International Docking System Standard (IDSS)

Interface Definition Document (IDD)

Revision F

July 2022

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REVISION AND HISTORY

REV.	DESCRIPTION	PUB. DATE
-	Initial Release	09-21-10
A	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.	05-13-11
B	Document Hard Capture System parameter values, figure updates, separation system force addition, editorial correction, and updates.	11-15-12
C	Document the narrow ring Soft Capture System (SCS) geometric parameters and update applicable figures. Added Appendix B on Magnetic Soft Capture.	11-20-13
D	Revision D is the first version of the document under NASA configuration control and released by NASA ERU. Revision D includes the following DCNs: DCN 001 DCN 002 DCN 003 DCN 004C DCN 005 DCN 006 DCN 007 DCN 008A DCN 009B DCN 010 DCN 011 DCN 012 DCN 013	08-04-15
E	Revision E includes the following DCNs: DCN 014 DCN 015A DCN 017 DCN 018 DCN 020 DCN 021	01-04-17
	DCN 022 DCN 023 DCN 024 DCN 025 DCN 027A	

REV.	**DESCRIPTION**	**PUB. DATE**
	DCN 029 DCN 032 DCN 033 DCN 037 DCN 038 DCN 039	
F	Revision F updates the following: - The ongoing development work in cis-lunar (Gateway, Orion, HLS) is a proving ground for standardization and interoperability. Additional requirements for cis-lunar have driven programs to make specific implementation decisions for resource umbilical, rendezvous targets, and berthing that are different than earlier definition associated with the ISS while honoring geometry and keep out zones. Other developments in LEO are coming in the future. The committee has chosen to remove some information from the standard (reference below) and point to program specific ICDs and specification while referencing this information at the IDSS website, www.internationaldeepspacestandards.com and or www.internationaldockingstandard.com. - Reference the preface for future goals of the committee with regards to these evolving interface definition. - Incorporate previously approved DCNs - Updates to Preface, Change Authority sections, and signature page. - Updated section 3.4 and moved resource transfers specifications (sections 3.4.1 thru 3.4.5) to program specific Interface Definition Documents (IDDs) and Specifications. - Updated section 3.5, Navigation and alignment Aids information (Section 3.5). Removed specific navigation target in Lieu of program specific IDDs and International Rendezvous System Interoperability Standard (IRSIS) document. - Update Appendix C and D - Remove Appendix E, Magnetic Capture Latch System, since it is out of scope. - Remove Appendix F, Berthing Compatibility Requirements, to IERIIS and CSA-GWY-ID-0001 documents. These documents are referenced in section 3.1.1.2. DCN 040A DCN 041A	01-31-22

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PREFACE

INTERNATIONAL DOCKING SYSTEM STANDARD (IDSS) INTERFACE DEFINITION DOCUMENT (IDD)

This International Docking System Standard (IDSS) Interface Definition Document (IDD) establishes a standard docking interface to enable collaborative endeavors between the international space fairing community while also supporting possible crew rescue operations. The IDSS was developed by the ISS participating partners and first baselined in 2010.

As the space community grows and in space activities expand beyond low earth orbit (LEO) and towards deep space, it is important to sustain the IDSS agreement and continue to evolve the original standard and prepare for future standards in-space and to surface systems on the moon and beyond.

The IDSS Committee will continue to pursue the goal of interoperability and standardization. In pursuing this goal, it is the intent of the IDSS International Committee to engage the global commercial spaceflight industry and Agency Programs for their perspectives. It is the Committee's vision by including industry and programs that buy-in will be achieved and future projects and programs will give the highest consideration for meeting the intent of the IDSS IDD. This will be critically important for future commercial and international cooperation and efficient operations of human and robotic space exploration.

The IDSS committee, JAXA, Roscosmos, ESA, CSA and NASA are committed partners in managing the IDSS. The IDSS committee chair, while in the early beginnings has been chaired by NASA, will in the future be sustained with a rotating chair and established by agreement by the Multilateral Control Board (MCB). Additionally, new members may be added and will be addressed and approved by the MCB. Configuration management of the IDSS document will be addressed in paragraph 1.2.

CONCURRENCE

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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 ISS Program International Partners (IPs) 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, 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, radiation, 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 and other Low Earth Orbit (LEO) platforms

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.

1.2 RESPONSIBILITY AND CHANGE AUTHORITY

Configuration Management (CM) of the IDSS will be the responsibility of NASA. The NASA Directorate Program Management Council (DPMC) will perform the CM function for the IDSS Committee which includes keeping the official record of the IDSS agreement and archive of all change proposal material documentation. The IDSS committee will be made up of International participants, JAXA, ROSCOSMOS, ESA, CSA, and NASA. All changes to the IDSS or any new docking standards and including proposals for new membership to the IDSS committee will be submitted to the IDSS Committee for review. The Multilateral Control Board (MCB) will be the responsible change board for all changes to the IDSS. The formal process for submitting and processing changes to the IDSS through the MCB is documented at the DPMC website.

1.3 CONVENTION AND NOTATION

Gateway Program defines its implementation of requirement verbs as follows:

a. “Shall” – Used to indicate a requirement that is binding, which must be implemented, and its implementation verified in the design.

b. “Should” – Used to indicate good practice or a goal which is desirable, but not mandatory and does not require formal verification

c. “May” – Used to indicate permission.

d. “Will” – Used to indicate a statement of fact or declaration of purpose on the part of the government that is reflective of decisions or realities that exist and are to be taken as a given and not open to debate or discussion.

e. "Is” or “Are” – Used to indicate descriptive material.

Rationales, included for many of the requirements, are intended to provide clarification, justification, purpose, and/or the source of a requirement. In the event that there is an inconsistency between a requirement and its rationale, the requirement always takes precedence.

2.0 DOCUMENTS

2.1 APPLICABLE DOCUMENTS

The following documents include specifications, models, standards, guidelines, handbooks, and other special publications. The documents listed in this paragraph are applicable to the extent specified herein.

None

2.2 REFERENCE DOCUMENTS

The following documents contain supplemental information to guide the user in the application of this document. These reference documents may or may not be specifically cited within the text of this document.

AMS 2700	Passivation of Corrosion Resistant Steels
AMS-4027	Aluminum Alloy, Sheet and Plate, 1.0Mg - 0.60Si - 0.28Cu - 0.20Cr (6061; -T6 Sheet, -T651 Plate), Solution and Precipitation Heat Treated
AMS QQ-A-200/8	Aluminum Alloy 6061, Bar, Rod, Shapes, Tube and Wire, Extruded
ASME B46.1	Surface Texture (Surface Roughness, Waviness and Lay)
ASTM A582	Standard Specification for Free-Machining Stainless Steel Bars
CSA-GWY-ID-0001	Gateway Extra-vehicular Robotics Interface Requirements and Definition Document
IERIIS	International External Robotics Interface Interoperability Standards
ISO 1151-1:1988	Flight Dynamics – Concepts, quantities and symbols – 4th edition, Part 1: Aircraft motion relative to the air
MIL-C-26074	Electroless Nickel Coatings
MIL-DTL-5002	Surface Treatments And Inorganic Coatings For Metal Surfaces Of Weapons Systems
MIL-L-46010	Lubricant, Solid Film, Heat Cured, Corrosion Inhibiting

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 presumes a pre-docking rendezvous phase along with a 2-stage approach to docking. The rendezvous stage involves an active docking vehicle navigating to the passive docking vehicle to align their docking interfaces for the docking stage. The passive vehicle provides three types of targets to assist the active vehicle in performing the precise alignment needed to mesh the mechanical interfaces at the start of the docking stage. Targets are available for longer to mid-range operations, as well as for short-range operations when the active vehicle is on the docking axis of the passive vehicle. These shorter range targets are available to the active vehicle for alignment to within the capture envelope specified by the docking system's initial contact condition (ICC) requirements. This completes the rendezvous stage.

The first stage of docking 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 3.1.1.1-1, Androgynous Docking Interface – Axial View and the Androgynous Docking Interface – Cross Sections [Figures 3.1.1.1-2, Section A-A (Cross-section through mid-plane of two petals) and 3.1.1.1-3, Detailed Section of Petal] 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.

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

3.1.1.2 BERTHING

Berthing spacecraft together using a manipulator/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 to support the capture and installation of visiting vehicles. Unberthing, the separation of two vehicles using a manipulator, has also been used extensively to disconnect a vehicle and release it for departure or relocate it to another berthing port.

Docking systems can be developed under specific mission requirements. Some systems may support docking only while others may support both docking and berthing. The additional set of optional requirements that permits a berthing and docking compatible IDSS implementation (IDSS+B) may be found on the IDSS website www.internationaldeepspacestandards.com and or www.internationaldockingstandard.com. In the future, standard requirements for an IDSS compatible berthing system may be documented in the International External Robotics Interface Interoperability Standard (IERIIS) and or the IDSS IDD. Meeting these additional requirements may permit the IDSS implementation to be used for either docking or manipulator berthing.

Note that due to other constraints and considerations (mass, operations), it may be preferable to have a dedicated berthing-only interface. In this scenario, an accepted international berthing interface may be utilized that employs some combination of peripheral active controlled devices and passive capture mechanisms (e.g. the ISS Common Berthing Mechanism (CBM), Probe-Cone, etc.). For clarity, note that the IDSS and IDSS+B standards do not define or address these berthing only interfaces.

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

xxº implies xxº ± 30’

3.2 MATING INTERFACE DEFINITION

An overview of the IDSS interface is shown in Figure 3.1.1.1-1. The IDSS docking interface shall conform to the definition as shown in Figure 3.1.1.1-2 and Figure 3.1.1.1-3. The HCS Mating Plane is defined as the seal plane between two vehicles' HCS tunnels when structurally mated.

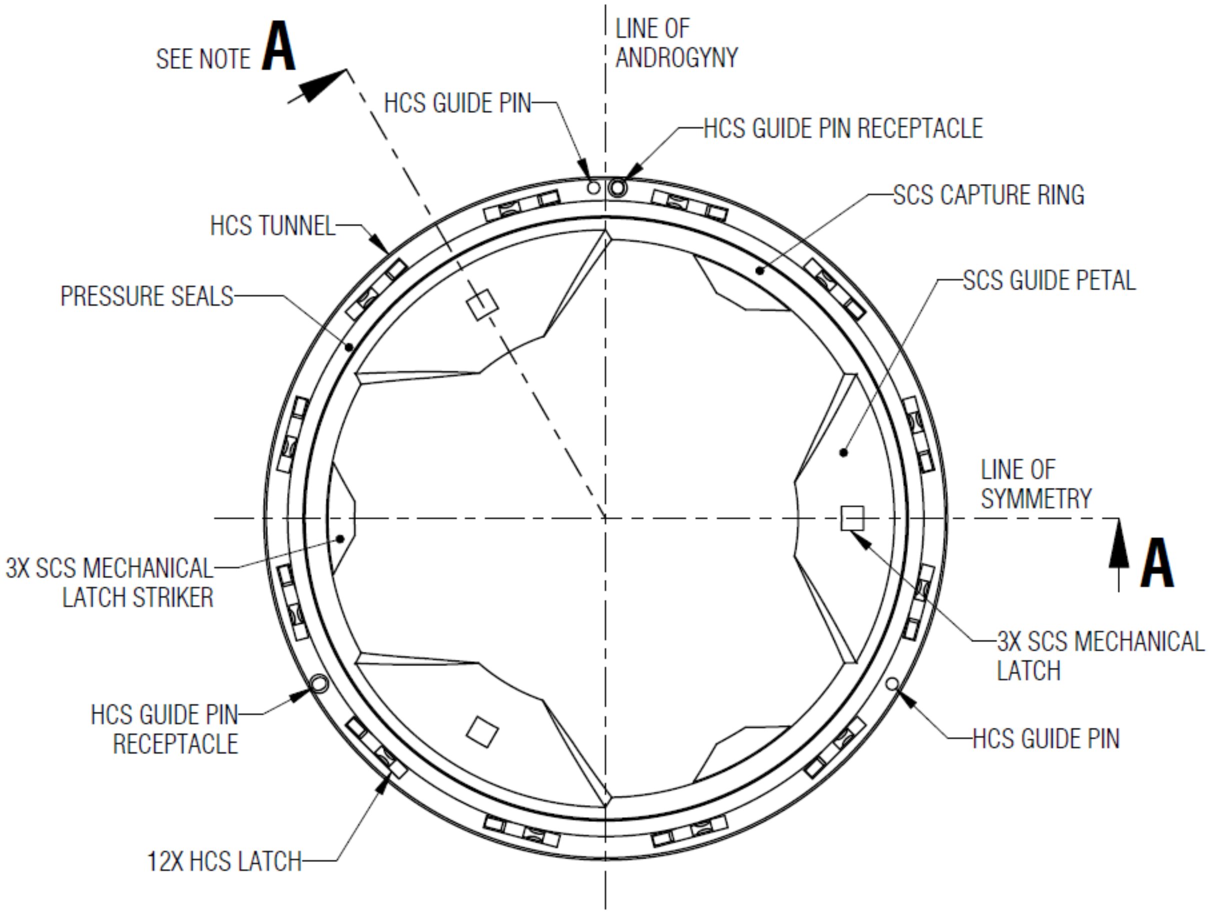
Two reference lines are a Line of Androgyny and a Line of Symmetry as shown in Figure 3.1.1.1-1. The docking axis is defined as shown in Figure 3.1.1.1-2.

Figure 3.2-1, Naming Convention for Hooks, Guide Pins, Petals, Latches and Latch Strikers, defines the naming convention for the docking system principal components.

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.

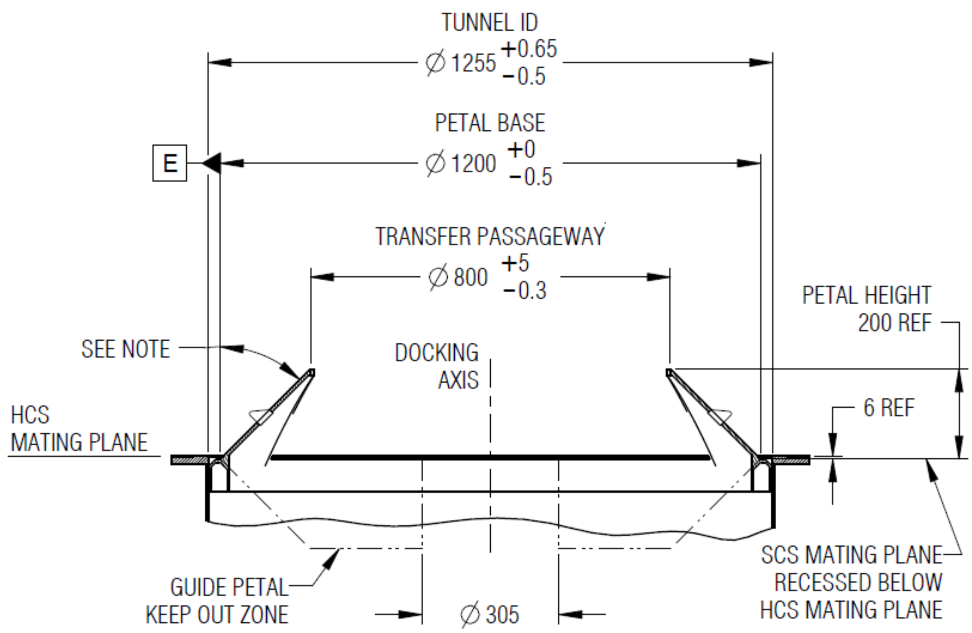
The SCS mating plane is the top surface of the capture ring for both active and passive modes.

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. A complete list of drawing symbols used throughout the document is identified in Appendix A.



Note: Refer to Figure 3.1.1.1-2 for Section A-A.

FIGURE 3.1.1.1-1 ANDROGYNOUS DOCKING INTERFACE – AXIAL VIEW



Note: Refer to Figure 3.1.1.1-3 for details

FIGURE 3.1.1.1-2 SECTION A-A (CROSS-SECTION THROUGH MID-PLANE OF TWO PETALS)

