defined *Figure 3-18: Load Response of Active Hook Mechanism*.
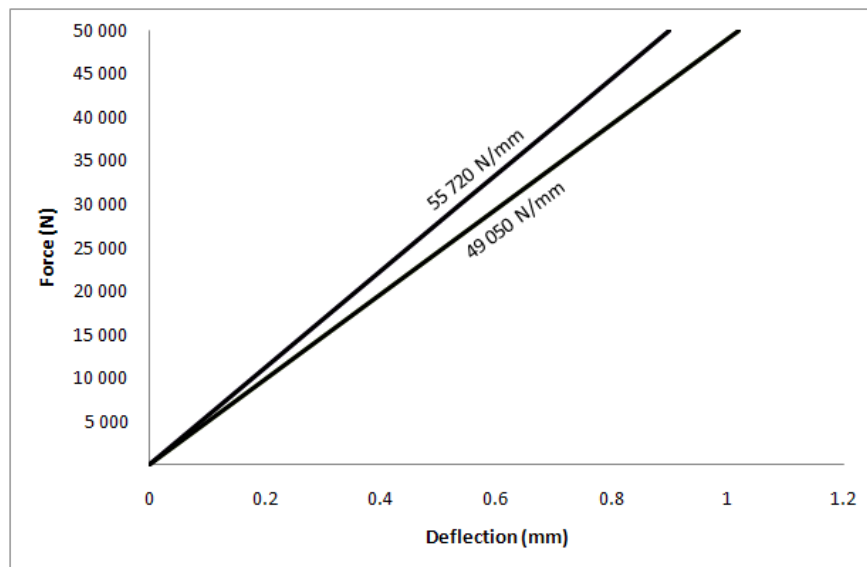
Figure 3-18: Load Response of Active Hook Mechanism

d) The load response (stiffness) of the Passive Hard Capture Hook Mechanism shall be between the upper and lower curves as defined in *Figure 3-19: Load Response of Passive Hook Mechanism (including Spring Washer Stack)*.
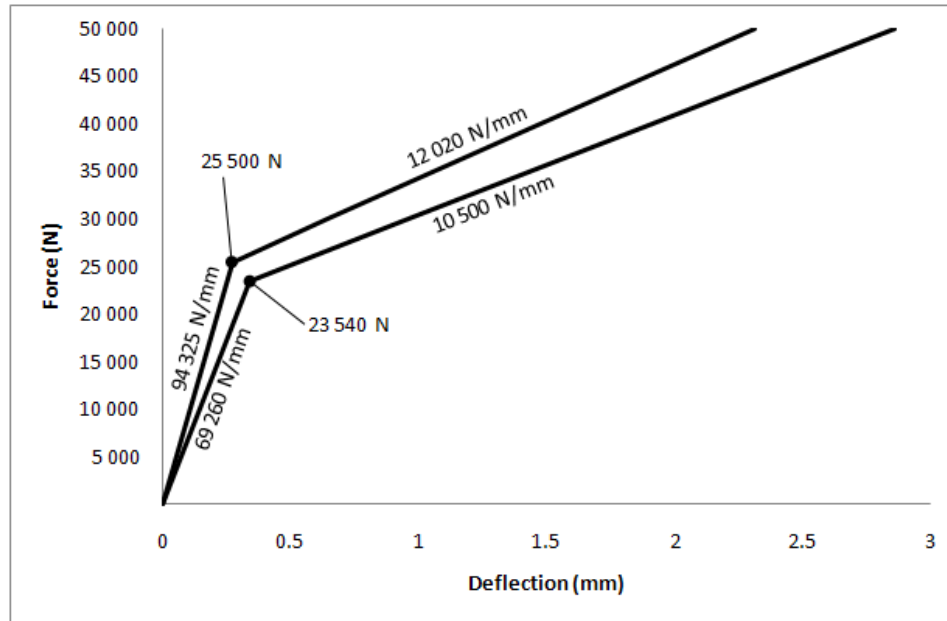
Figure 3-19: Load Response of Passive Hook Mechanism (including Spring Washer Stack)

3.2.3.5 Hard Capture Striker Areas

The HCS has designated areas for striker zones used by the opposing docking system. These striker areas can be used for various HCS sensory components or other subsystems such as separation system push-off devices. IDSS compliant systems shall abide by the designated striker zones defined in *Figure 3-10: HCS Interface - Axial View* and *Figure 3-11: HCS Interface - Sensor Striker Zone*.

