
# VACUUM PUMP SYSTEM TO SCIENCE INSTRUMENT ICD VPS_SI_01

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AFRC
Armstrong Flight Research Center
Edwards, CA 93523

ARC
Ames Research Center
Moffett Field, CA 94035

German Space Agency, DLR
Deutsches Zentrum für Luft und Raumfahrt

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**AUTHOR:**

AFRC / James Milak, Flight Systems Engineer, SOFIA — Date: 5/19/2014

ARC / Chris Koehler, Mission Operations Engineer, SOFIA — Date: 5-20-2014

**CONCURRENCE:**

DLR / Michael Hustwhol, Telescope Assembly Lead, SOFIA — Date: 5-27-2014

AFRC / Michael Tobermann, Operation Director, SOFIA — Date: 5/19/14

ARC / Lisa Bjarke, Observatory Systems Director — Date: 5/19/14

ARC / Erick Young, Science Mission Operations Director — Date: 5/19/14

AFRC / Jeanette Le, SOFIA Chief Engineer — Date: 5/28/2014

APPROVAL:

AFRC / Eddie Zavala, Program Manager, SOFIA — Date: 9 May 2014

DLR / Alois Himmes, DLR Program Manager, SOFIA — Date: 15 Aug 2014

# Revision History

| REV | DATE | DESCRIPTION | APPROVAL |
|---|---|---|---|
| - | 5/19/2014 | Initial Baseline release per PRG-CCR-164 | PMB |
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# VACUUM PUMP SYSTEM TO SCIENCE INSTRUMENT ICD – VPS_SI_01

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## 1. SCOPE

The scope of this document is the interfaces between the Science Instrument (SI) and the SOFIA Aircraft Vacuum Pump System (VPS). Because USRA / Mission Operations will provide the vacuum lines from the VPS connections located next to the Telescope Assembly (TA) Counterweight Plate to the SI, three separate physical interfaces are defined:

(1) VPS to USRA-provided vacuum lines
(2) USRA-provided vacuum lines to SI (for pumping on the SI cryogen bath)
(3) USRA-provided vacuum lines routed within the Instrument Flange (INF) tub (for pumping on an SI-provided structure contained within the tub, such as a pressure coupler)

## 2. PURPOSE

The purpose of this Interface Control Document (ICD) is to describe and define the interfaces between the VPS connections on the Telescope Assembly (TA) and the SI and the INF tub. This includes information on VPS performance and usage needed by the SI teams.

## 3. REFERENCE DOCUMENTS

The following documents are related items and are not all referenced within the document. The latest revisions of the following documents form a part of this requirement to the extent specified herein.

| | |
|---|---|
| SOF-AR-ICD-SE03-2015 | ICD SI_AS_01, PI EQUIPMENT TO PI RACK TO AIRCRAFT INTERFACE |
| SOF-AR-ICD-SE03-2029 | ICD MCCS_SI_05, PRINCIPAL INVESTIGATOR PATCH PANEL TO PRINCIPAL INVESTIGATOR EQUIPMENT RACK(S) |
| SOF-DA-ICD-SE03-052 | ICD MCCS_SI_04, MCCS/SI FUNCTIONAL INTERFACE-COMMAND PROTOCOL |
| SOF-DF-ICD-SE03-018 | ICD TA_AS_11, TELESCOPE ASSY/AIRCRAFT SYSTEM EXHAUST TUBE AND VACUUM LINES INTERFACE |
| SOF-DA-ICD-SE03-036 | ICD TA_SI_01, CABLE LOAD ALLEVIATOR DEVICE/SCIENCE INSTRUMENT CABLE INTERFACE |
| SOF-DA-ICD-SE03-037 | ICD TA_SI_02, SCIENCE INSTRUMENT MOUNTING FLANGE INTERFACE |
| APP-DA-SPE-SE01-2049 | VACUUM PUMP SYSTEM SPECIFICATION |
| SOF-DWG-MG-4300.0.00 R05 | Balancing Subassembly |

# 4. ACRONYMS

| | |
|---|---|
| bar | A Unit of Pressure, One bar roughly equals to One Atmosphere |
| CLA | Cable Load Alleviator |
| CWP | Counterweight Plate |
| GSE | Ground Support Equipment |
| ICD | Interface control document |
| ID | Inner Diameter |
| INF | Instrument Flange |
| KF | Klein Flange |
| NPT | National Pipe Thread |
| OD | Outer Diameter |
| PTFE | Polytetrafluoroethylene |
| PI | Principle Investigator |
| SI | Science Instrument |
| SSMO | SOFIA Science and Mission Operations |
| TA | Telescope Assembly |
| USRA | Universities Space Research Association |
| VPS | Vacuum Pump System |