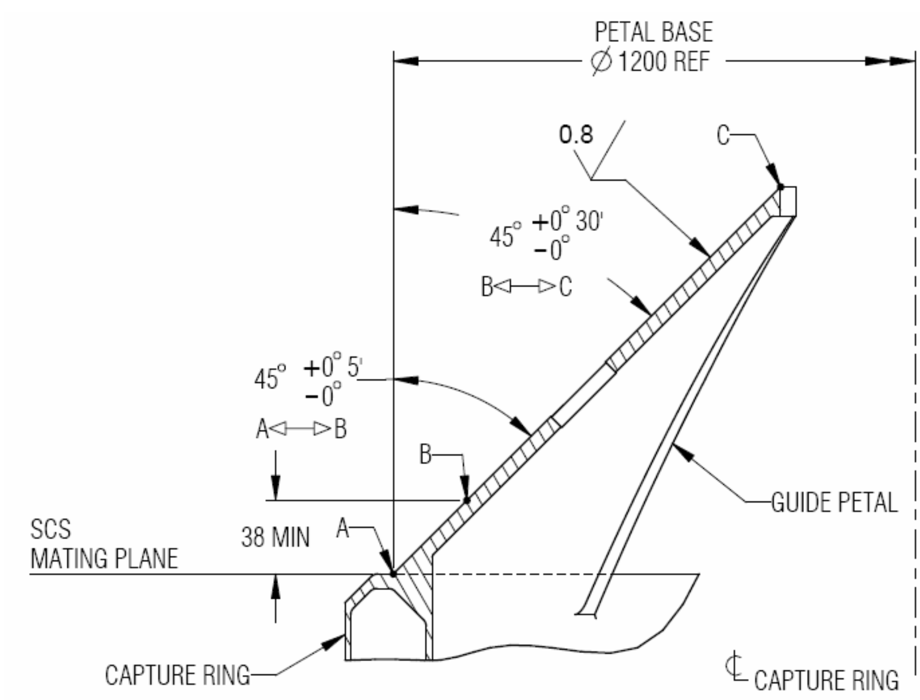
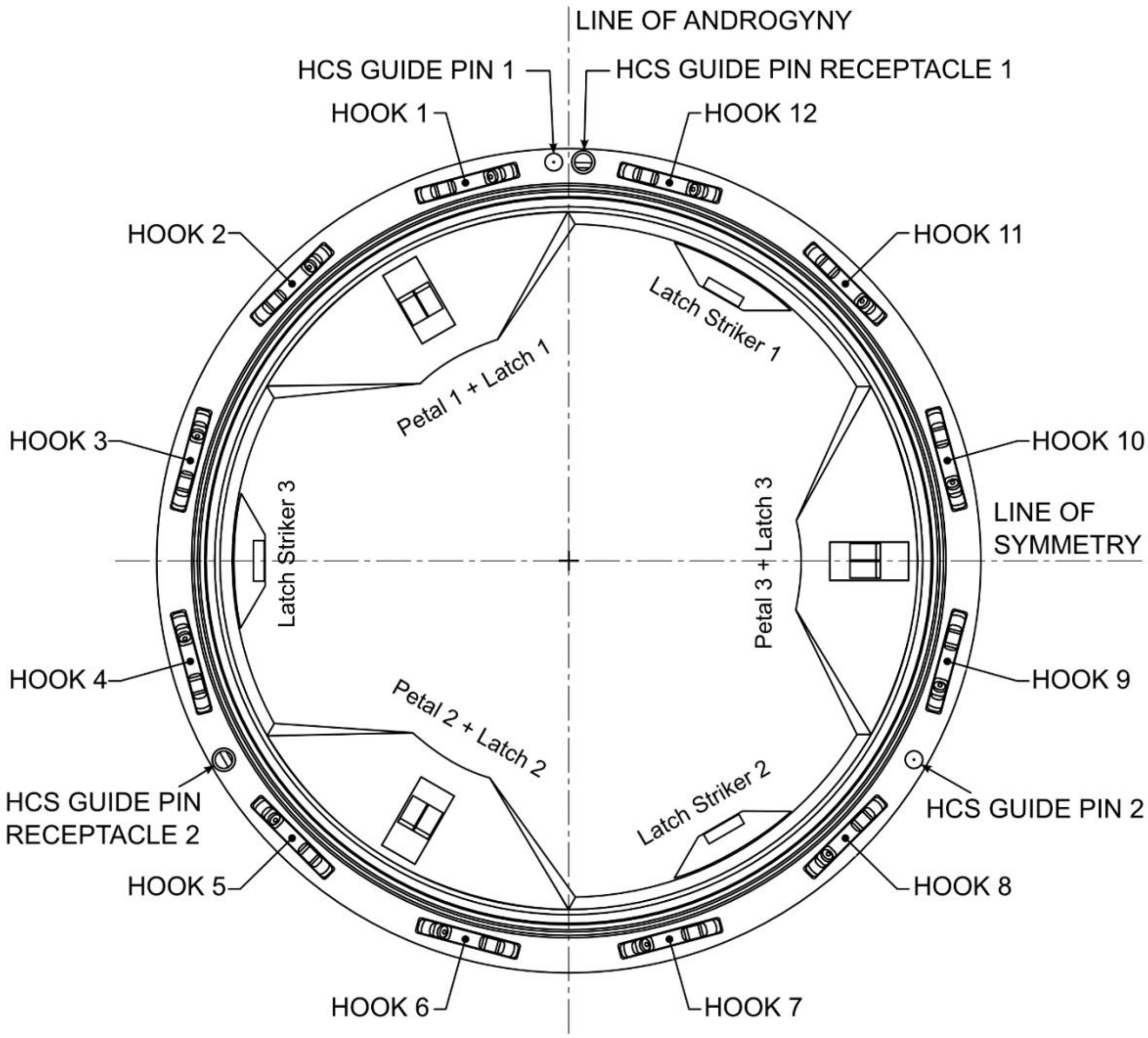


FIGURE 3.1.1.1-3 DETAILED SECTION OF PETAL



Note: The naming convention given here is to provide a common way to reference these items, and it is the designer's choice whether, or how, to place physical labels on the items themselves.

FIGURE 3.2-1 NAMING CONVENTION FOR HOOKS, GUIDE PINS, PETALS, LATCHES AND LATCH STRIKERS

3.2.1 TRANSFER PASSAGEWAY

The docking system shall maintain the minimum transfer passageway diameter as shown in Figure 3.1.1.1-2.

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 the SCS Interface - Capture System [Figure 3.2.2-1, Capture System Overview, and Figure 3.2.2-2, Striker Zone Detail]. 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.

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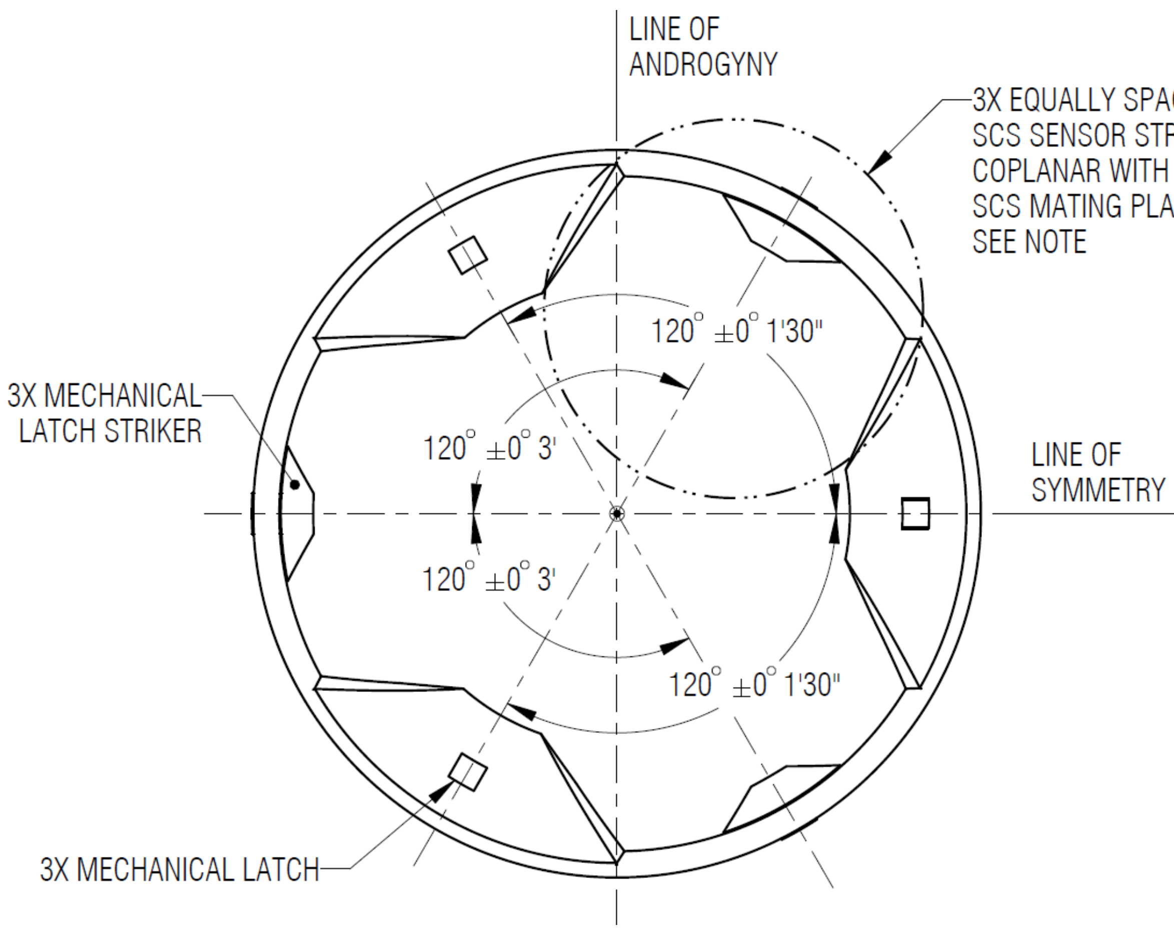
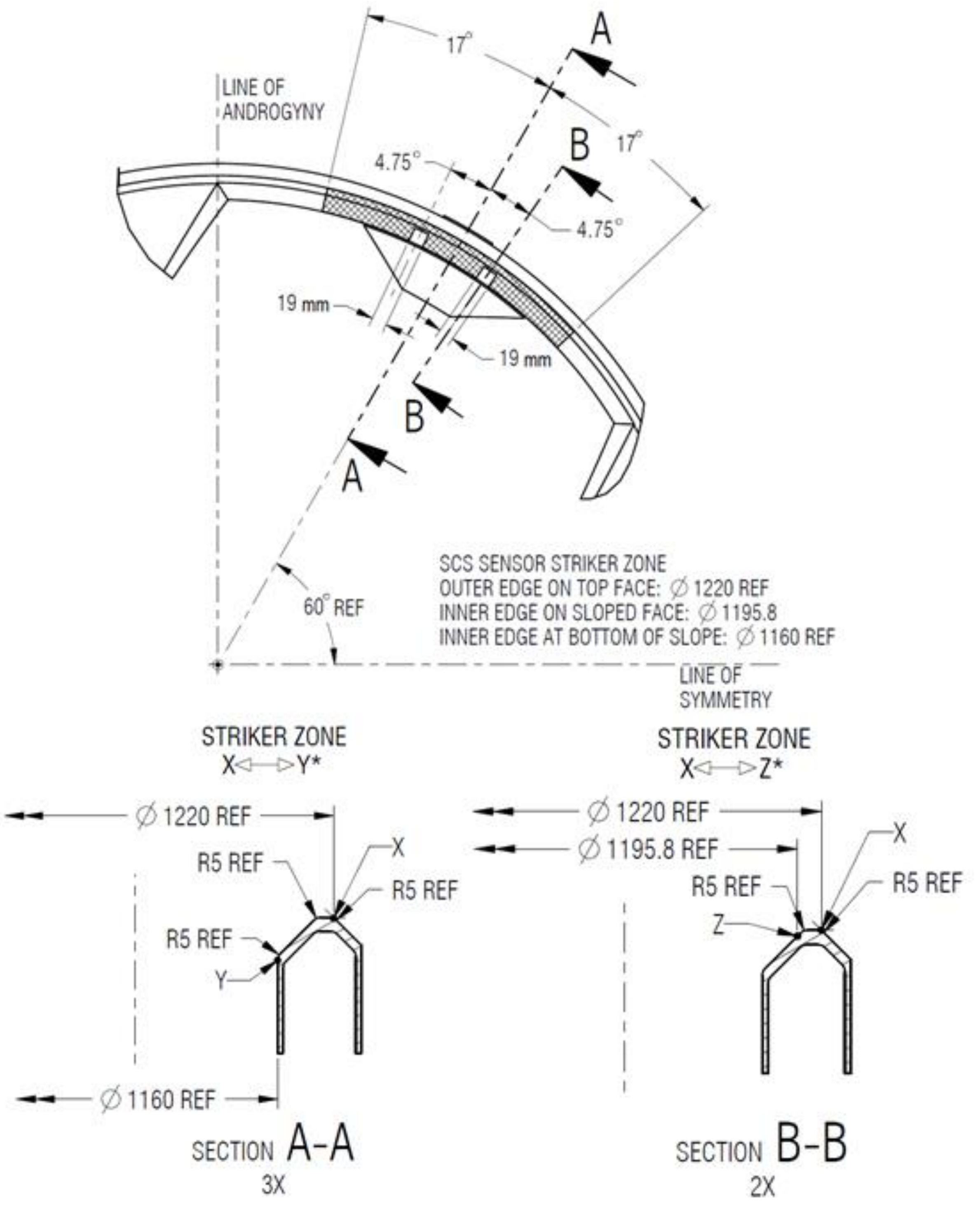


Note: Refer to Figure 3.2.2-2 for striker zone details

FIGURE 3.2.2-1 CAPTURE SYSTEM OVERVIEW

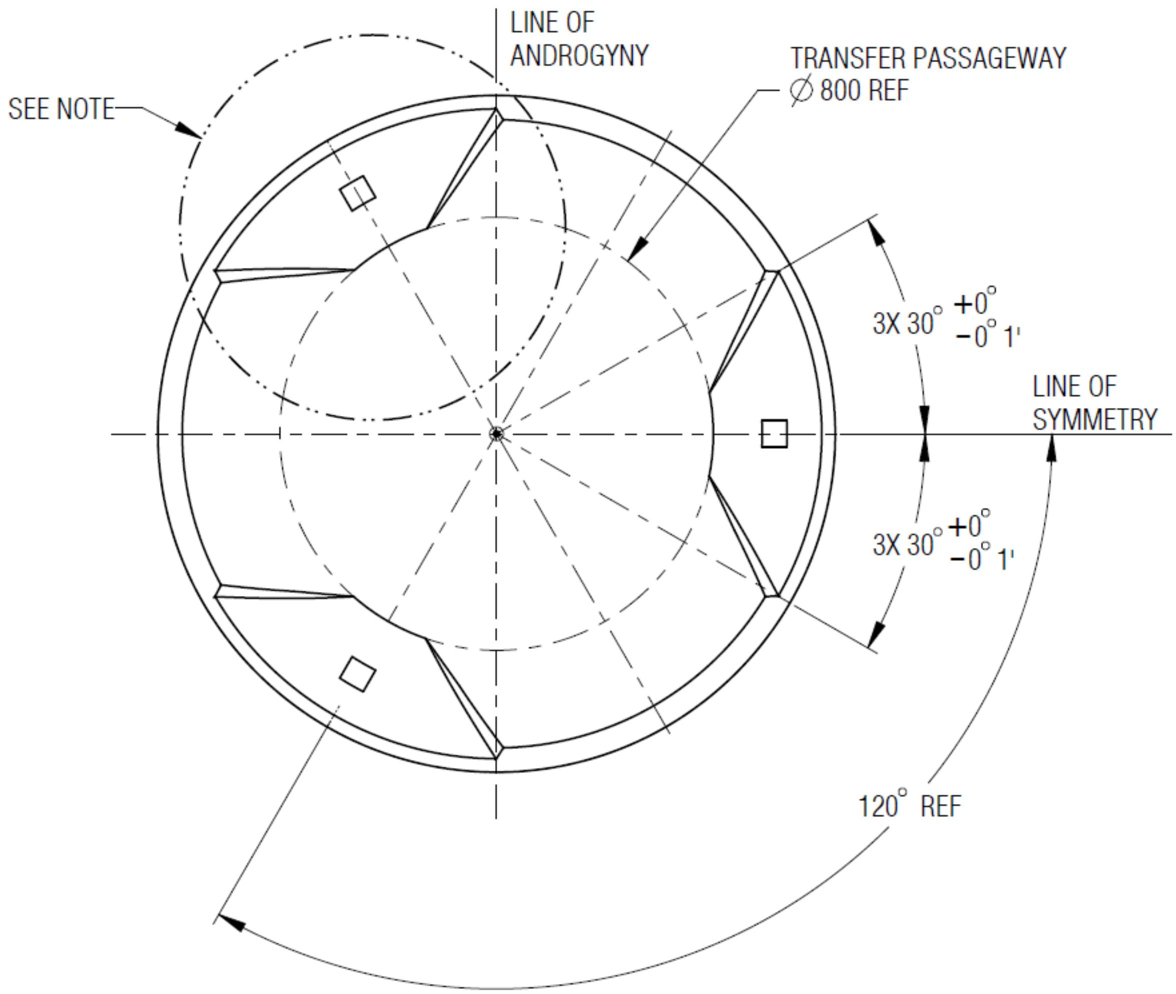


* SCS sensor striker zone is the actual contour of the capture ring surfaces as shown.

FIGURE 3.2.2-2 STRIKER ZONE DETAIL

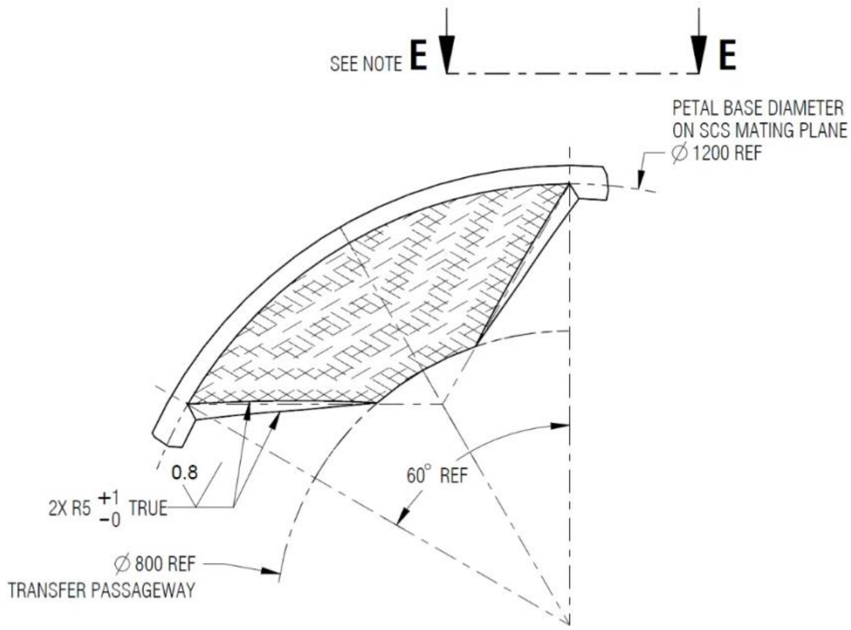
3.2.2.1 GUIDE PETAL SYSTEM

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 3.2.2.1-1, SCS Interface – Guide Petal System Overview. Additional SCS interface details that shall be implemented are shown in the SCS Interface – Guide Petal System Details [Figures 3.2.2.1-2, Petal Detail, 3.2.2.1-3, Petal Profile Detail, and 3.2.2.1-4, View E-E – Guide Petal Outline] and Figure 3.2.2.1-5, SCS Interface – Capture Ring Profile.



Note: Refer to Figure 3.2.2.1-2 and Figure 3.2.2.1-3 for Petal details.