3.2.3.6 Separation System - General

IDSS compliant systems shall implement a retractable separation system that can be remotely commanded to fully retract below the interface plane without application of external forces. The separation system may include one or more plungers to provide an initial undocking separation force. The number of plungers is a choice left to the docking system designer, provided that they comply with to the Hard Capture Striker designated areas (see 3.2.3.5).

3.2.3.6.1 Separation System – Force Limits

    a) Total separation force shall be < 2670 N when the HCS interface is fully mated.

    b) Total separation force shall be ≥ 1778 N at 4.2 mm above the HCS Mating Plane.

3.2.3.6.2   Separation System – Energy

Total energy available from the separation system shall be between 39.2 N-m and 47.5 N-m when the HCS interface is fully mated.

3.2.3.7   HCS Compressive Force Resistance During SCS Retraction

During the SCS retraction for hard mate, sensors on the mating HCS mechanisms, such as "Ready-to-Hook" or "Undocking-Complete" indicators, will be compressed. A limit on the total resistance force produced by all sensors on the passive HCS system during SCS retraction is to be defined as follows:

> The total resistance force contributed by all HCS sensors on the passive side shall be ≤ 85 N at a separation of ≥ 4.2 mm between the HCS Mating Planes.

3.2.3.8   Resource Transfer Umbilical

The resource transfer umbilicals are not yet standardized in the IDSS. Umbilical connectors transfer resources between the mated vehicles. These resources may include power, data, and ground safety wire, water source and water return, fuel, tank pressurization, and oxidizer.

3.2.4   Electrical Bonding

3.2.4.1   Soft Capture System

IDSS compliant systems shall establish bond paths to mitigate electrical hazards on the integrated subsystem interfaces.

IDSS compliant mechanisms protect against electrostatic discharge through the soft capture system. The bond path may be through any metal to metal contact provisions for this purpose. The requirement is from initial contact to hard capture during the docking operation.

Bonding resistance for the SCS after soft capture shall be 1 ohm or less TBC.

3.2.4.2   Hard Capture System

IDSS compliant mechanisms are to be protected against RF emissions. The bond path is through metal to metal contact on the seal interface between two IDSS compliant HCS mechanisms.

> Bonding resistance for the HCS after latching shall be 2.5 milliohms or less.

3.2.5 Environments

Materials used in the construction of the docking interface shall allow proper mating while experiencing the following conditions:

a) Temperature difference between the two mating interfaces of up to 55°C
b) External pressure environment < 1.0 x 10-4 Pa

3.2.6 Materials and Surface Finishes

In general, the interface features defined herein, except for the pressure seals, should have stiffness and hardness comparable to that of metal alloys commonly used in aerospace vehicle primary structures, and which do not significantly impede relative motion. Interface surfaces which slide against each other to assist in docking interface alignment should incorporate a surface coating or finish that has low friction characteristics. The resultant coefficient of friction between two mating systems is an integrated performance characteristic which affects soft capture success.

Specific material selection for the pressure seals will be at the designer's discretion.

3.3 Docking Performance

In addition to the physical geometric interface requirements, a set of common design parameters enveloping the reference missions and conditions is provided. For the SCS, this set includes interface loads, vehicle mass properties, and initial contact conditions. For the HCS, this set includes mated loads. Of these common design parameters, only the loads have been defined as requirements. The other common design parameters, if accommodated in the docking system design, increase the probability of successful docking between different spacecraft.

3.3.1 Soft Capture System

The SCS docking performance is defined by the mechanism's ability to capture and attenuate. During the capture phase, the mechanism is contending with the spacecraft misalignment to achieve capture. During the attenuation phase, the mechanism is limiting the relative motion and limiting the loads.

3.3.1.1 Initial Contact Conditions

Initial contact conditions are the instantaneous relative states of the active docking interface with respect to the passive docking interface at docking interface first contact (first physical touch). They are used to define the lateral and angular misalignment, and translational and angular velocity errors when compared to perfect interface alignment and zero relative velocity at the docking interfaces. To increase the probability of

successful docking between different spacecraft, it is recommended that IDSS-compliant mechanisms capture and attenuate vehicles within the initial contact conditions shown in *Table 3-1: Initial Contact Conditions*. The set of limiting initial contact conditions provided in *Table 3-1: Initial Contact Conditions* represents the values used in the derivation of the loads defined in *Table 3-4: SCS Maximum Interface Loads* and *Table 3-5: SCS Maximum Component Loads* and represents the achievable capture envelope provided by an IDSS-compatible mechanism's passive interface.