# 5. SI TO VPS INTERFACE REQUIREMENTS

## 5.1. Physical Layout

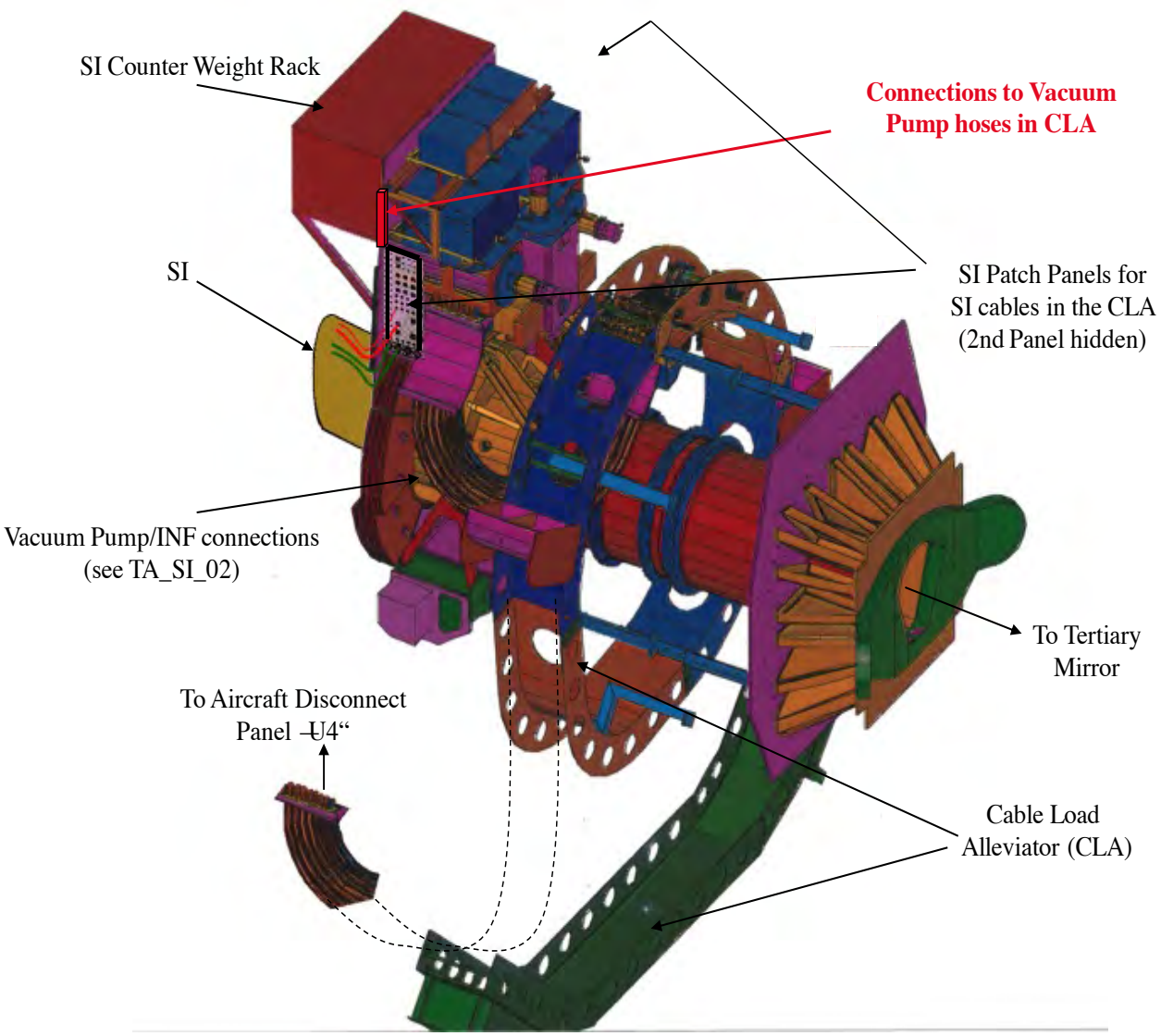



**Figure 1. Side-view of SI mounting location on TA**

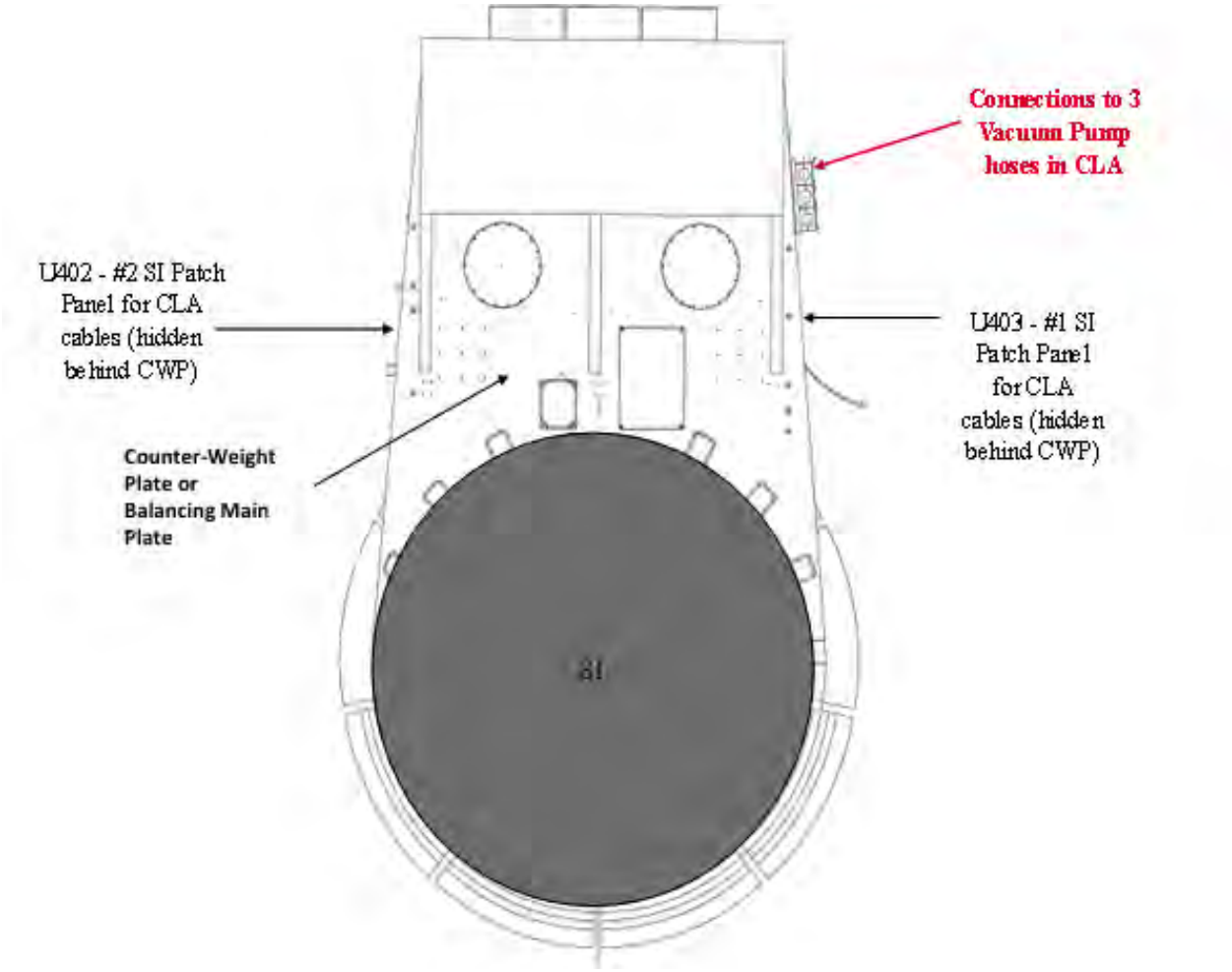



**Figure 2. Front-view of SI mounting location on the TA**

The U,V,W coordinates of vacuum I/F (defined here in the TA coordinate system) are:

| | | |
|---|---|---|
| **U** | 86.42 inches | 2195 mm |
| **V** | 27.56 inches | 700 mm |
| **W** | 59.06 inches | 1500 mm |

Note that the center of the TA Instrument Mounting Flange (IMF) is located at U,V,W = 89.96,0,3.31 inches (2285,0,84 mm).