FIGURE 3.2.2.1-1 SCS INTERFACE – GUIDE PETAL SYSTEM OVERVIEW



Note: Refer to Figure 3.2.2.1-4 for View E-E

FIGURE 3.2.2.1-2 PETAL DETAIL

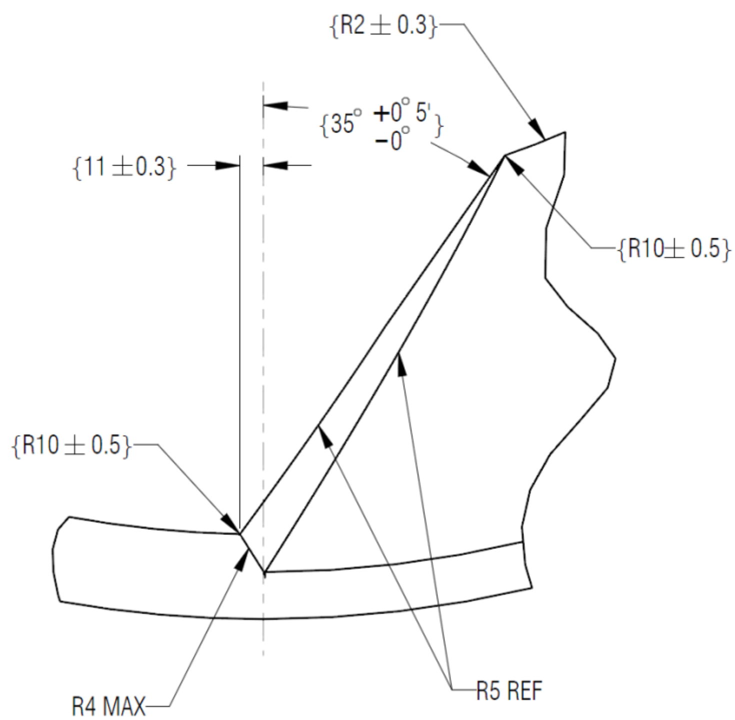
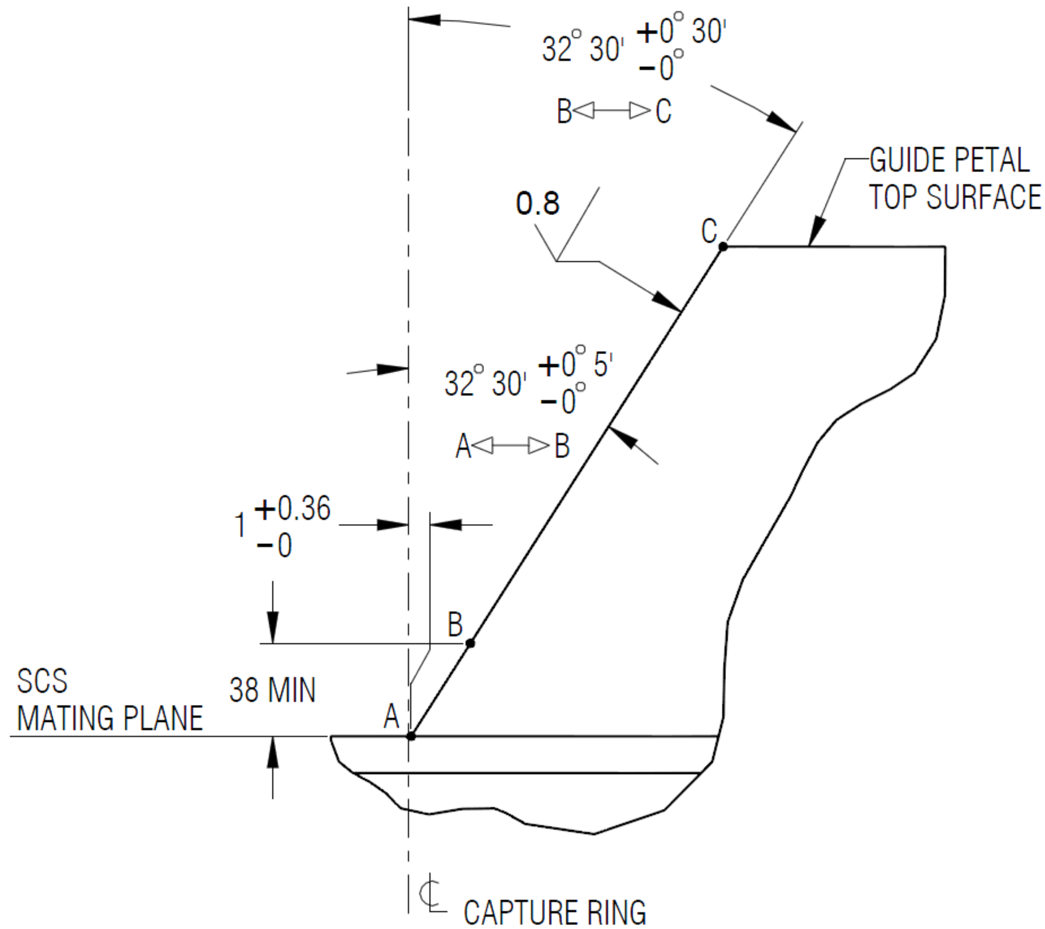


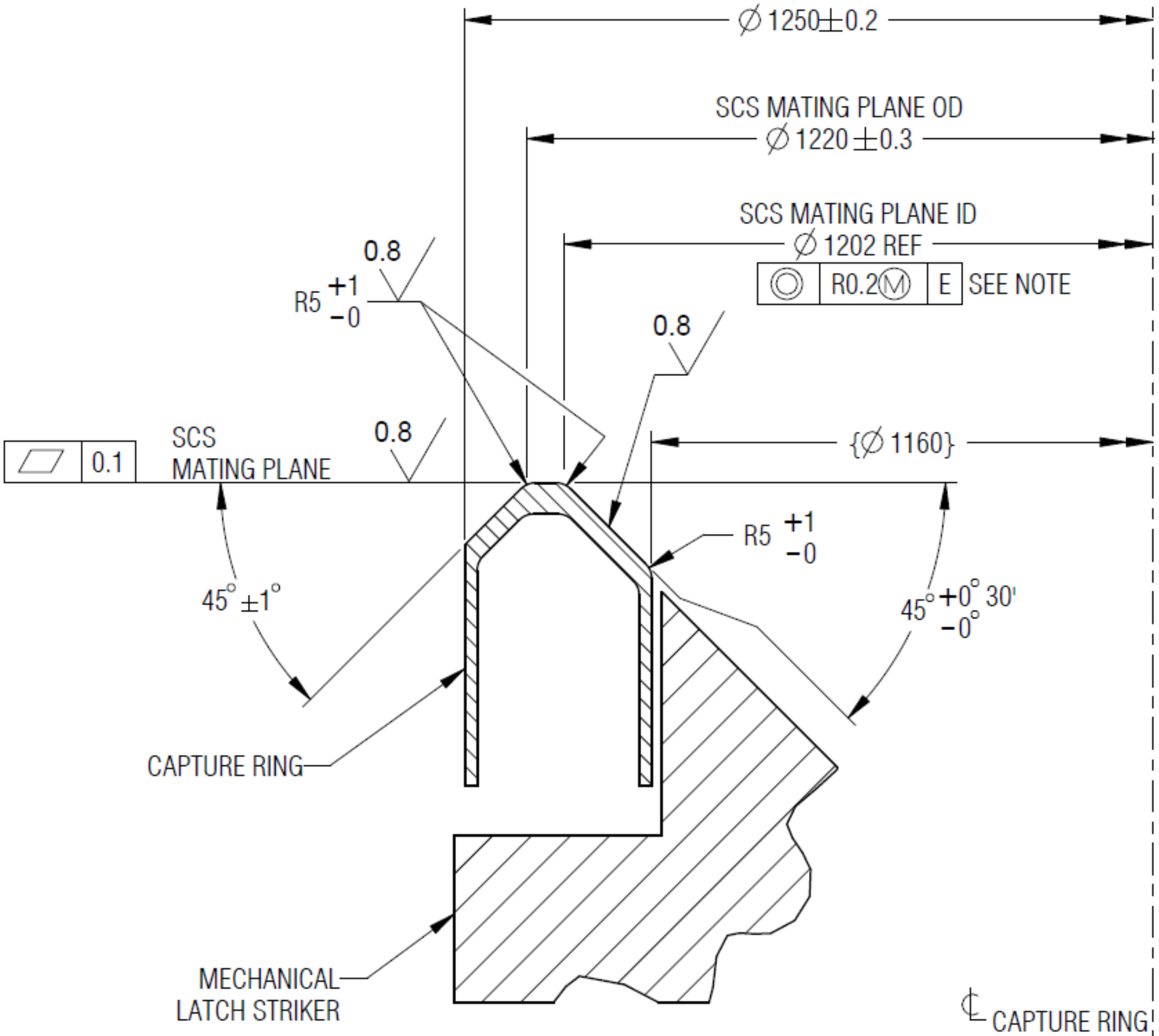
FIGURE 3.2.2.1-3 PETAL PROFILE DETAIL



Notes:

1. In Petal Detail view, dimensions projected on the SCS mating plane are shown.
2. Petal outline shown is on the external conic surface of the petal system.

FIGURE 3.2.2.1-4 VIEW E-E - GUIDE PETAL OUTLINE



Note: Datum E is defined in Figure 3.1.1.1-2.

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

FIGURE 3.2.2.1-5 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 3.2.2.3-1 (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 Figures 3.2.2-1 and 3.2.2-2. The mechanical latches and strikers shall conform to the definition of the Latch Striker for Mechanical Systems shown in Figures 3.2.2.4-1, Cross Sectional View through Centerline of Mechanical Latch Striker; 3.2.2.4-2, Radial View; and 3.2.2.4-3, Top View; and Figure 3.2.2.4-4, Active Mechanical Soft Capture Latch Interface. Interpretation of the dimensional parameters describing the mechanical capture latch striker is critical in terms of its performance. The ability of a visiting vehicle to achieve successful capture is highly dependent upon the implementation of the parameters as defined in the noted figures. A detailed explanation of the relationship between the interface dimensions defined in Figure 3.2.2.4-1 can be found in section 3.2.2.4.1.

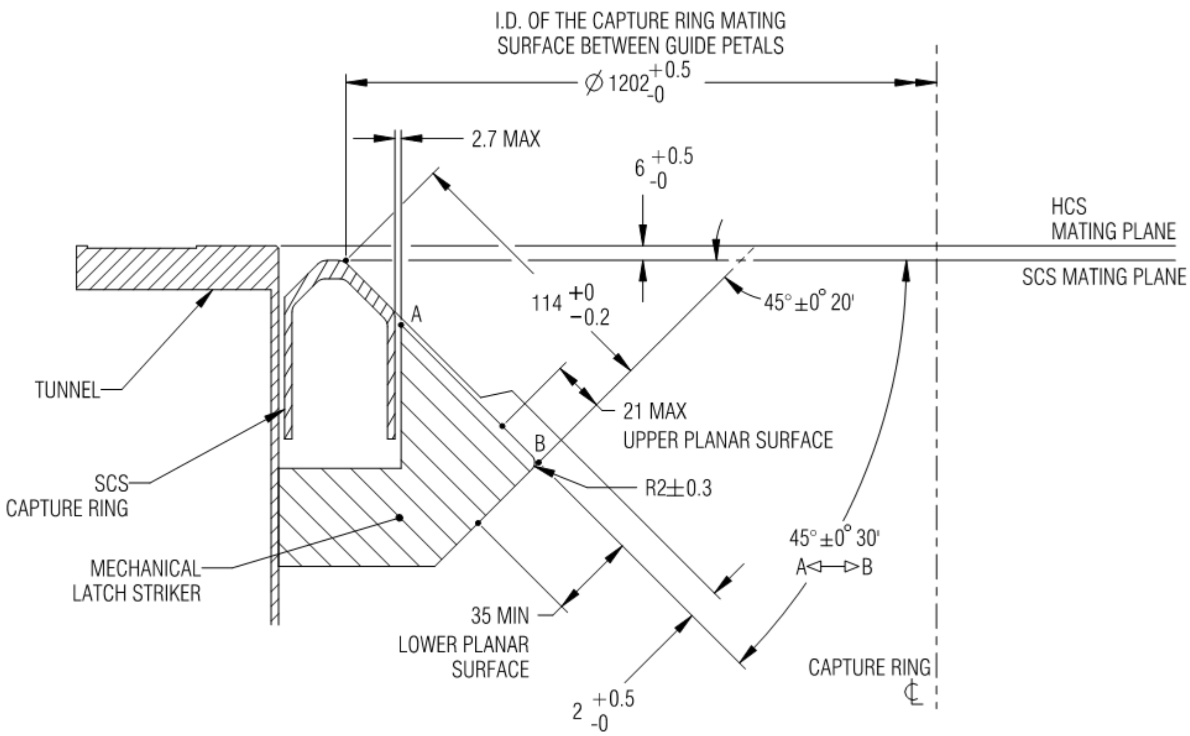
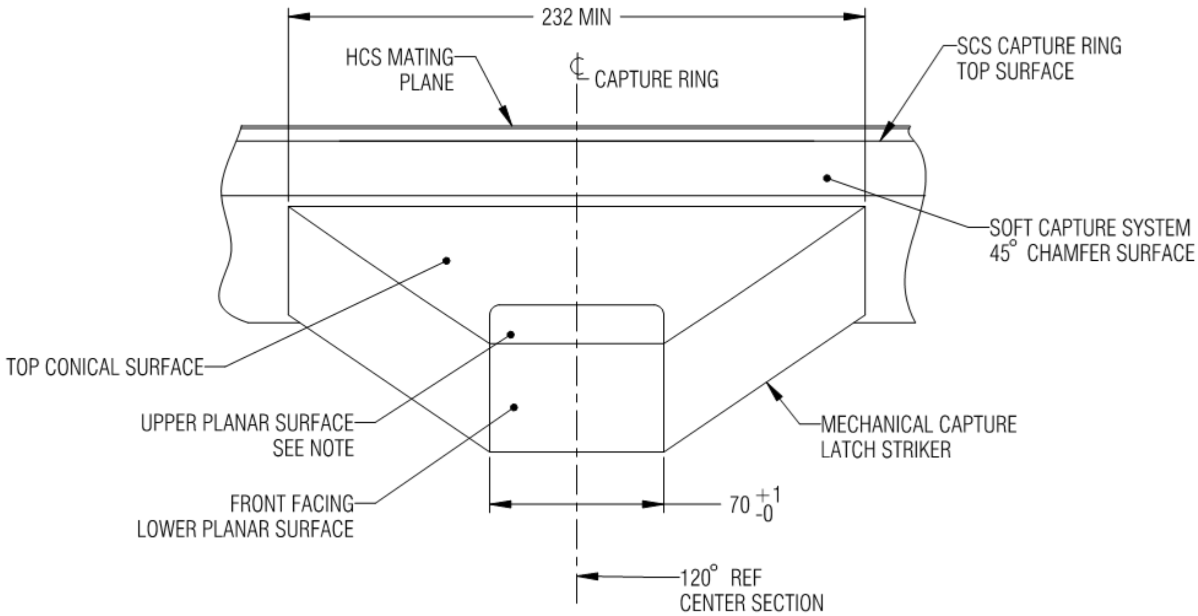


FIGURE 3.2.2.4-1 CROSS SECTIONAL VIEW THROUGH CENTERLINE OF MECHANICAL LATCH STRIKER



Notes:

1. All dimensions are linear dimensions.
2. 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 3.2.2.4-2 RADIAL VIEW

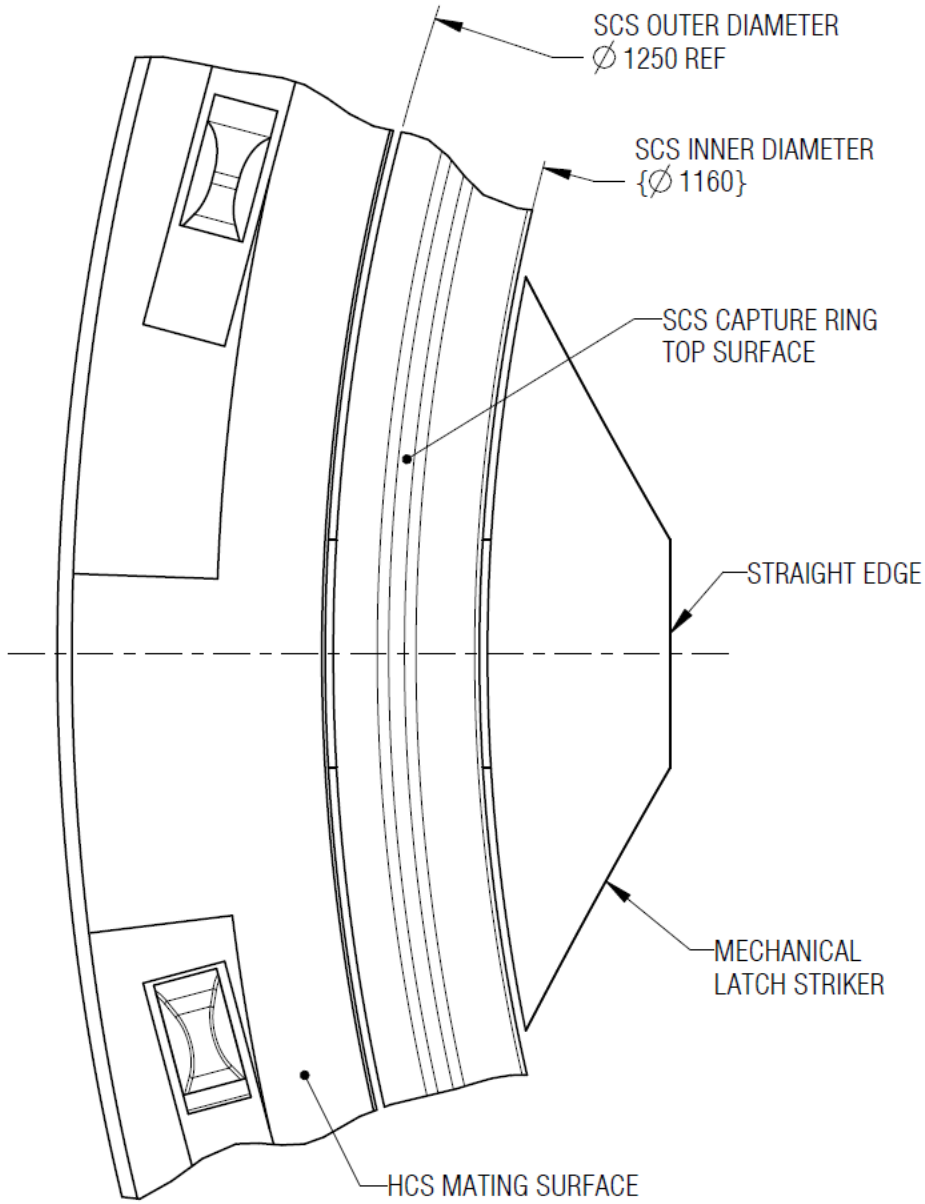
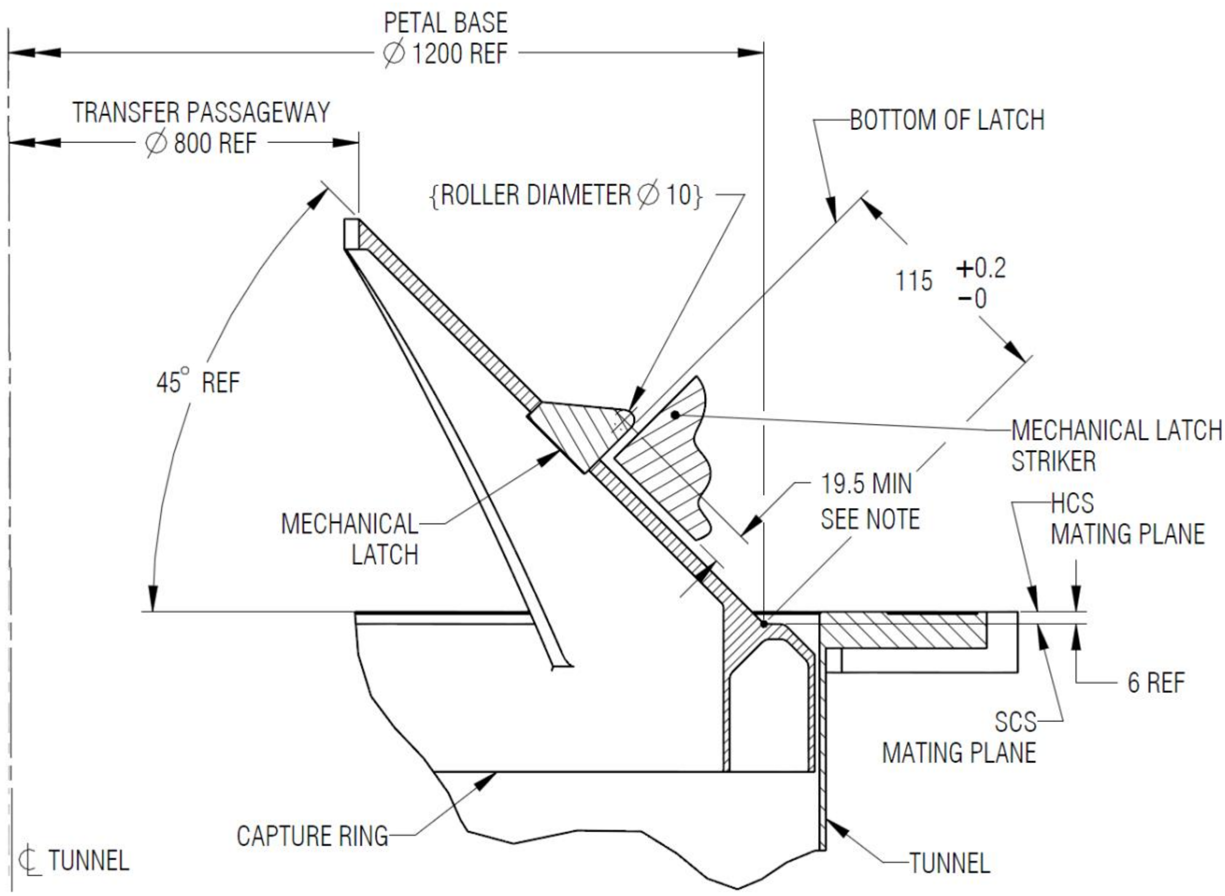