Table 3-1: Initial Contact Conditions

Initial Condition	Limiting Value
Closing (axial) rate	0.05 to 0.10 m/sec
Lateral (radial) rate	0.04 m/sec
Pitch/Yaw rate	0.20 deg/sec (vector sum of pitch/yaw rate)
Roll rate	0.20 deg/sec
Lateral (radial) misalignment	0.10 m
Pitch/Yaw misalignment	4.0 deg (vector sum of pitch/yaw)
Roll Misalignment	4.0 deg

Notes:

1. Initial contact conditions are independent and are to be applied simultaneously, with the exception that the lateral rate at the vehicle cg resulting from the combination of lateral (radial) rate and the pitch/yaw angular rate should not exceed the lateral (radial) rate limit.
2. Mean closing (axial) rate may be adjusted depending on vehicle mass combinations. Refer to *Table 3-2: Vehicle Mass Properties*.
3. Post contact thrust may be used to achieve necessary capture performance.
4. Lateral (radial) misalignment is defined as the minimum distance between the center of the active soft capture ring and the longitudinal axis of the passive soft capture ring at the moment of first contact between the guide petals.

3.3.1.2 Vehicle Mass Properties

To increase the probability of successful docking between different spacecraft, it is recommended that IDSS-compliant mechanisms capture and attenuate vehicles with the mass properties shown in *Table 3-2: Vehicle Mass Properties*. The set of design case vehicle mass properties provided in *Table 3-2: Vehicle Mass Properties* represents the values used in the derivation of the loads defined in *Table 3-4: SCS Maximum Interface Loads* and *Table 3-5: SCS Maximum Component Loads*.

Table 3-2: Vehicle Mass Properties

Article	Mass (kg)	Moment of Inertia (kg*m2)						Coordinates of the Hard Capture System Mating Plane Center (m)		
		Ixx	Iyy	Izz	Ixy	Ixz	Iyz	X	Y	Z
IDSS-350T	3.50E+5	1.15E+8	6.20E+7	1.65E+8	-2.30E+6	-5.00E+5	-4.60E+5	20.0	0	2
IDSS-25T	25 000	70 000	169 000	169 000	0	0	0	5.4	0	0
IDSS-20T	20 000	55 000	135 000	135 000	0	0	0	4.3	0	0
IDSS-15T	15 000	41 000	71 000	71 000	0	0	0	4.1	0	0
IDSS-10T	10 000	17 000	42 000	42 000	0	0	0	3.5	0	0
IDSS-5T	5 000	3 400	18 000	18 000	0	0	0	2.3	0	0

Notes:
1. Moments of inertia (MOI) are about center of gravity (CG) and products of inertia (POI) are positive integral.
2. Mass properties defined in coordinate system located at CG with X-axis along vehicle longitudinal axis and positive toward the docking interface.

3.3.1.3 Vehicle Motion Limits

Reserved.

Table 3-3: Vehicle Motion Limits

Reserved.

3.3.1.4 Loads

The active SCS of IDSS-compliant mechanisms shall meet all of its functional and performance requirements without exceeding the loads defined in *Table 3-4: SCS Maximum Interface Loads* and *Table 3-5: SCS Maximum Component Loads*.

Table 3-4: SCS Maximum Interface Loads

Load	Limiting Value
Tension	3 900 N
Compression (Static)	3 500 N
Compression (Dynamic, up to 0.1sec)	6 500 N
Shear	3 200 N
Bending	2 800 N*m
Torsion	1 500 N*m
Notes: 1. Values are design limit loads. 2. Values are defined at the center of the SCS mating plane (*Figure 3-1: Androgynous Docking Interface – Axial View*). 3. Values are 3σ maxima and are to be applied simultaneously, not to exceed the component values shown in Table 3-5. 4. Shear loads may be applied in any direction in the SCS mating plane. 5. Bending moment may be applied about any axis in the SCS mating plane.	

Table 3-5: SCS Maximum Component Loads

Load	Limiting Value			
Mechanical Latch Striker Tension	3 000 N			
Magnetic Latch Striker Tension	2 300 N			
Striker (Ring to Ring) Compression	3 000 N			
Petal Edge Length	0%	10%	60%	80%
Petal Contact Loads	3 500 N	2 300 N	2 300 N	1 000 N
Notes: 1. Values are design limit loads. 2. The petal contact load is to be applied to the petal edge from the root of the petal to 80% of the petal length. 3. The petal contact load is to be applied to the outer face of the petal from the root of the petal to 60% of the petal length.				