Ref: SOF-DWG-MG-4300.0.00 R05 "Balancing Subassembly"
Ref: Figure 4-1 ENLARGED – Appendix "SOF-DA-ICD-SE03-037 (TA_SI_02)

## 5.2. Pump Lines

- 3 Flexible lines, 1.25”ID, 1.63”OD, approximately 11.5 meters in length (see TA_AS_11_FL, Appendix B) run from the CLA disconnect panel, through the CLA, to the Counterweight Plate (CWP) of the TA. (See figures 1 and 2). See TA_SI_01 Annex 1 (pages 55-62) for the line specification. Of these 3 flexible lines, only 2 are connected to the VPS manifold and pumps, with the 3rd being designated as an in-place spare.
- There is additional 3m between the CLA disconnect panel and the VPS shutoff valves on the VPS manifold.
- The vacuum interface at the CWP is a KF40 flange on a rigid KF tee. The smaller KF16 flange perpendiculars to those KF40 flanges are used for electronic pressure transducers that are provided by the VPS (pressure transducers are not shown in Figure 3).

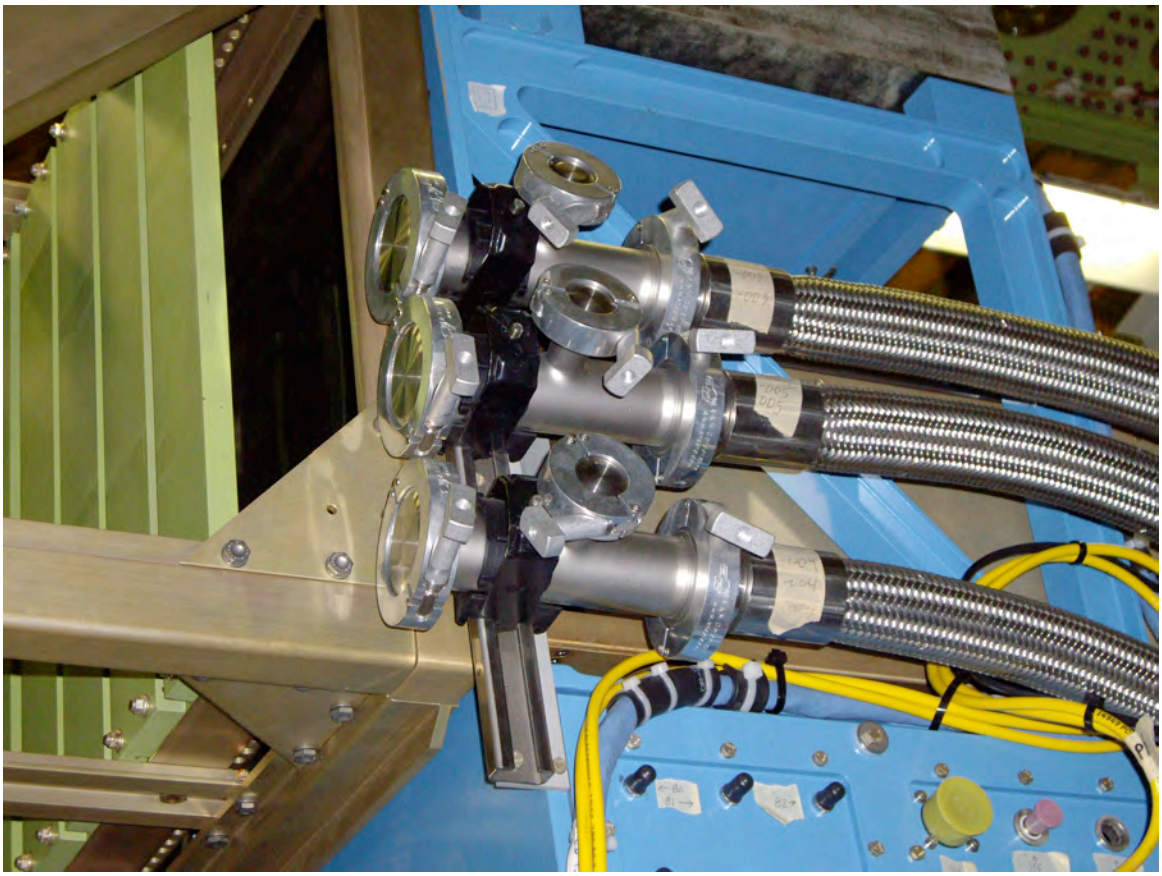


**Figure 3. Vacuum Interface at Counterweight Plate**

- Vacuum lines from the CWP to the SI will be provided by USRA and will be in a variety of lengths and diameters, terminated at both ends with KF flanges. USRA will provide clamping hardware (see Appendix A). The vacuum lines will be stainless steel bellows, rigid stainless tubing, braided stainless steel jacketed PTFE, or similar material suitable for use on aircraft. The lines will be restrained by a NASA-approved method at each end and every 6 feet.
- Vacuum lines from the CWP to the INF tub are within the scope of the VPS and will be provided and installed as part of the VPS, but otherwise match those provided by USRA for the lines between the CWP and the SI.