FIGURE 3.2.2.4-3 TOP VIEW



Note: Nominal minimum latch engagement.

FIGURE 3.2.2.4-4 ACTIVE MECHANICAL SOFT CAPTURE LATCH INTERFACE

3.2.2.4.1 MECHANICAL CAPTURE LATCH STRIKER DIMENTIONS DESCRIPTION

The dimensional parameters that describe the mechanical capture latch striker and its location as shown in Section 3.2.2.4 and Figures 3.2.2.4-1, 3.2.2.4-2, 3.2.2.4-3, and 3.2.2.4-4 may be implemented in a variety of ways. In order to achieve the desired performance characteristics for soft capture, it is necessary to establish a common interpretation of the parameters in order to maintain a consistent set of interfaces. Systems that implement the mechanical capture latch striker feature as part of the design of the soft capture system shall adhere to the following interpretation of parameters.

3.2.2.4.1.1 INTERPRETATION OF PARAMETERS

The key parameters that define the critical mechanical capture latch striker interfaces are identified below. Reference designations are assigned to each of the dimensions (noted as **A** through **F**) and each is used in establishing the critical features (Ref. Figure 3.2.2.4.1.1-1, Mechanical Capture Latch Striker Parameter Explanation - Part 1, and Figure 3.2.2.4.1.1-2, Mechanical Capture Latch Striker Parameter Explanation - Part 2):

1. Define/Locate point **X** as follows (Refer to Figure 3.2.2.4.1.1-1):

a. Detect/define the center section of the mechanical capture latch striker. Note: Center sections are referenced at 120 degree intervals relative to primary datum as shown in Figure 3.2.2.4-2.

b. Detect/define SCS 45 degree chamfer surface at the center section of the mechanical capture latch striker (Step a.).

c. Point **X** is established as being the intersection of the three planes: SCS mating plane that is local to the mechanical capture latch striker, the SCS 45 degree chamfer surface (conic surface), and the plane formed by the center section of mechanical capture latch striker (Step a.).

Note: Point **X** should lie within the limits of diameter **A.**

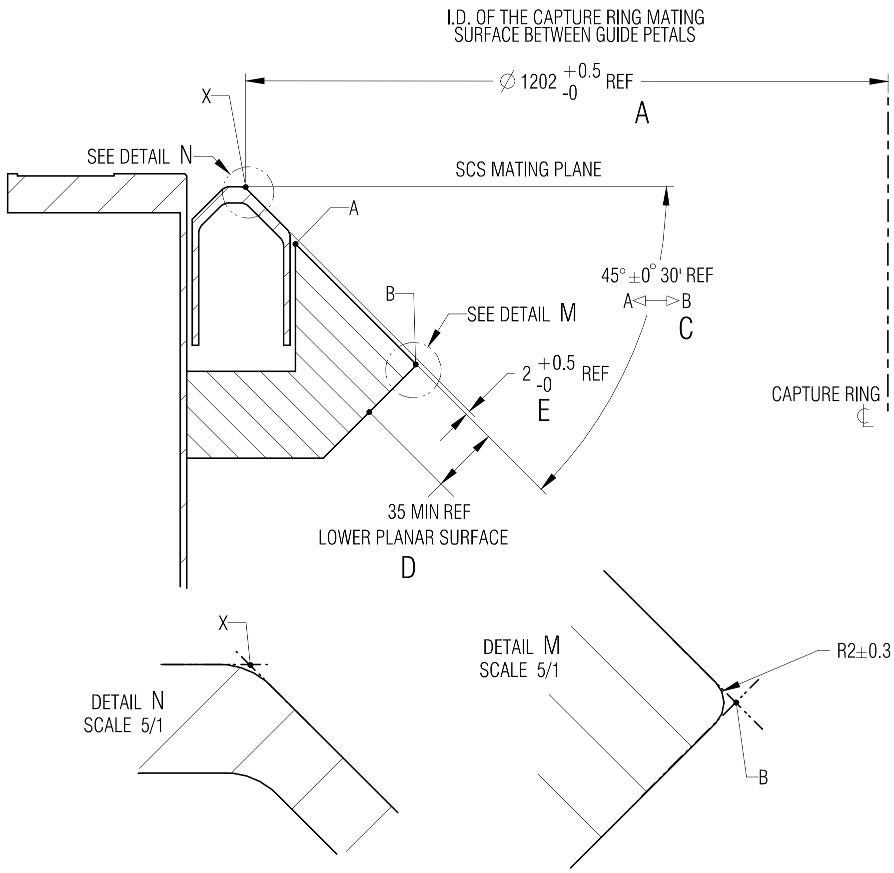


FIGURE 3.2.2.4.1.1-1 MECHANICAL CAPTURE LATCH STRIKER PARAMETER EXPLANATION – PART 1

2. Establish **E** dimension (2 +0.5/-0) as follows (Refer to Figure 3.2.2.4.1.1-1):

   a. Locate the lines formed by the center section of the mechanical capture latch striker and its intersection with both the top conical surface and upper planar surface of the mechanical capture latch striker as defined by dimension **C**.

b. Locate the point at the intersection of the three planes: center section of the mechanical capture latch striker, the front facing lower planar surface defined by dimension **D**, and the upper planar surface defined by dimension **C**.

c. Verify dimension **E** by confirming lines and point defined in Step a and b fall within the acceptable combined dimension **E** and **C** tolerance zones.

3. Establish **B** dimension (114 +0/-0.2) as follows (Figure 3.2.2.4.1.1-2):

a. Detect/define the front facing surface of the mechanical capture latch striker as defined by the dimension **F** and the lower planar surface as defined by dimension **D**. **F** is defined as being 45 degree to a line located in the 120 degree center section and perpendicular to the SCS mating plane.

b. Locate the line formed by the intersecting two planes defined by the center section of the mechanical capture latch striker and the front facing surface of the mechanical capture latch striker (Step a.).

c. Establish dimension **B** to be perpendicular to the line formed in Step b and up to point **X**

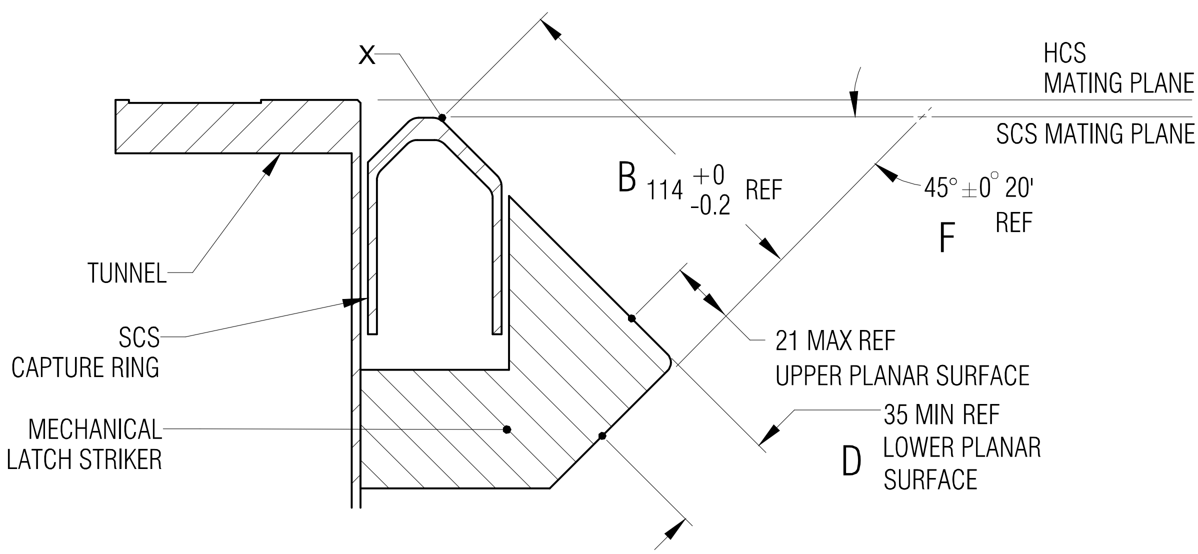


FIGURE 3.2.2.4.1.1-2 MECHANICAL CAPTURE LATCH STRIKER PARAMETER EXPLANATION – PART 2

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 passive SCS sensors shall be ≤ 50N”.

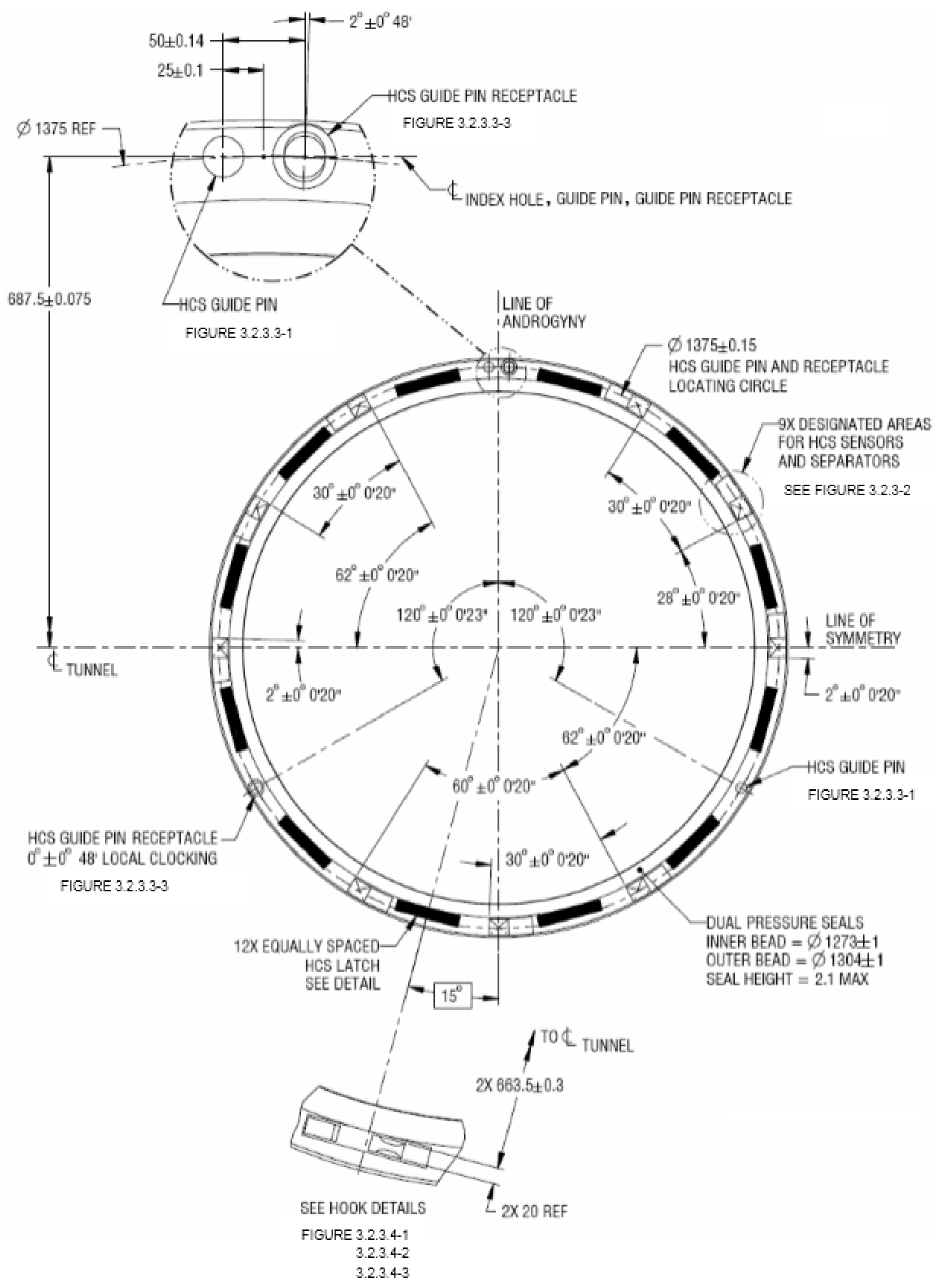
3.2.2.6 SOFT CAPTURE SENSOR STRIKERS

Designated areas for striker zones used by all SCS sensors from the opposing docking system are defined as shown in Figures 3.2.2-1 and 3.2.2-2. Active systems shall place their sensors such that they will strike the passive IDSS interface within these zones. Passive systems 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.

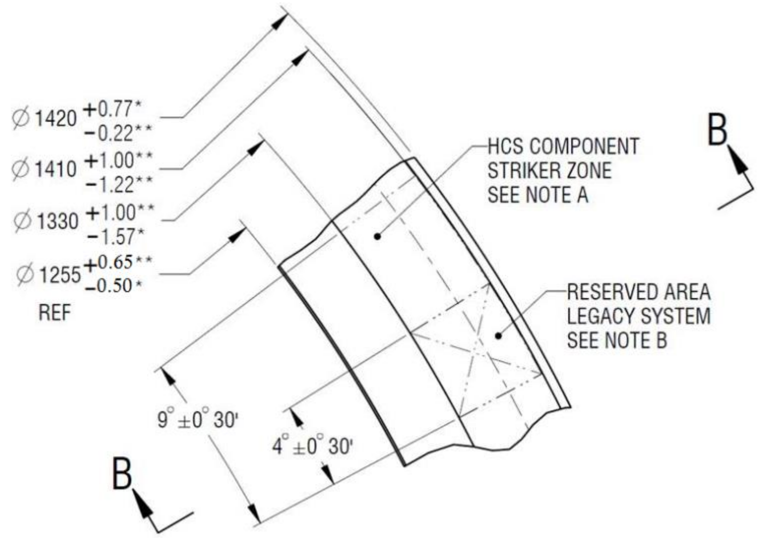
The HCS interface shall conform to the definition as shown in Figure 3.2.3-1, HCS Interface – Axial View, and Figure 3.2.3-2, HCS Interface – Sensor Striker Zone. HCS components that are not critical for transferring mated loads or maintaining pressurization are intentionally omitted from these figures for clarity. Designated striker regions are identified for participants to configure peripheral hardware (e.g. separation system and sensors).



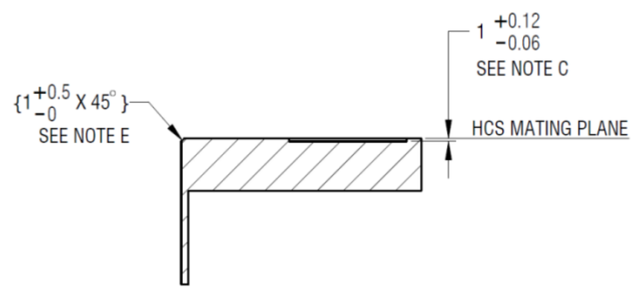
Notes:

1. Boxed angular dimensions are shown as Basic Dimensions that illustrate the theoretical construction lines.
2. No dimensional tolerances are to be applied to the Basic Dimensions.
3. Separation systems shall be retracted below the HCS mating plane prior to closure of HCS interface.

FIGURE 3.2.3-1 HCS INTERFACE - AXIAL VIEW



Sensor Striker Zone



Section B-B

Notes:

* To accommodate NDS legacy

** To accommodate Androgynous Peripheral Attachment System (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 D, D.1.1 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 D, D.1.1 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 3.2.3-2 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 3.2.3-1. The pressure seals are located internally with respect to the tangential hook location. Seal parameters shall be as defined below. Also see Table 3.3.2.1-1, 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 the Guide Pin Details [Figures 3.2.3.3-1, Guide Pin, and 3.2.3.3-2, Section C-C] and the Guide Pin Receptacle Details [Figures 3.2.3.3-3, Guide Pin Receptacle, and 3.2.3.3-4, Section D-D] 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.