3.3.2 Hard Capture System

3.3.2.1 Mated Loads

IDSS-compliant mechanisms shall certify to the loads shown in *Table 3-6: HCS Maximum Mated Loads* and *Table 3-7: HCS Mated Load Sets* for design loads, as a minimum. These loads are applied at the center of the HCS interface, as defined in *Figure 3-10: HCS Interface - Axial View*.

Table 3-6: HCS Maximum Mated Loads

Load Set	Mated ISS	Trans-Lunar
Maximum Design Pressure	1 100 hPa	0 h Pa
Seal Closure Force	97 150 N	97 150 N
Compressive Axial Load	17 700 N	300 000 N
Tensile Axial Load	17 700 N	100 000 N
Shear Load	16 700 N	10 000 N
Torsion Moment	15 000 Nm	15 000 Nm
Bending Moment	68 700 Nm	40 000 Nm

Table 3-7: HCS Mated Load Sets

Load Set	Case 1	Case 2	Case 3	Case 4
Design Pressure	1 100 hPa	1 100 hPa	1 100 hPa	0 hPa
Seal Closure Force	97 150 N	97 150 N	97 150 N	97 150 N
Compressive Axial	5 000 N	17 700 N	13 700 N	300 000 N
Tensile Axial Load	5 000 N	17 700 N	13 700 N	100 000 N
Shear Load	5 000 N	14 800 N	16 700 N	10 000 N
Torsion Moment	15 000 Nm	15 000 Nm	15 000 Nm	15 000 Nm
Bending Moment	65 300 Nm	39 200 Nm	68 700 Nm	40 000 Nm

Notes: (for *Table 3-6* and *Table 3-7*)
a) Values are design limit loads.
b) Hard capture hook preload and tunnel stiffness will be such that, when under external loading within limits, there remains metal-to-metal contact in the local vicinity of the hooks.
c) Shear loads may be applied in any direction in the HCS mating plane.
d) Bending moment may be applied about any axis in the HCS mating plane.
e) The outer seal bead is to be used for all pressure calculations.
f) Load cases are defined in *Table 3-7: HCS Mated Load Sets* and *Table 3-6: HCS Maximum Mated Loads* is a summary of the maximum loads.
g) Case descriptions:
    i. Case 1 – Attitude control by Orbiter-sized vehicle, combined with crew activity.
    ii. Case 2 – Interface loads due to ISS segment berthing.
    iii. Case 3 – Orbiter-sized vehicle translation with payload attached to ODS.
    iv. Case 4 – Unpressurized high axial tension load case; modified from Constellation Trans-lunar Injection loads analysis.

APPENDIX A

To maintain simplicity for the standard, a set of generic zones, called the HCS Component Striker Zones, are defined on the HCS mating flange (shown in *Figure 3-10: HCS Interface - Axial View*) as striker zones for various peripheral components and sensors. These zones are the passive flat surface that a docking system designer may choose to use as striker areas for the corresponding devices.

The HCS Component Striker Zones are nine identical segments around the circumference of the HCS. A reference numbering scheme for the segments is shown in *Figure A-1: HCS Component Striker Zone Reference Numbers*. Each segment consists of a Free Area and a Reserved Area.

For both the Free Area and the Reserved Area, the striker area is a flat surface with a few local exceptions. These exceptions are various small holes used for the underlying subsystems (such as attach points for the Latching System), and for other purposes. Many times, these small holes will not interfere with the striking device. The details of these small holes and other features are provided herein for a designer to consider when utilizing the striker zone.

In the Free Area, the same small exceptions occur repeatedly, and these features should be easier to work around to place striking components. The Reserved Area is where legacy systems, such as APAS or NDS, have already located components which will be difficult to work around in some locations, and the use of these areas will require careful, detailed coordination with those designs to assure no interference. These features within the striker zones are shown in *Figure A-2: APAS Features within Striker Zones* and *Figure A-3: NDS Features within Striker Zones*.
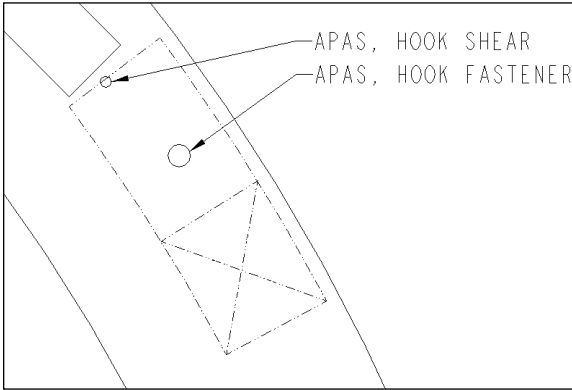
In summary, using the Free Areas is recommended, though the locations of some small holes must be considered. Using the Reserved Areas will require collaboration with the relevant legacy system and/or mission specific information.
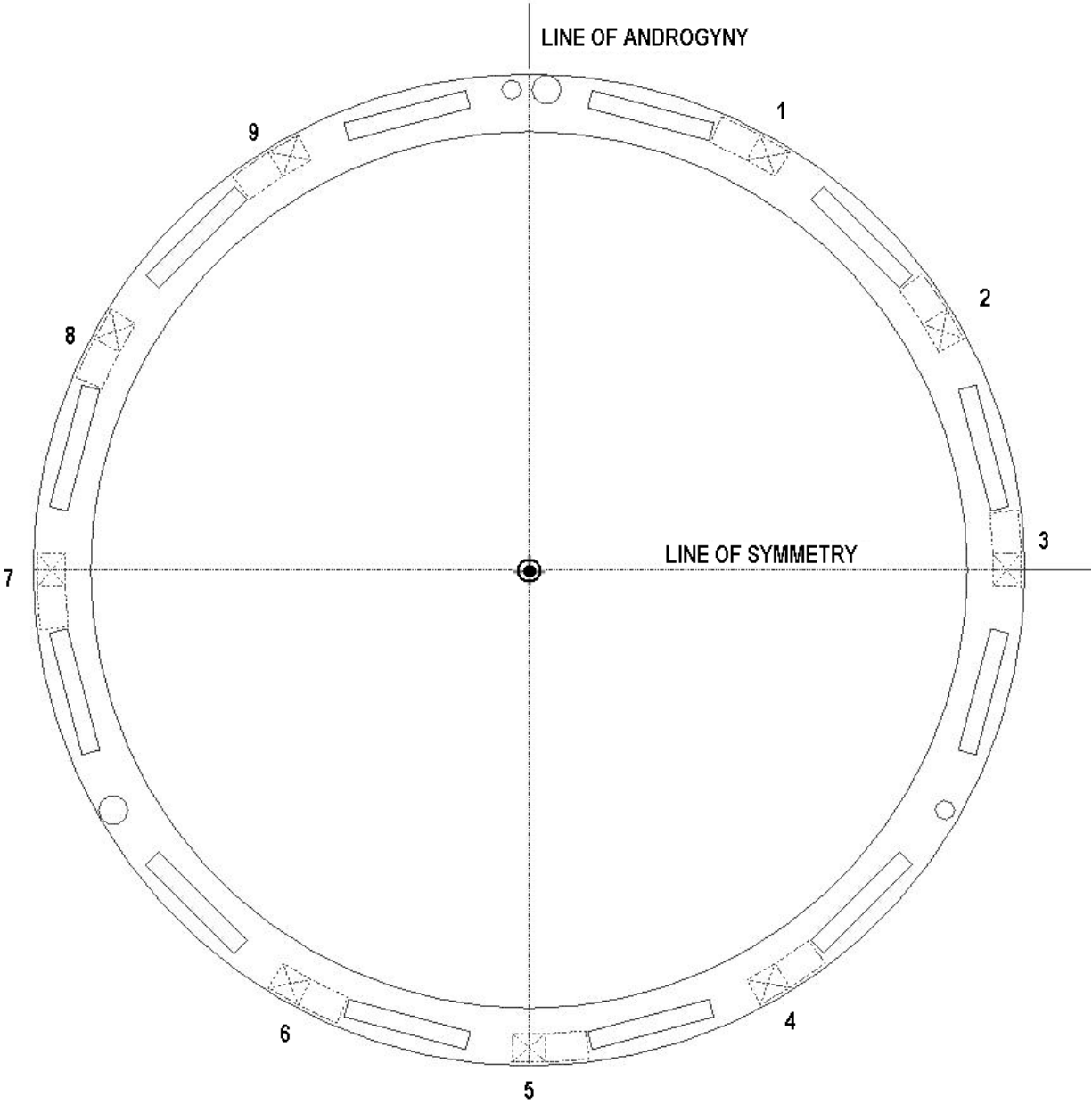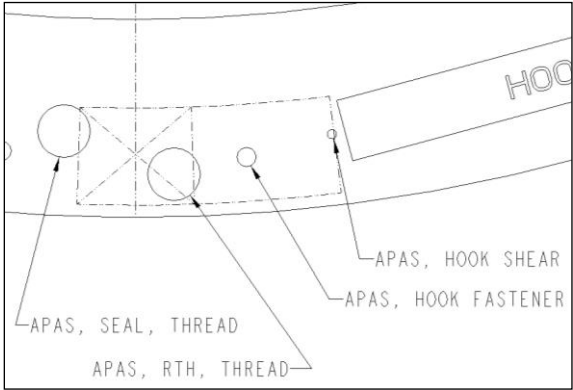
Figure A-1: HCS Component Striker Zone Reference Numbers
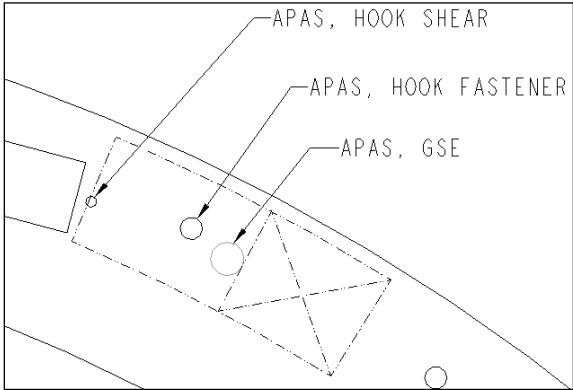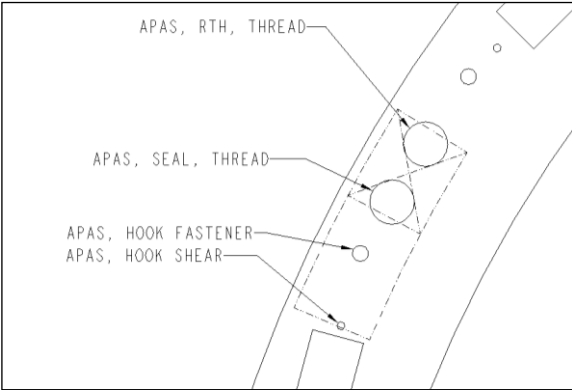
Detail applies at the following locations:
1, 3, 4, 7, 9