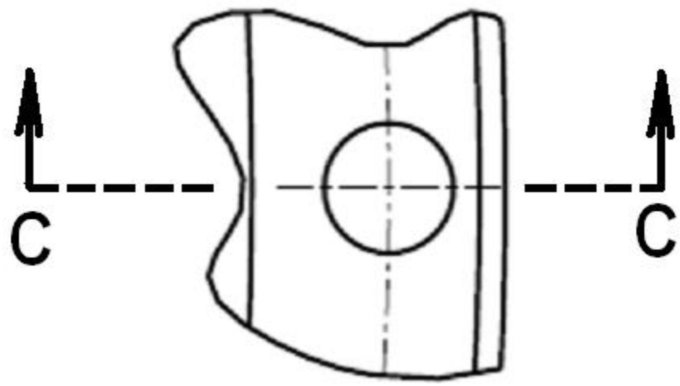


FIGURE 3.2.3.3-1 GUIDE PIN

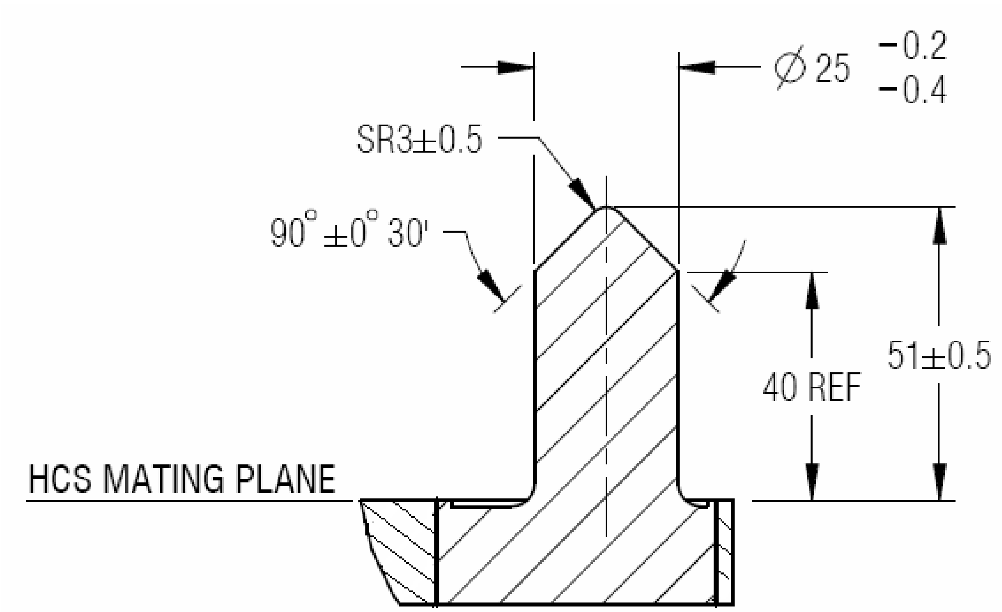


FIGURE 3.2.3.3-2 SECTION C-C

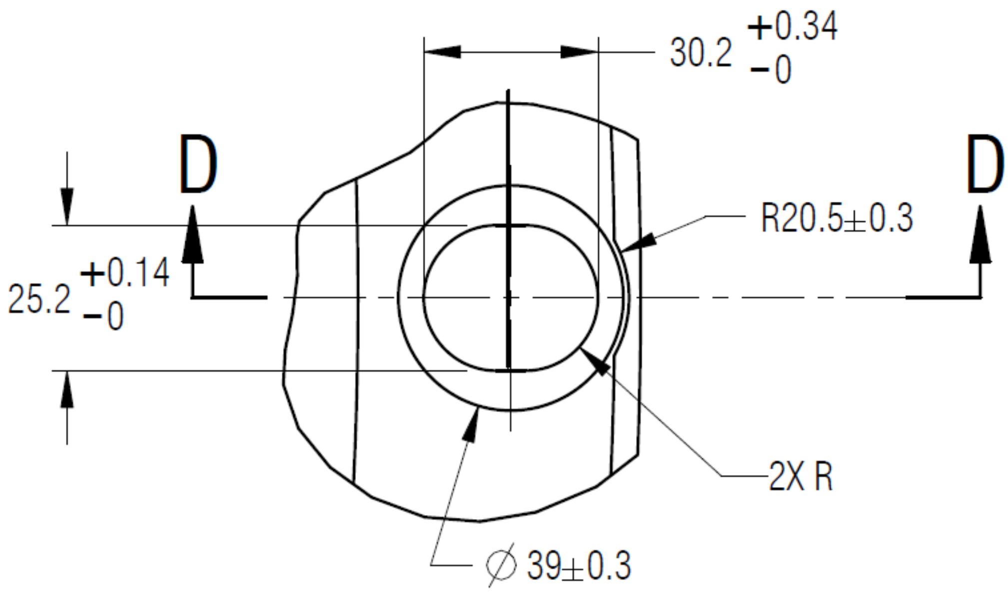
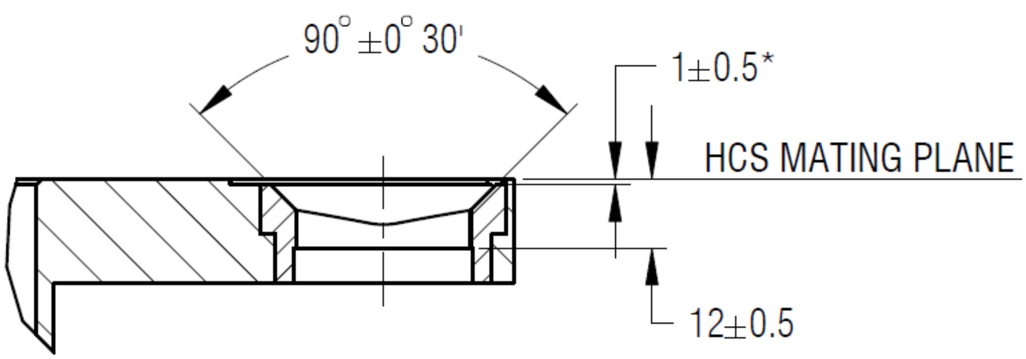


FIGURE 3.2.3.3-3 GUIDE PIN RECEPTACLE



***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 3.2.3.3-4 SECTION D-D

3.2.3.4 HARD CAPTURE HOOKS

The HCS shall incorporate 12 pairs of active and passive hooks, located as shown in Figure 3.2.3-1. 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 the HCS Hooks – Side Views [Figures 3.2.3.4-1, Ready to Dock Configuration, 3.2.3.4-2, Ready to Hook Configuration, and 3.2.3.4-3, Fully Mated Configuration], Figure 3.2.3.4-4, HCS Active Hook, and the HCS Passive Hook [Figures 3.2.3.4-5, Passive Hook, and 3.2.3.4-6, Passive Hook Detail View]. The motion of the active hook shall be bounded by the envelope shown in Figure 3.2.3.4-7, HCS Active Hook Motion Envelope.

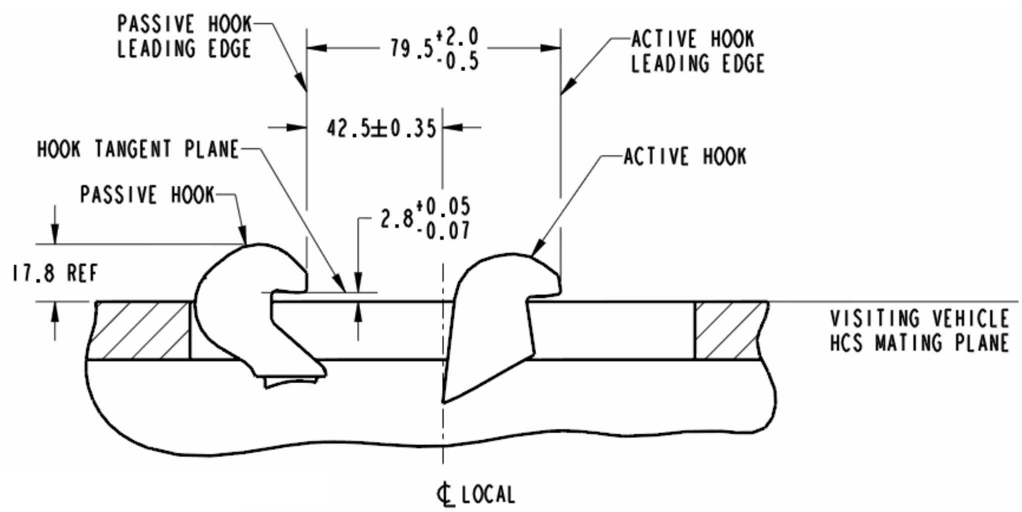


FIGURE 3.2.3.4-1 READY TO DOCK CONFIGURATION

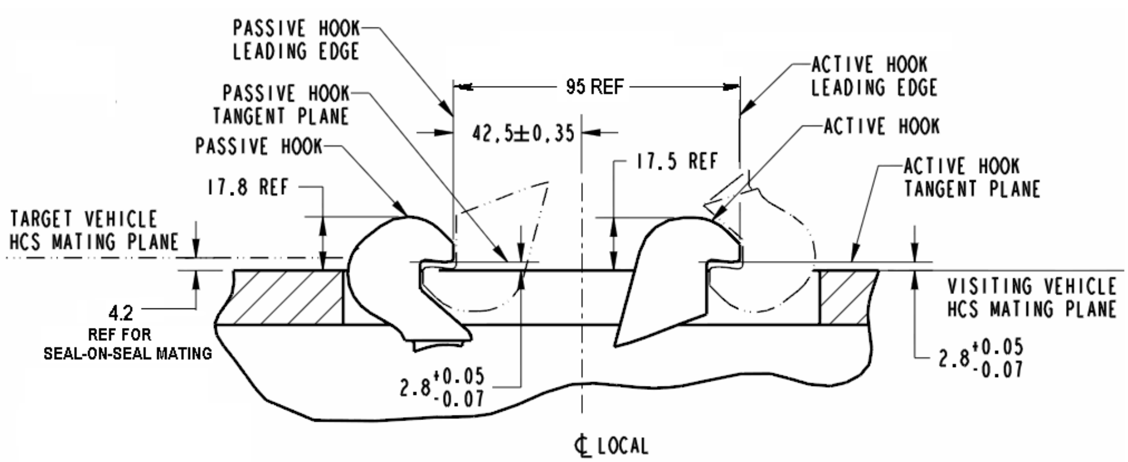


FIGURE 3.2.3.4-2 READY TO HOOK CONFIGURATION

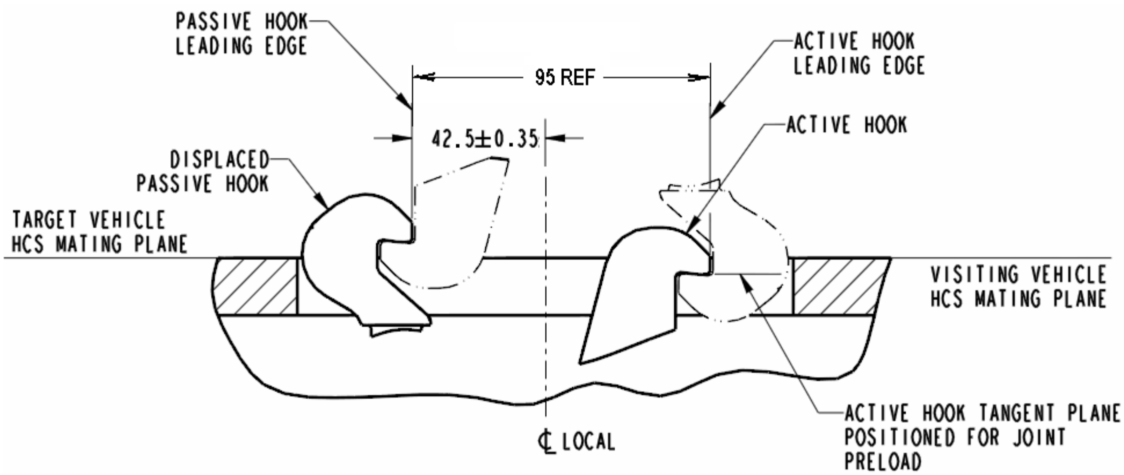


FIGURE 3.2.3.4-3 FULLY MATED CONFIGURATION

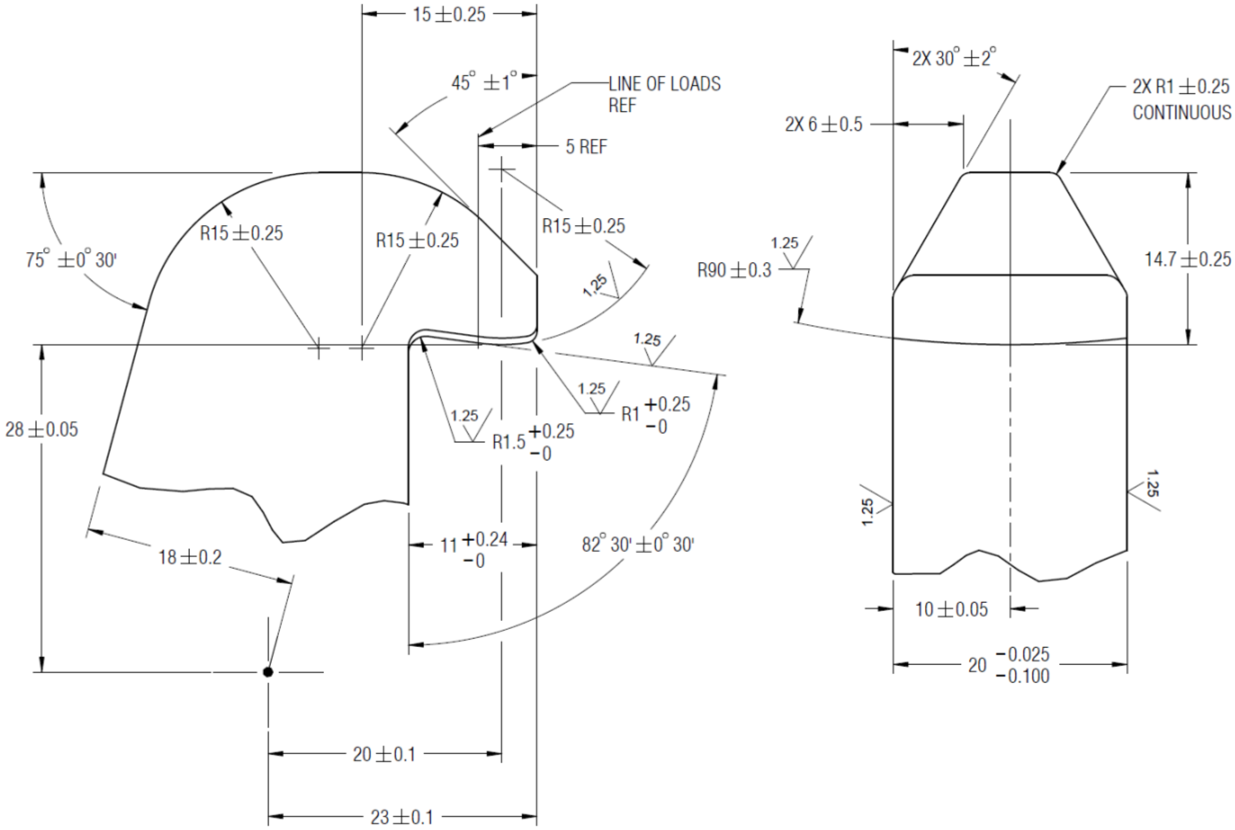


FIGURE 3.2.3.4-4 HCS ACTIVE HOOK

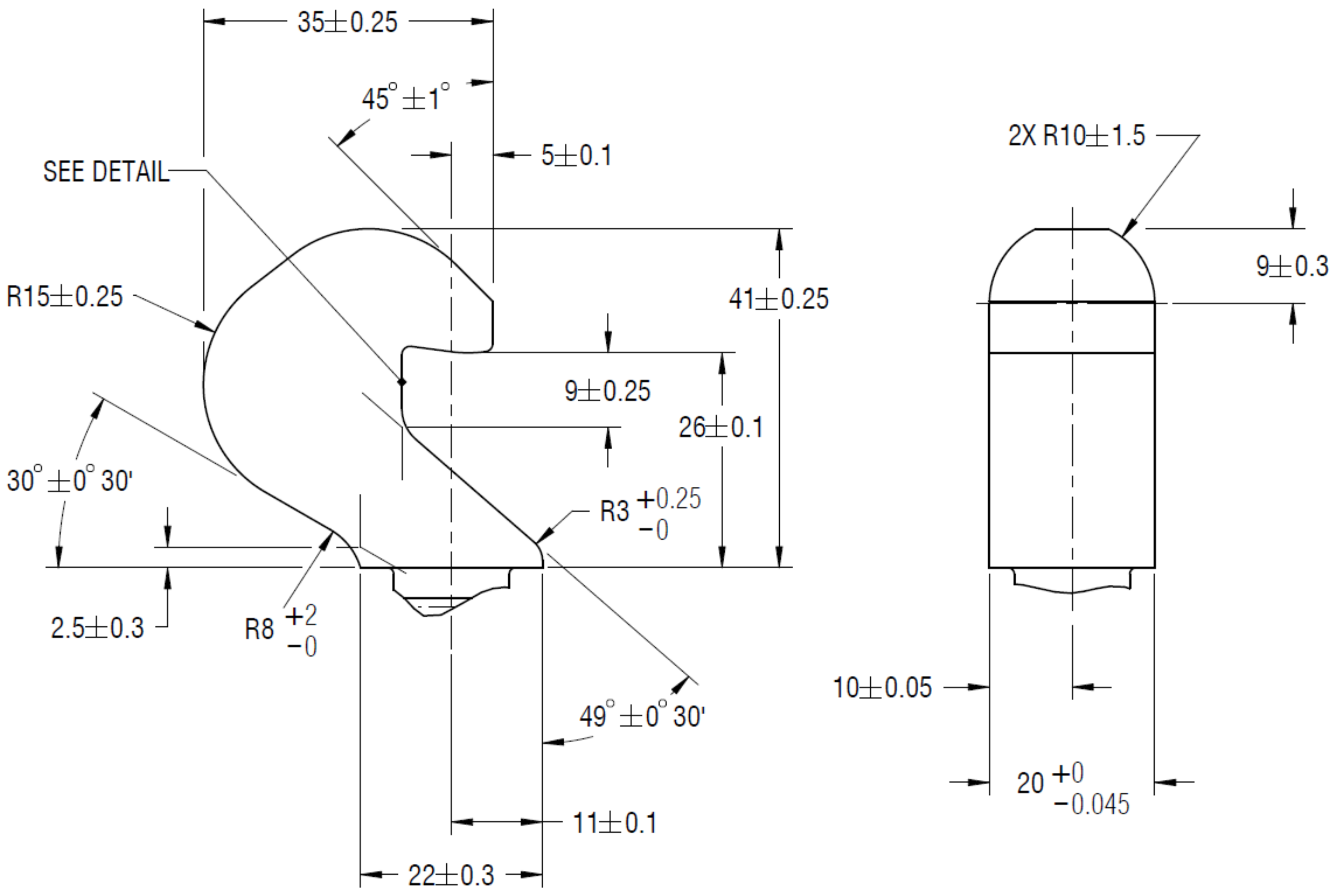


FIGURE 3.2.3.4-5 PASSIVE HOOK

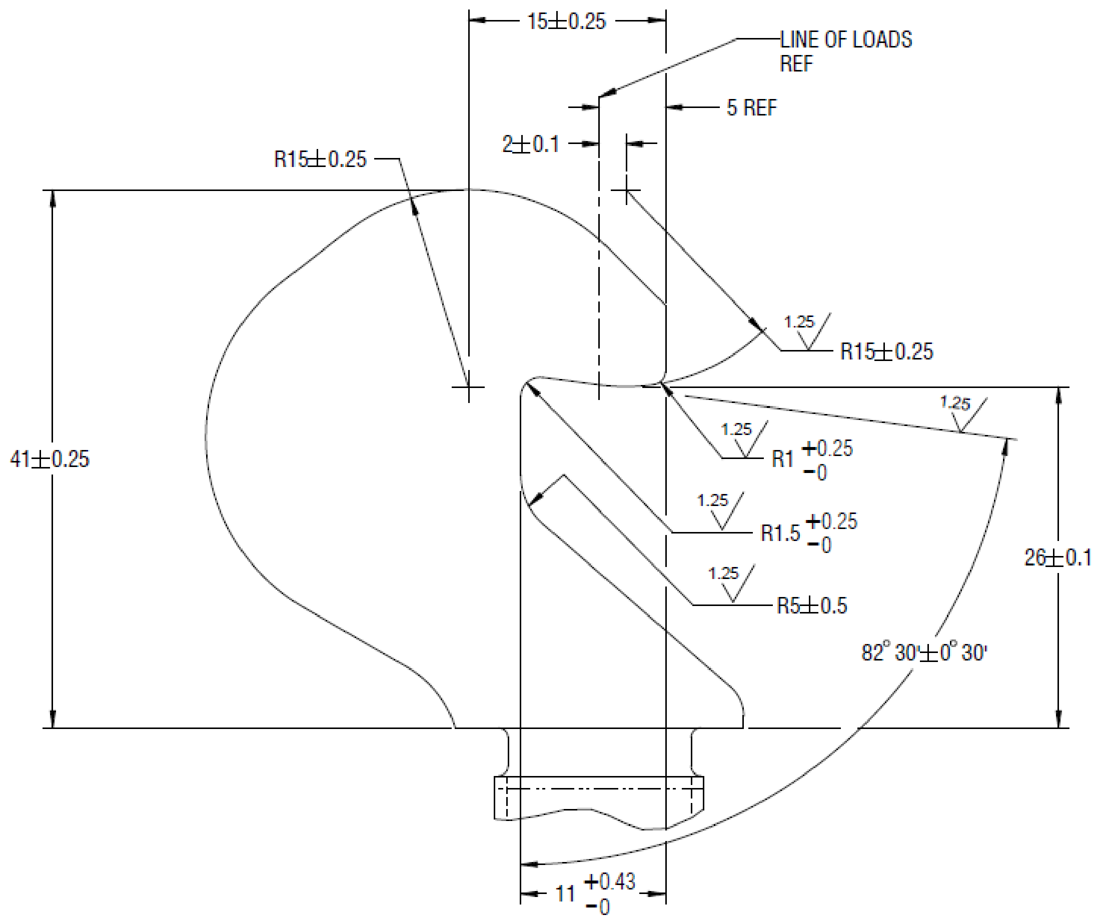


FIGURE 3.2.3.4-6 PASSIVE HOOK DETAIL VIEW

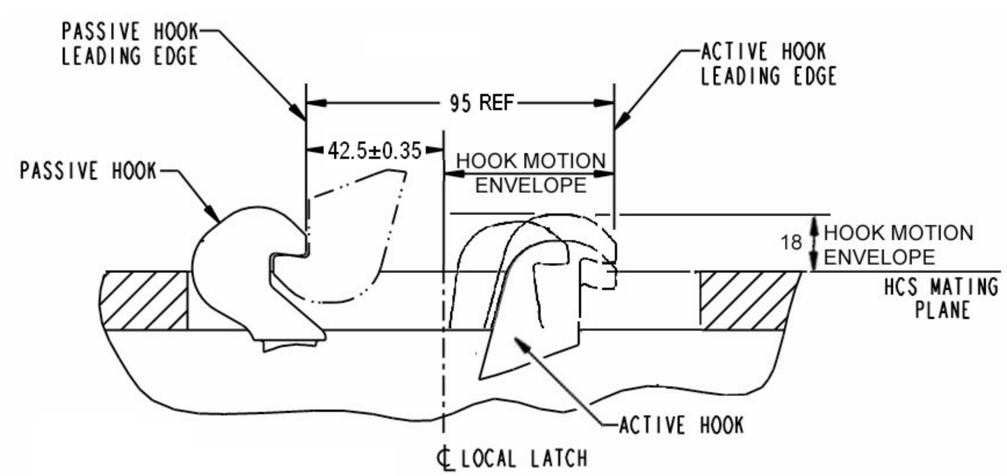


FIGURE 3.2.3.4-7 HCS ACTIVE HOOK MOTION ENVELOPE

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 3.2.3.4-8, Load Response of Active Hook Mechanism.

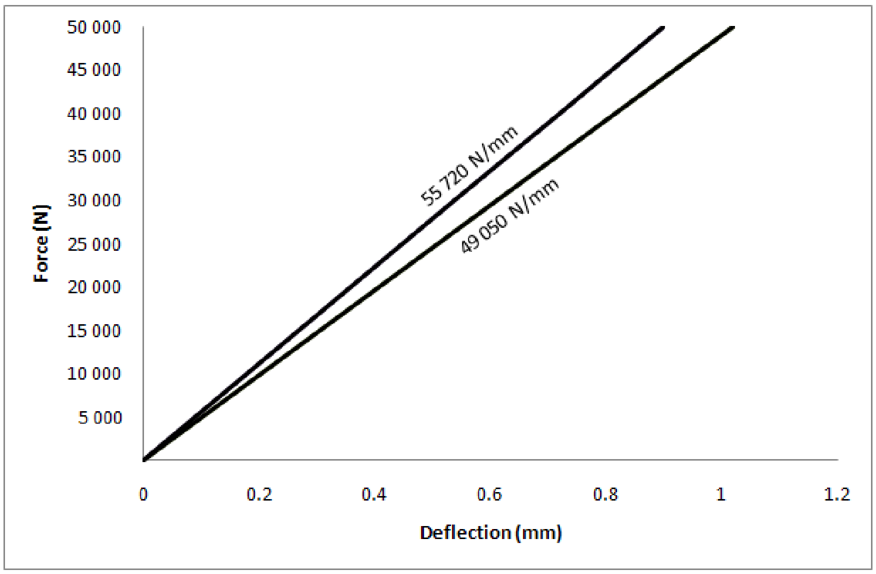


FIGURE 3.2.3.4-8 LOAD RESPONSE OF ACTIVE HOOK MECHANISM

D. The load response (stiffness) of the Passive Hard Capture Hook Mechanism shall be between the upper and lower curves as defined in Figure 3.2.3.4-9, Load Response of Passive Hook Mechanism (including Spring Washer Stack).

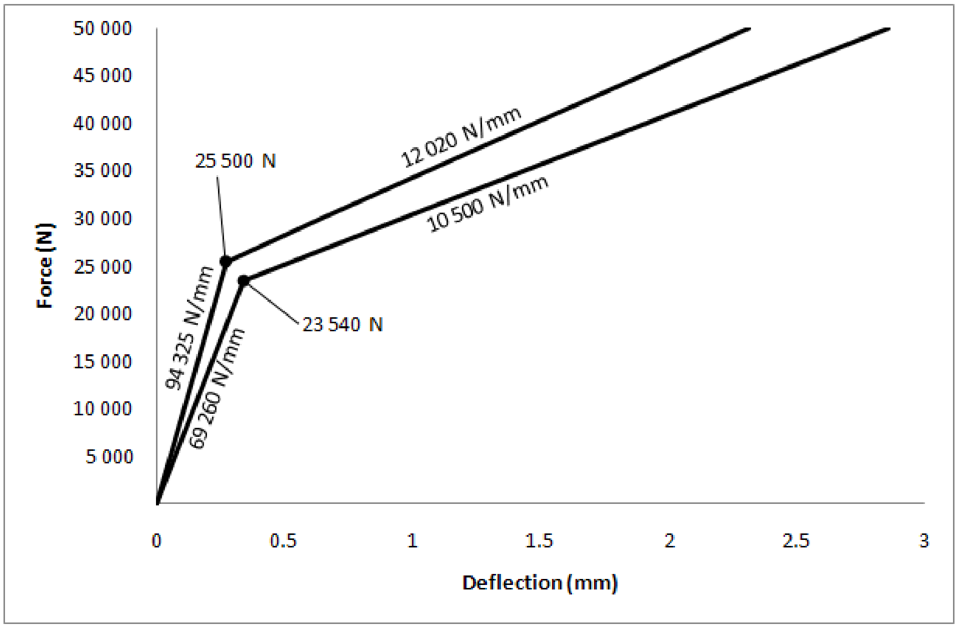


FIGURE 3.2.3.4-9 LOAD RESPONSE OF PASSIVE HOOK MECHANISM (INCLUDING SPRING WASHER STACK)

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 3.2.3-1 and Figure 3.2.3-2.

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 shall provide a symmetric undocking separation force. The number of separators is a choice left to the docking system designer, provided that they comply with 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.

3.2.4 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.

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 ICCs. 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 AND COORDINATE SYSTEMS

ICCs are 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 alignment and zero relative velocity at the docking interfaces.

The coordinate systems of docking units and docking objects are used to define the motion during docking and ICCs. An overview and description of coordinate systems is provided in Table 3.3.1.1-1, Coordinate Systems Used for Docking Motion Description. Figures 3.3.1.1-1 and 3.3.1.1-2 define the coordinate systems of the docking system and the docking objects.

The transition between coordinate systems is achieved by three rotations, performed in order corresponding to ISO 1151-1:1988, Flight Dynamics – Concepts, quantities and symbols – 4th edition, Part 1: Aircraft motion relative to the air.

A. Yaw – yaw angle Ψ_Z is defined positive about +Z-axis, using right-handed rule.

B. Pitch – pitch angle θ_Y is defined positive about +Y-axis, using right-handed rule.

C. Roll – roll angle φ_X is defined positive about +X-axis, using right-handed rule.

To increase the probability of successful docking between different spacecraft, it is recommended that IDSS-compliant mechanisms capture and attenuate vehicles within ICCs shown in Table 3.3.1.1-2, Initial Contact Conditions.

The set of limiting ICCs provided in Table 3.3.1.1-2 represents the values used in the derivation of the loads defined in Table 3.3.1.4-1, SCS Maximum Interface Loads, and Table 3.3.1.4-2, SCS Maximum Component Loads, and represents the achievable capture envelope provided by IDSS-compatible mechanism's passive interface.

TABLE 3.3.1.1-1 COORDINATE SYSTEMS USED FOR DOCKING MOTION DESCRIPTION

#	Name	Symbol	Position	Orientation	Purpose
1. Coordinate systems of docking system interfaces					
1.1	Active SCS ring coordinate system	$X_{AR}Y_{AR}Z_{AR}$	Active ring center	$+X_{AR}$: closing direction, $+Y_{AR}$: line of symmetry, through petal number 3	• Docking mechanism motion description • Description of ring contact interaction

TABLE 3.3.1.1-1 COORDINATE SYSTEMS USED FOR DOCKING MOTION DESCRIPTION

#	Name	Symbol	Position	Orientation	Purpose
				$+Z_{AR}$: make right coordinate system, (see Figure 3.3.1.1-2)	
1.2	Passive SCS ring coordinate system	$X_{PR}Y_{PR}Z_{PR}$	Passive ring center	$X_{PR}Y_{PR}Z_{PR}$ – according to $X_{AR}Y_{AR}Z_{AR}$	• Description of ring contact interaction
1.3	Coordinate system of initial position of active docking mechanism	$X_{AI}Y_{AI}Z_{AI}$	Active ring center before first contact	$+X_{AI}$: closing direction, $+Y_{AI}$: line of symmetry, through petal number 3 $+Z_{AI}$: make right coordinate system, (see Figure 3.3.1.1-1)	• Description of initial position for docking
1.4	Coordinate system of active docking mechanism base	$X_{AB}Y_{AB}Z_{AB}$	Center of active docking mechanism base	$X_{AB}Y_{AB}Z_{AB}$ – according to $X_{AD}Y_{AD}Z_{AD}$, (see Figure 3.3.1.1-1)	• Docking mechanism motion description
1.5	Coordinate system of active docking/HCS mating plane	$X_{AD}Y_{AD}Z_{AD}$	Center of active docking plane	$+X_{AD}$: closing direction, $+Y_{AD}$: line of symmetry, through petal number 3 $+Z_{AD}$: make right coordinate system, (see Figure 3.3.1.1-1)	• Docking mechanism movement description relative to active docking/HCS mating plane • Contact interaction analysis of HCS elements
1.6	Coordinate system of passive docking/HCS mating plane	$X_{PD}Y_{PD}Z_{PD}$	Center of passive docking plane	$X_{PD}Y_{PD}Z_{PD}$ – according to $X_{AD}Y_{AD}Z_{AD}$	
			2. Coordinate systems of docking objects		
2.1	Motion coordinate system of active object (1)	$X_1Y_1Z_1$	At the active object center of gravity (CG)	$+X_1$: closing direction, $+Y_1$: according to $+Y_{AD}$ $+Z_1$: make right coordinate system, (see Figure 3.3.1.1-1 and Figure 3.3.1.1-2)	• Objects motion description relative to inertial coordinate system • Active object motion description relative to passive object
2.2	Motion coordinate system of passive object (2)	$X_2Y_2Z_2$	At the passive object CG	$X_2Y_2Z_2$ – according $X_1Y_1Z_1$ by zero mis-alignments	