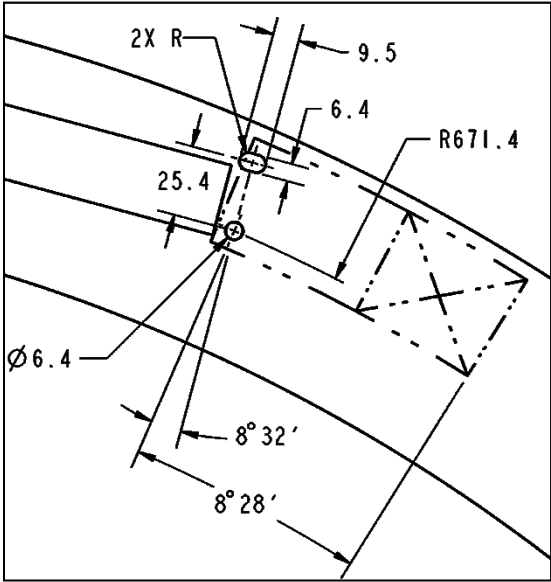Detail Applies at the following locations
2, 6

Detail applies at the following location:
5

Detail Applies at the following location:
8

Figure A-2: APAS Features within Striker Zones

Detail applies at all locations.

Figure A-3: NDS Features within Striker Zones

APPENDIX B   MAGNETIC CAPTURE LATCH SYSTEM

In order to allow developers and participating partners to this standard the flexibility to design and build docking mechanisms to their program needs and requirements, this Appendix B describes a preliminary concept for a Magnetic Capture Latch System, geometrically compatible with the Mechanical Capture Latch System described in Section 3.2.2.4.

The Magnetic Capture Latch System is expected to offer the following features in comparison to the Mechanical Capture Latch System:

- no latch activation force is required to engage the Magnetic Capture Latch System, thereby favoring berthing,
- the activation of the Magnetic Capture Latch System is independent of the masses and approaching speeds of the mating vehicles,
- it avoids the disturbance introduced by activation load of some Mechanical Latch Capture System implementations to the sensing elements of an Actively Controlled SCS measuring the interface contact forces during the docking process,
- it allows expedited release of the Magnetic Capture Latch System, no need for re-setting of the Magnetic Capture Latch System for a new docking attempt.

Based on the above features, the Magnetic Capture Latch System is expected to be suitable for a wide range of docking/berthing vehicles as required for future Exploration missions, while reducing the number of movable parts.

Upon agreement by the interested partners, this Magnetic Capture Latch System may be implemented as an option for a specific collaborative mission, in conjunction with, or as a replacement of the Mechanical Capture Latch System.

The Magnetic Capture Latch System described in this Appendix may be realized in combination with the Mechanical Capture Latch System described in Section 3.2.2.4. Therefore a docking system implementing the strikers of both the Magnetic Capture Latch System and the Mechanical Capture Latch System can successfully mate with an active docking system implementing either the Magnetic Capture Latch System or the Mechanical Capture Latch System. The implementation of a magnetic latching system shall not impact the performance of the mechanical latching system.

For optimal soft capture magnetic force, the magnetic capture latch system shall provide each striker with surface compliance to the mating magnet. This will ensure maximum surface contact to obtain maximum magnetic force. This compliance is to account for hardware fabrication and assembling tolerances. In addition, the material selection for the striker is crucial for obtaining the required magnetic force.

In case the optional Magnetic Capture Latch System is used, *Figure B-1: Cross Sectional View Through Centerline of Magnetic Latch Striker* and *Figure B-2: Radial View* replace *Figure 3-8a: Cross Sectional View through Centerline of Mechanical Latch Striker* and *Figure 3-8b: Radial View* respectively and provide the information required to develop it.
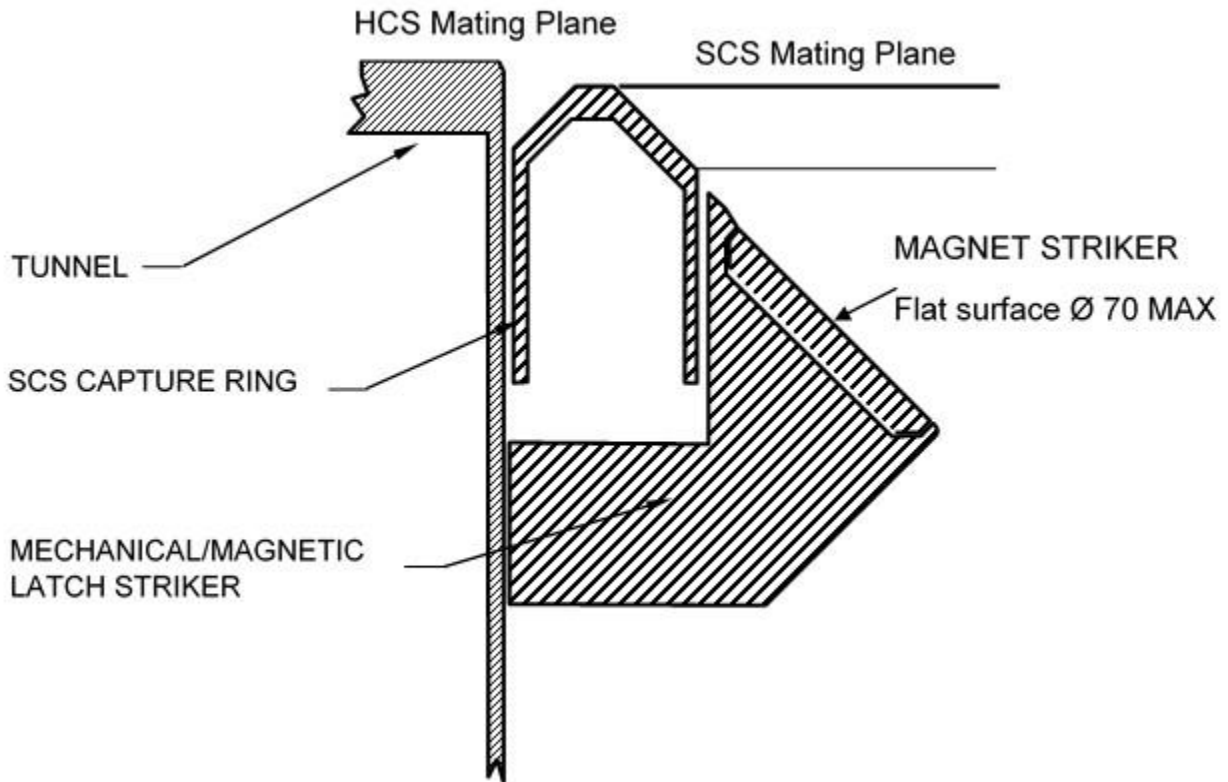
Figure B-1: Cross Sectional View Through Centerline of Magnetic Latch Striker
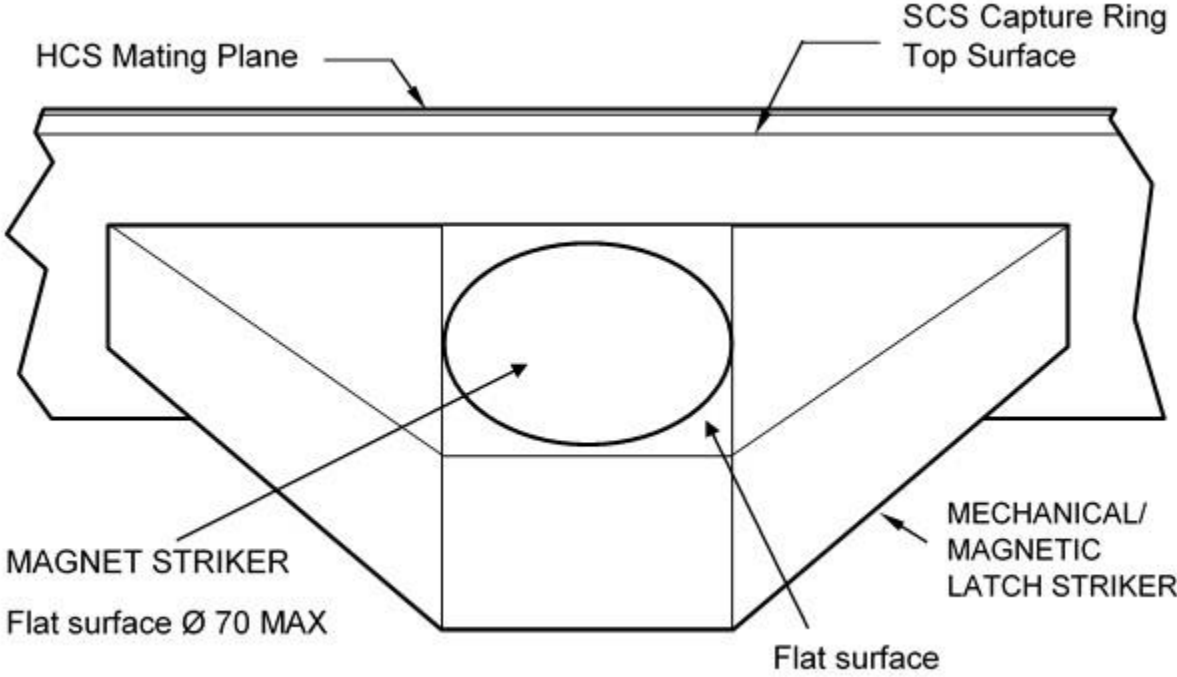
Figure B-2: Radial View