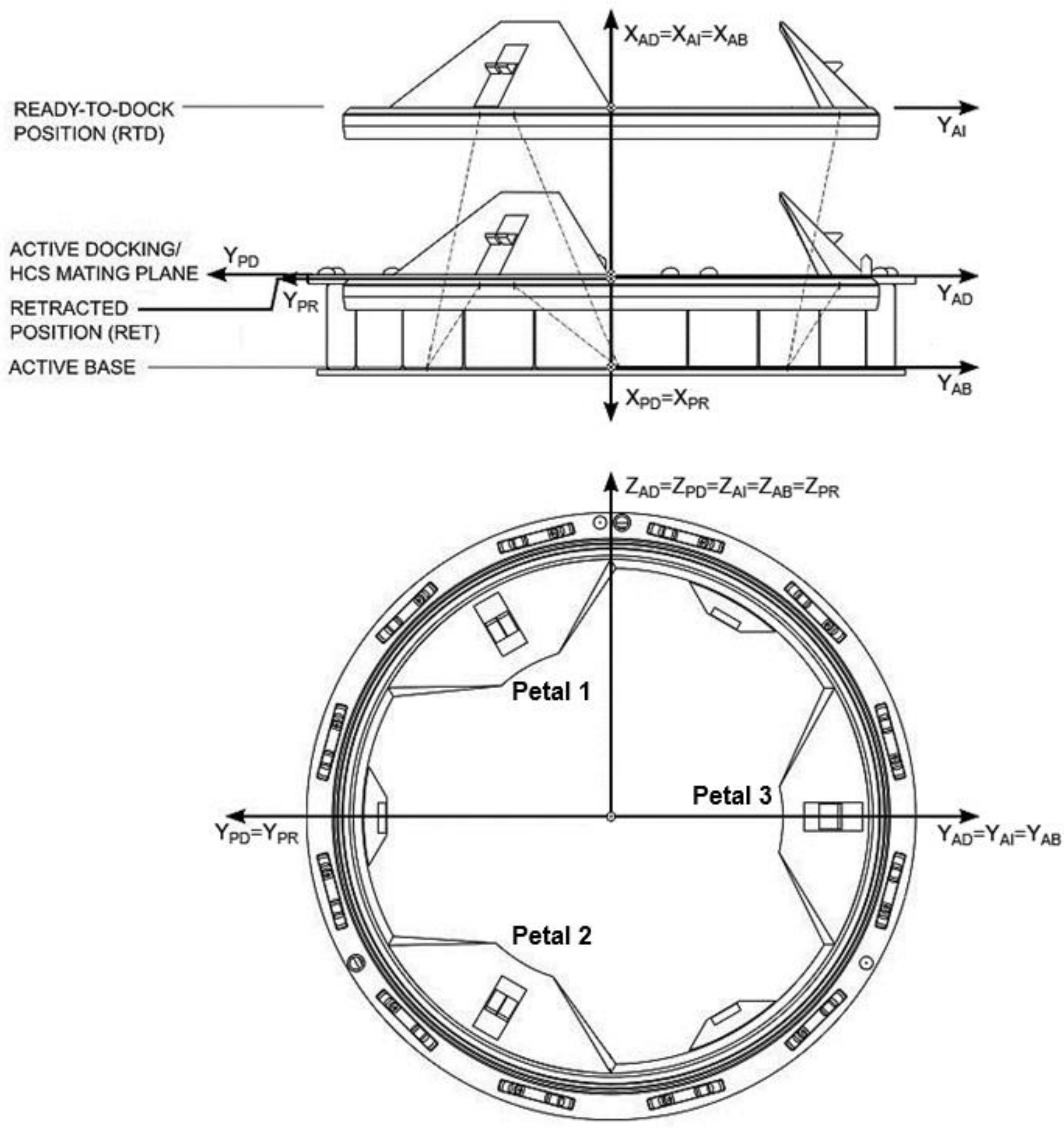


FIGURE 3.3.1.1-1 COORDINATE SYSTEMS OF DOCKING SYSTEM

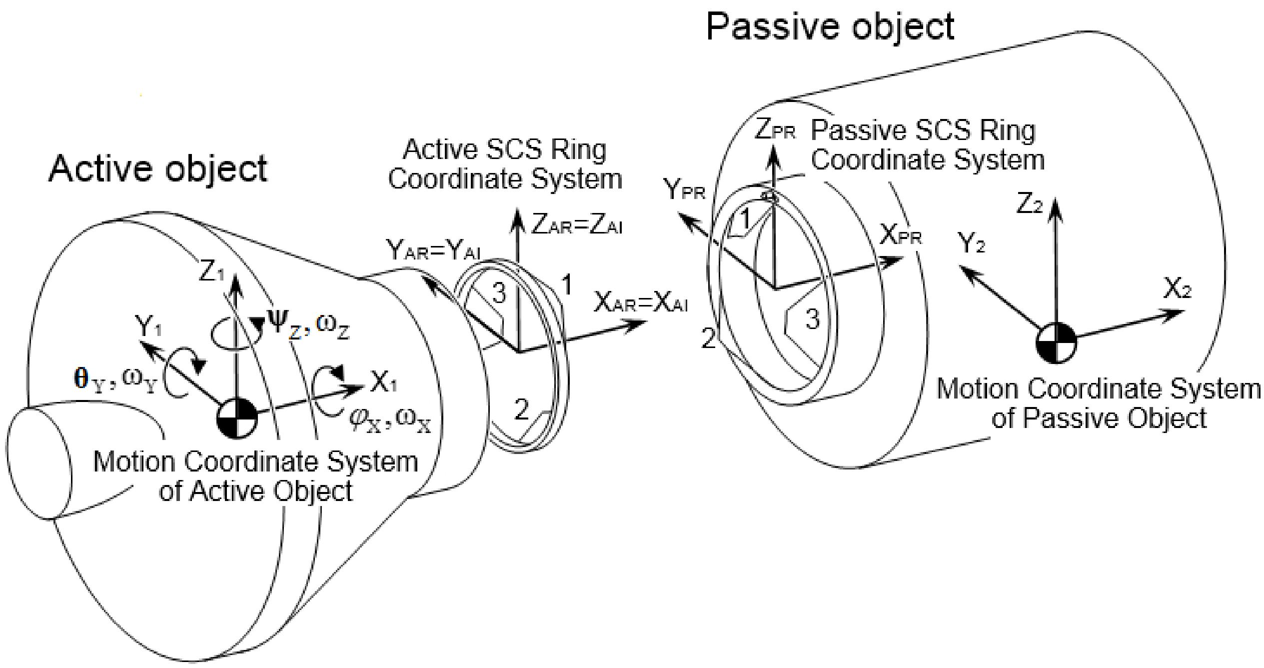


FIGURE 3.3.1.1-2 COORDINATE SYSTEM OF DOCKING OBJECTS (ACTIVE AND PASSIVE)

TABLE 3.3.1.1-2 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 3.3.1.2-1.

Initial Condition	Limiting Value
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 3.3.1.2-1, Vehicle Mass Properties. The set of design case vehicle mass properties provided in Table 3.3.1.2-1 represents the values used in the derivation of the loads defined in Table 3.3.1.4-1 and Table 3.3.1.4-2.

TABLE 3.3.1.2-1 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.

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 3.3.1.4-1 and Table 3.3.1.4-2.

TABLE 3.3.1.4-1 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 3.1.1.1-1).
3. Values are 3σ maxima and are to be applied simultaneously, not to exceed the component values shown in Table 3.3.1.4-2.
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 3.3.1.4-2 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 3.3.2.1-1, and Table 3.3.2.1-2, 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 3.2.3-1.

TABLE 3.3.2.1-1 HCS MAXIMUM MATED LOADS

Load Set	Mated ISS	Trans-Lunar
Maximum Design Pressure	1 100 hPa	0 hPa
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 3.3.2.1-2 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 3.3.2.1-1 and Table 3.3.2.1-2)
1. Values are design limit loads.

2. 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.
3. Shear loads may be applied in any direction in the HCS mating plane.
4. Bending moment may be applied about any axis in the HCS mating plane.
5. The outer seal bead is to be used for all pressure calculations.
6. Load cases are defined in Table 3.3.2.1-2, and Table 3.2.2.1-1 is a summary of the maximum loads.
7. Case descriptions:
   Case 1 – Attitude control by Orbiter-sized vehicle, combined with crew activity.
   Case 2 – Interface loads due to ISS segment berthing.
   Case 3 – Orbiter-sized vehicle translation with payload attached to ODS.
   Case 4 – Unpressurized high axial tension load case; modified from Constellation Trans-lunar Injection loads analysis.

3.4 RESOURCE TRANSFER UMBILICALS

The IDSS accommodates umbilical connectors for transfer of electrical and fluid resources between two docked vehicles. All umbilical connectors shall be recessed below the docking mating plane during docking. Recessed connector designs will enable low impact docking systems utilization and potential crew rescue for cross program or cross world developer implementations. During undocking, the connectors are nominally deactivated and driven to the unmated recessed position prior to unlatching the hooks. Ten umbilical connector locations are available for utilization by docking system developers. Keep Out Zones (KOZs) for umbilical hardware are shown in Figure 3.4-1, Umbilical Connector Keep-Out Zones.

Program specific resource transfer specifications can be found in program specific Interface Definition Documents (IDDs) and Specifications. Reference material for program resource umbilical implementations is provided at the International Deep Space Interoperability Standards website www.internationaldeepspacestandards.com and or www.internationaldockingstandard.com.

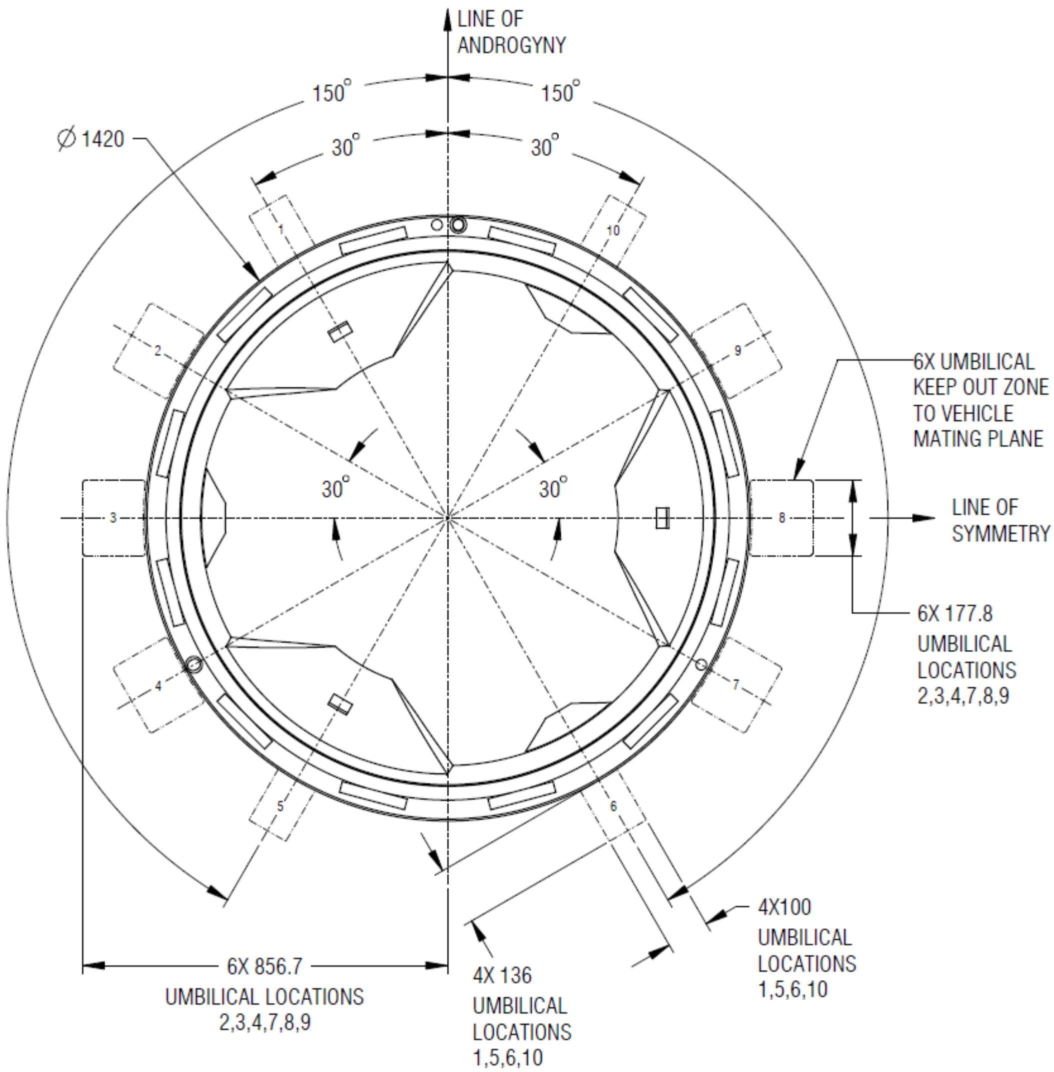


FIGURE 3.4-1 UMBILICAL CONNECTOR KEEP-OUT ZONES

3.5 RENDEZVOUSN AND ALIGNMENT AIDS

Program specific Rendezvous and Alignment Aids are not defined in this standard. Program specific rendezvous and alignment aid specifications may be found in program specific Interface Definition Documents (IDDs). Guidance for program specific R & A IDDs may be found at www.internationaldockingstandard.com. For ISS IDA, IDSS Revision E may be utilized. This revision may also be found on the IDSS website.

APPENDIX A - ACRONYMS, ABBREVIATIONS AND SYMBOLS DEFINITION

APAS	Androgynous Peripheral Attachment System
AWG	American Wire Gauge
C	Celsius
CBM	Common Berthing Mechanism
CC&DH	Command, Control and Data Handling
CG	Center of Gravity
cm	centimeter
DC	Direct Current
deg	degree
DOF	Degree of Freedom
DPMC	Directorate Program Management Council
e.g.	for example
EMA	Electro-Mechanical Actuator
EMI	Electromagnetic Interference
ESDMD	Exploration Systems Development Mission Directorate
F	Fahrenheit
FRAM	Flight Releasable Attachment Mechanism
HCS	Hard Capture System
HEO	Human Exploration & Operations
hPa	Hecto Pascal(s)
IBDM	International Berthing and Docking Mechanism
ICC	Initial Contact Condition
IDA	International Docking Adapter
IDD	Interface Definition Document
IDS	International Docking System
IDSS	International Docking System Standard
IDSS+B	Berthing compatible IDSS implementation
IEEE	Institute of Electrical and Electronic Engineers
IERIIS	International External Robotics Interface Interoperability Standards
In	Inches
IRSIS	International Rendezvous System Interoperability Standards
ISS	International Space Station
kg	kilogram

kgf	kilograms force
KOZ	Keep Out Zone
LEO	Low Earth Orbit
m	meters
MAX	Maximum
MCB	Multilateral Control Board
MIL	Military
MIN	Minimum
mm	Millimeters
MOI	Moments of Inertia
N	Newton(s)
NASA	National Aeronautics and Space Administration
NDS	NASA Docking System
nm	nanometers
Nm	Newton-Meter(s)
ODS	Orbiter Docking System
ohm	Ohms
Pa	Pascal
PDTU	Power/Data Transfer Umbilical
PIT	Peripheral Infrared Target
PMA	Pressurized Mating Adapter
POI	Products of Inertia
PR	Passive Ring
R	Radius
rad	Radian
RECP	Receptacle
REF	Reference
RF	Radio Frequency
RMS	Root Mean Square
RSS	Root Sum Square
RTN	Return
RX	Receive
SCS	Soft Capture System
Sec	Second
SOMD	Space Operations Mission Directorate
SR	Spherical Radius

SSRMS	Space Station Remote Manipulator System
STD	Standard
Sys	System
TBC	To Be Confirmed
TBD	To Be Determined
TBR	To Be Resolved
TBS	To Be Supplied
THK	Thick
tonne	metric ton = 1000 kilograms
TX	Transmit
US	United States
VDC	Volts Direct Current
$\omega = [\omega_X, \omega_Y, \omega_Z]^T$	Angular Velocity Vector
[XX]	Basic (Theoretical) Dimension
◁—▷	Between
℄	Centerline
○	Circularity
◎	Concentricity
□—◀	Datum Feature
↧	Depth / Deep
⌀	Diameter
△	Difference
TRUE	Dimension in a view that does not show true feature shape
▱	Flatness
○	Maximum Material Condition
⊥	Perpendicularity
θ_Y	Pitch Angle (relative to Y Axis)
⌖	Position
φ_X	Roll Angle (relative to X Axis)
SR	Spherical Radius

$\surd$	Surface Finish
Ψ_z	Yaw Angle (relative to Z Axis)

APPENDIX B - GLOSSARY <RESERVED>

APPENDIX C - OPEN WORK

Table C-1 lists the specific To Be Determined (TBD) items in the document that are not yet known. The TBD is inserted as a placeholder wherever the required data is needed and is formatted in bold type within brackets. The TBD item is numbered based on the section where the first occurrence of the item is located as the first digit and a consecutive number as the second digit (i.e., <TBD 4-1> is the first undetermined item assigned in Section 4 of the document). As each TBD is solved, the updated text is inserted in each place that the TBD appears in the document and the item is removed from this table. As new TBD items are assigned, they will be added to this list in accordance with the above described numbering scheme. Original TBDs will not be renumbered.

TABLE C-1 TO BE DETERMINED ITEMS

TBD	Section	Description
None		

Table C-2 lists the specific To Be Resolved (TBR) issues in the document that are not yet known. The TBR is inserted as a placeholder wherever the required data is needed and is formatted in bold type within brackets. The TBR issue is numbered based on the section where the first occurrence of the issue is located as the first digit and a consecutive number as the second digit (i.e., <TBR 4-1> is the first unresolved issue assigned in Section 4 of the document). As each TBR is resolved, the updated text is inserted in each place that the TBR appears in the document and the issue is removed from this table. As new TBR issues are assigned, they will be added to this list in accordance with the above described numbering scheme. Original TBRs will not be renumbered.

TABLE C-2 TO BE RESOLVED ISSUES

TBR	Section	Description
None		

APPENDIX D - LEGACY HARDWARE

D.1.0 DOCKING SYSTEM

D.1.1 HARD CAPTURE SYSTEM HERITAGE STRIKER ZONES

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 3.2.3-1) 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 D.1.1-1, 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, NDS and IDA, 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 D.1.1-2, APAS Features within Striker Zones, Figure D.1.1-3, NDS Features within Striker Zones and Figure D.1.1-4, IDA Features within Striker Zones.

The International Docking Adapter implementation of spring pusher separation devices lies within areas noted as being “reserved” legacy zone regions. Verification of docking operations with visiting vehicles equipped with both current and future implementations of IDSS compliant systems has been performed and it has been determined that there is no impact to performance. The locations of the separator devices within the “reserved” zones are shown in Figure D.1.1-5, Radial and Angular Locations of IDA Separator Installations within Striker Zones, and Figure D.1.1-6, IDA Separator Installation Cutout Details.

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.

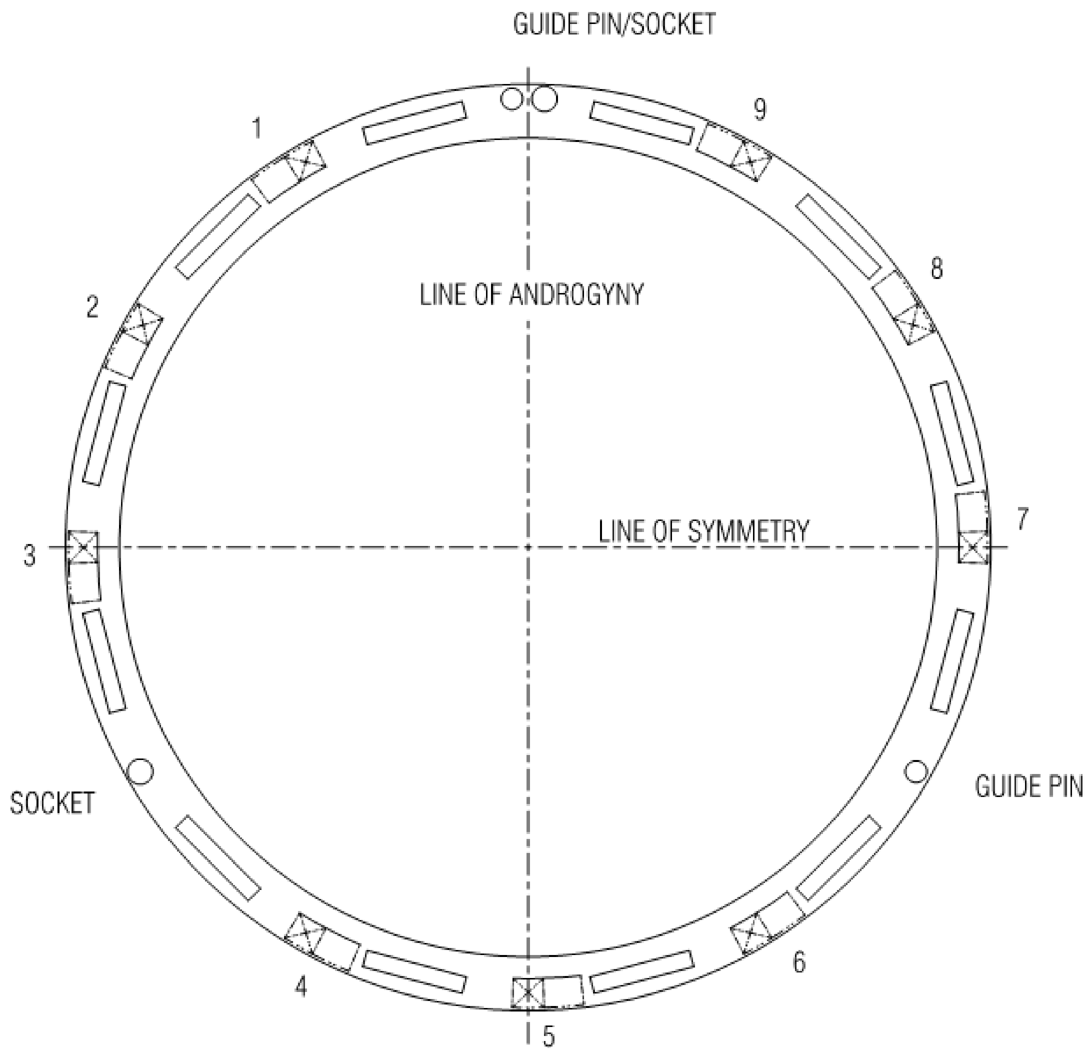
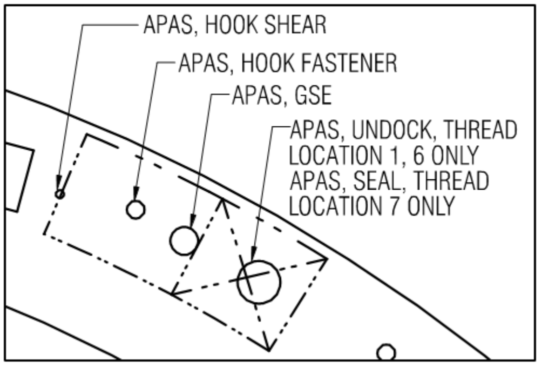
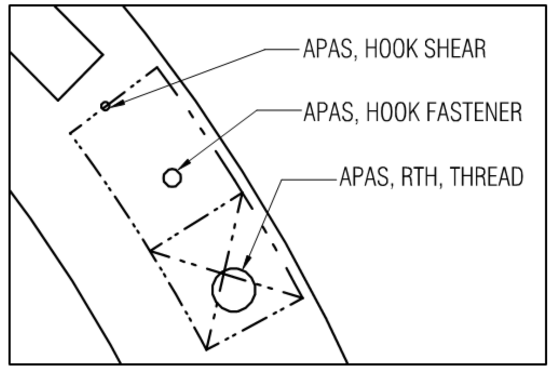


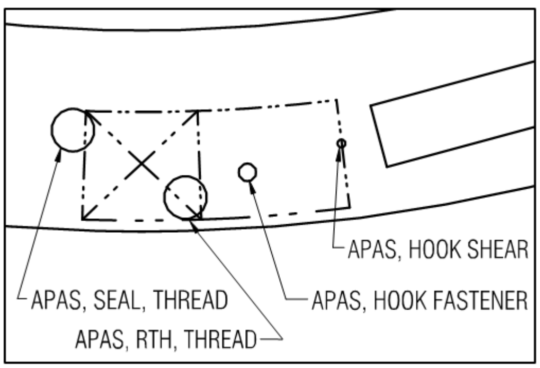
FIGURE D.1.1-1 HCS COMPONENT STRIKER ZONE REFERENCE NUMBERS

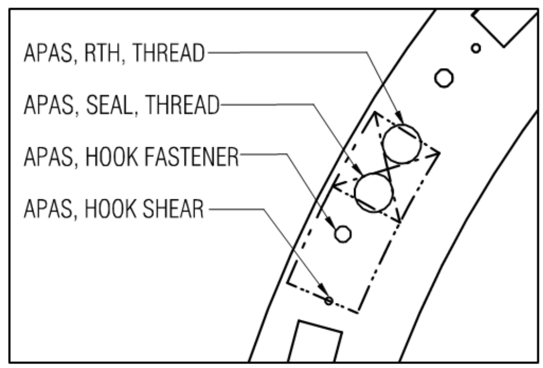




Detail applies at the following locations:
7

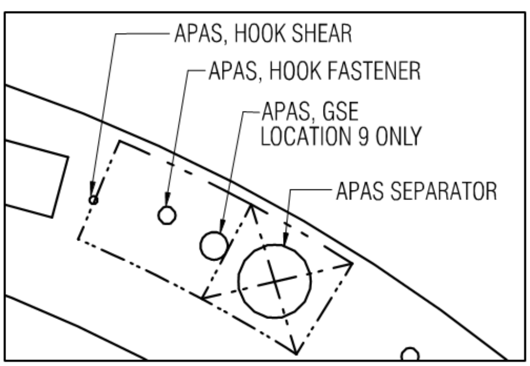
Detail applies at the following 1, 6,
location: 8

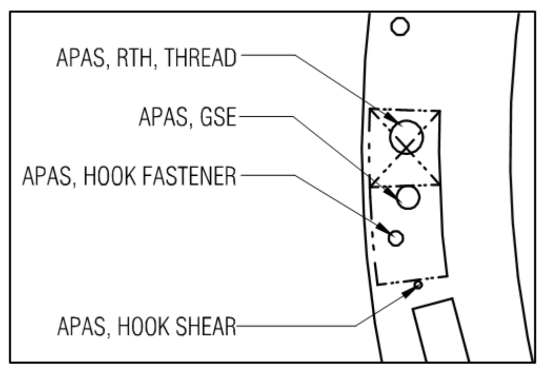




Detail applies at the following location:
5

Detail Applies at the following location:
2

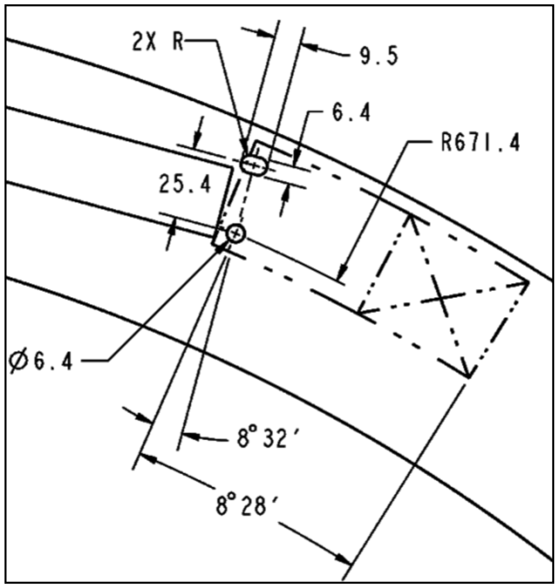




Detail applies at the following locations:

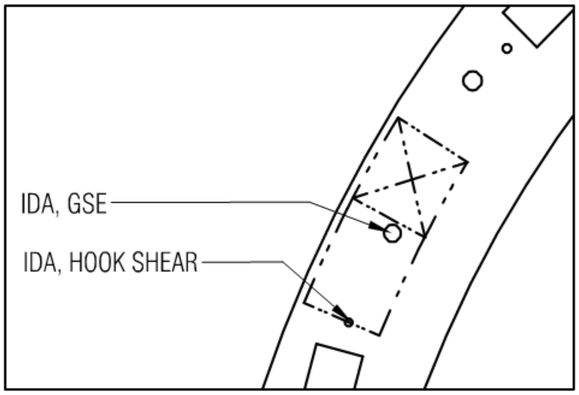
Detail applies at the following 4, 9
location: 3

FIGURE D.1.1-2 APAS FEATURES WITHIN STRIKER ZONES

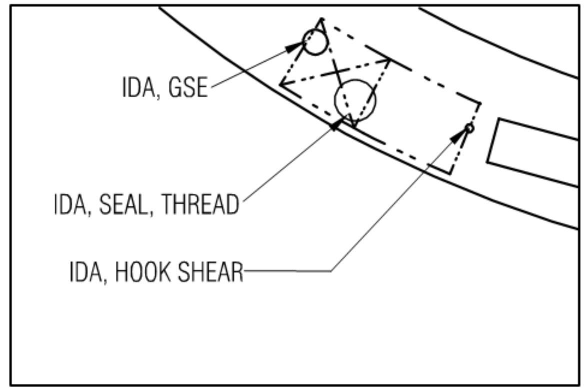


Detail applies at all locations.

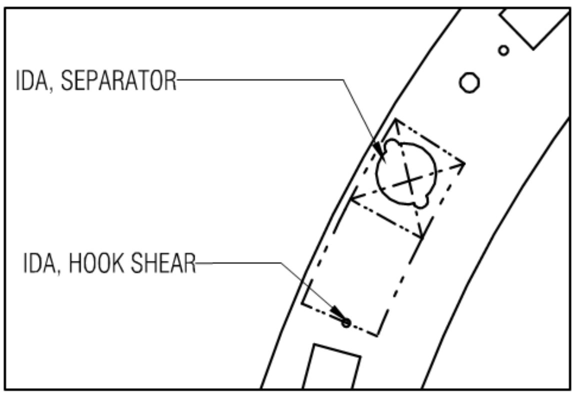
FIGURE D.1.1-3 NDS FEATURES WITHIN STRIKER ZONES



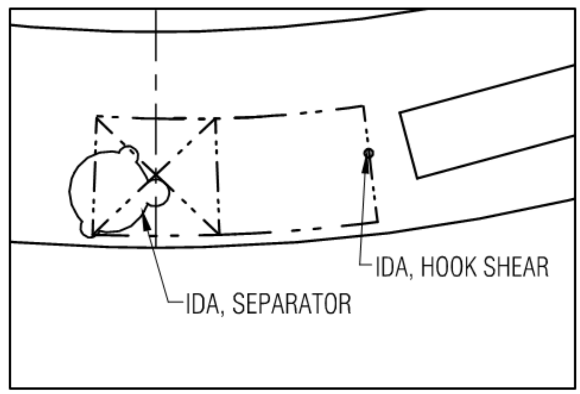
Detail applies at the following locations:



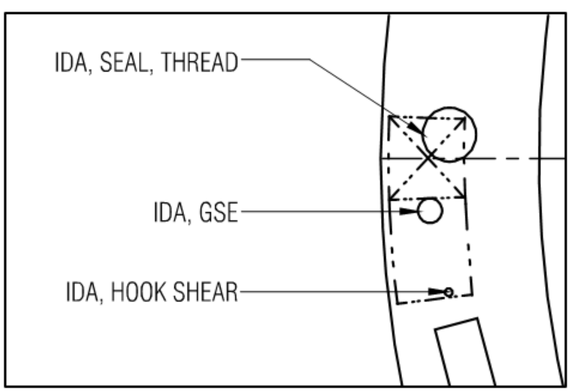
Detail applies at the following 1, 6
location: 4



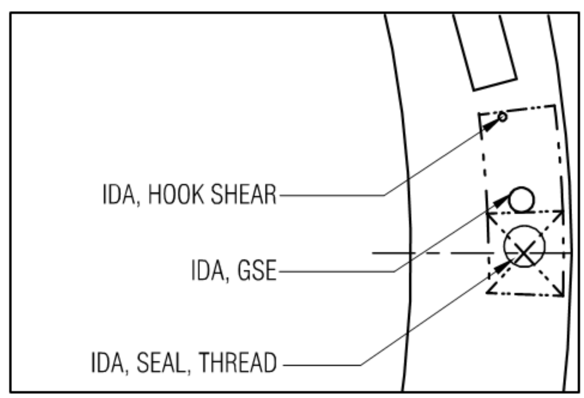
Detail applies at the following locations:
8*



Detail applies at the following 2,
location: 5*



Detail applies at the following location:



Detail applies at the following 3
locations: 7, 9

* For separator location and cutout details, see Figures D.1.1-5 and D.1.1-6

FIGURE D.1.1-4 IDA FEATURES WITHIN STRIKER ZONES

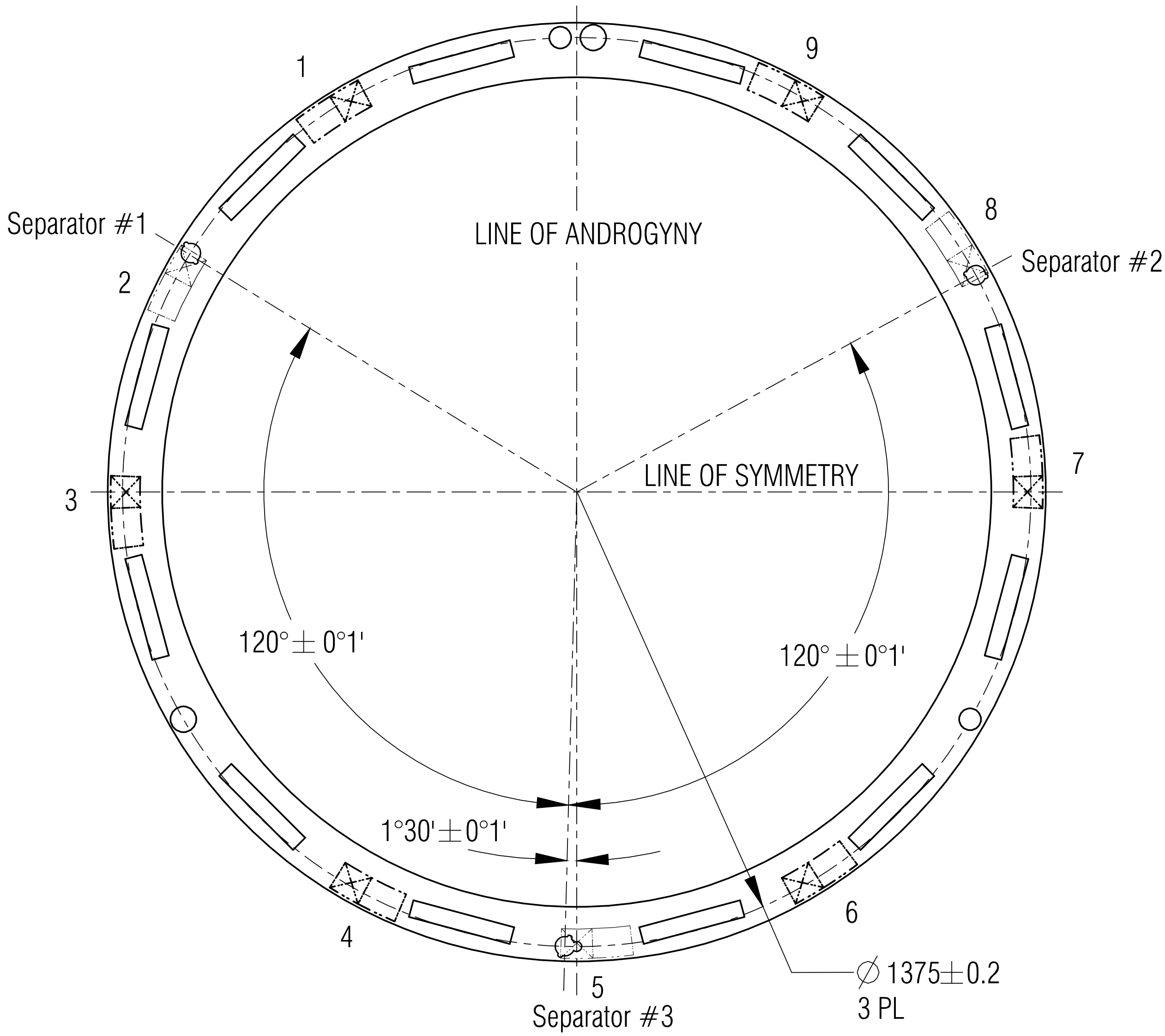
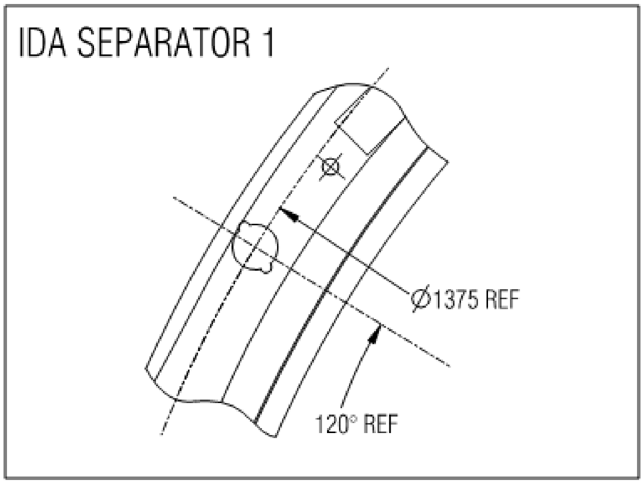
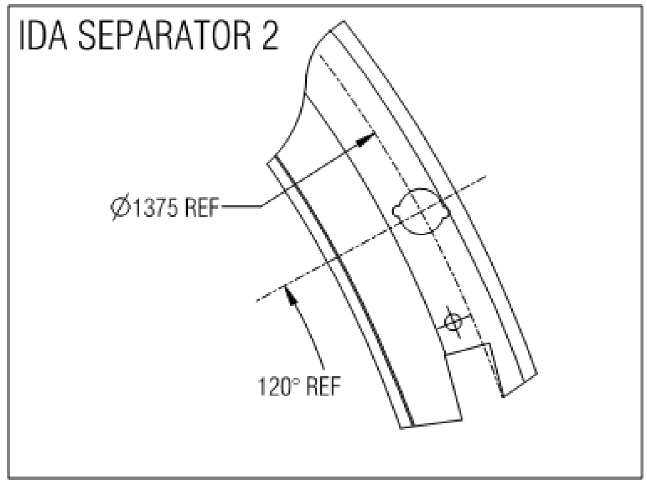


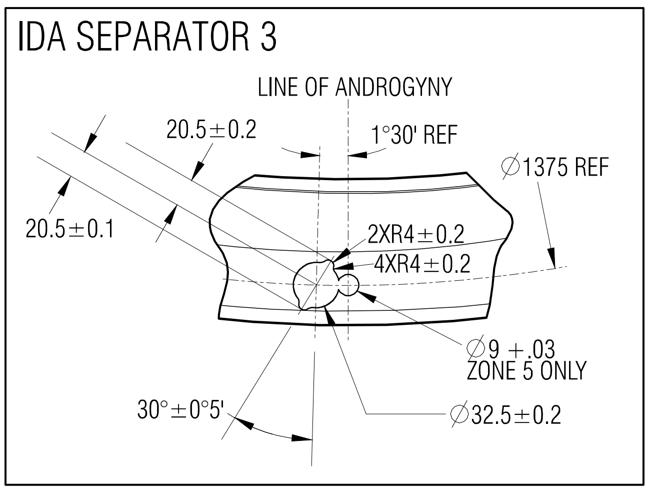
FIGURE D.1.1-5 RADIAL AND ANGULAR LOCATIONS OF IDA SEPARATOR INSTALLATIONS WITHIN STRIKER ZONES



Detail Applies at the following locations: 2



Detail Applies at the following locations: 8



Detail Applies at the following locations: 5

Note: Separator cutout details apply at zones 2, 5, and 8 except as noted

FIGURE D.1.1-6 IDA SEPARATOR INSTALLATION CUTOUT DETAILS