Note: Dimensions on *Figure B-1: Cross Sectional View Through Centerline of Magnetic Latch Striker* and *Figure B-2: Radial View* are identical to those in *Figure 3-8a: Cross Sectional View through Centerline of Mechanical Latch Striker* and *Figure 3-8b: Radial View* other than those explicitly indicated in this *Appendix B*

APPENDIX C   ACRONYMS AND ABBREVIATIONS

APAS	Androgynous Peripheral Assembly System
C	Celsius
CG	Center of Gravity
CSA	Canadian Space Agency
deg	degree
ESA	European Space Agency
F	Fahrenheit
HCS	Hard Capture System
hPa	Hecto Pascal(s)
IDD	Interface Definition Document
IDSS	International Docking System Standard
ISS	International Space Station
kg	kilogram
kgf	kilograms force
LEO	Low Earth Orbit
m	meters
MCB	Multilateral Control Board
MEXT	Ministry of Education, Culture, Sports, Science and Technology – Japan
MIN	Minimum
mm	Millimeters
MOI	Moments of inertia
Ⓜ	Minimum Material Condition
N	Newton(s)
NASA	National Aeronautics and Space Administration
NDS	NASA Docking System
Nm	Newton-Meter(s)
ODS	Orbiter Docking System
ohm	Ohms
Pa	Pascal
POI	Products of inertia
RF	Radio Frequency
sec	second
SCS	Soft Capture System
SSRMS	Space Station Remote Manipulator System
TBC	To Be Confirmed
TBD	To Be Determined
tonne	metric ton = 1000 kilograms