### 5.3. Backfill Capability

- VPS provides a He backfill capability that may be used during ground operations with the appropriate Ground Support Equipment (GSE). Figure 4 shows the bleed / backfill valves (the arrows point to black dust covers to protect the ¼ inch hose barb connections and to keep the debris / dust out).
- Figure 4 also shows 2 protective yellow covers which are installed during pre-flight operations to ensure that the valves are correctly configured in the closed position during nominal operations, and which are removed when a backfill operation is executed.

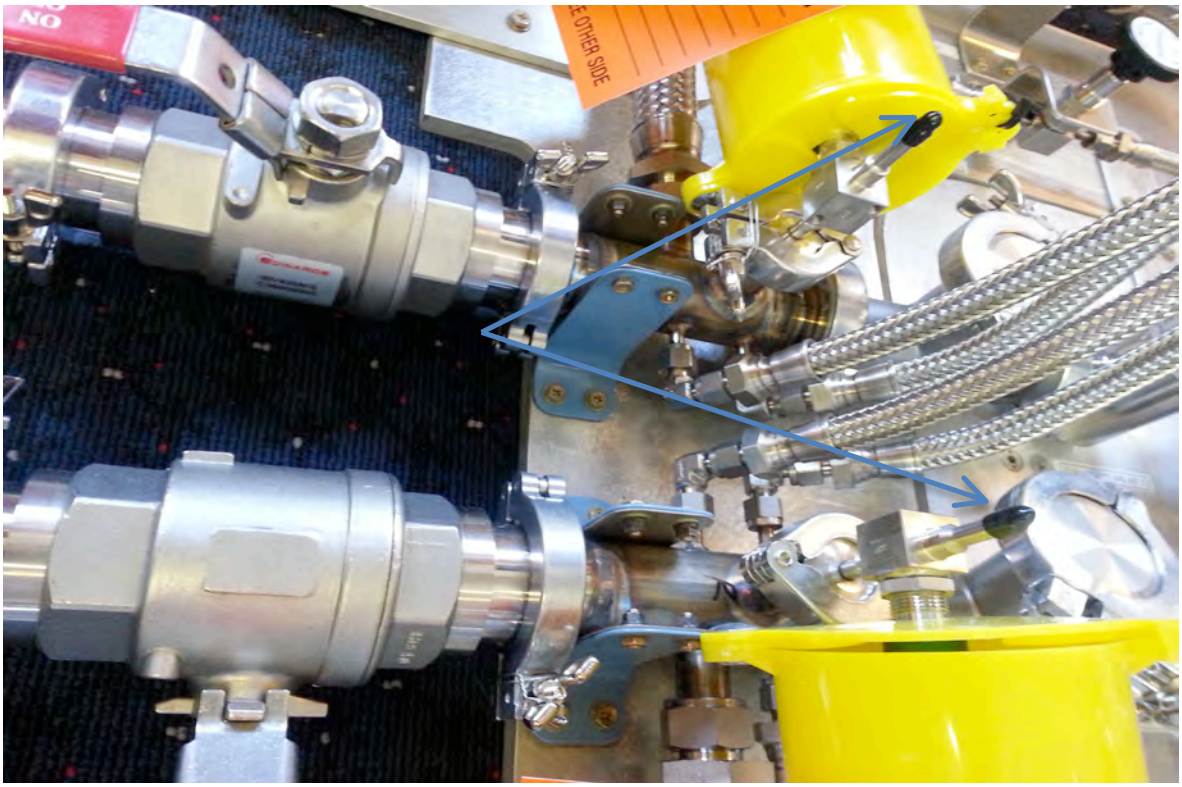



**Figure 4: VPS Bleed / Backfill Valves**

- SIs may use the VPS-provided bleed / backfill valves in order to backfill the vacuum lines (i.e., to bring an LHe cryogen reservoir back to ambient pressure using a He supply bottle, to ensure that no air or humidity is permitted to enter, condense or freeze, or to introduce dry nitrogen into the INF "tub", e.g., to protect hygroscopic SI entrance window).
- However, SIs may opt to perform bleed and/or backfill operations using alternate SI-specific means. For example, the FIFI-LS team has adopted a different approach for slowly backfilling their LHe reservoir(s) w/ He gas, which does not involve filling the entire VPS vacuum line with He. Figure 5 shows a GSE He supply bottle connected directly to the FIFI-LS vacuum manifold.

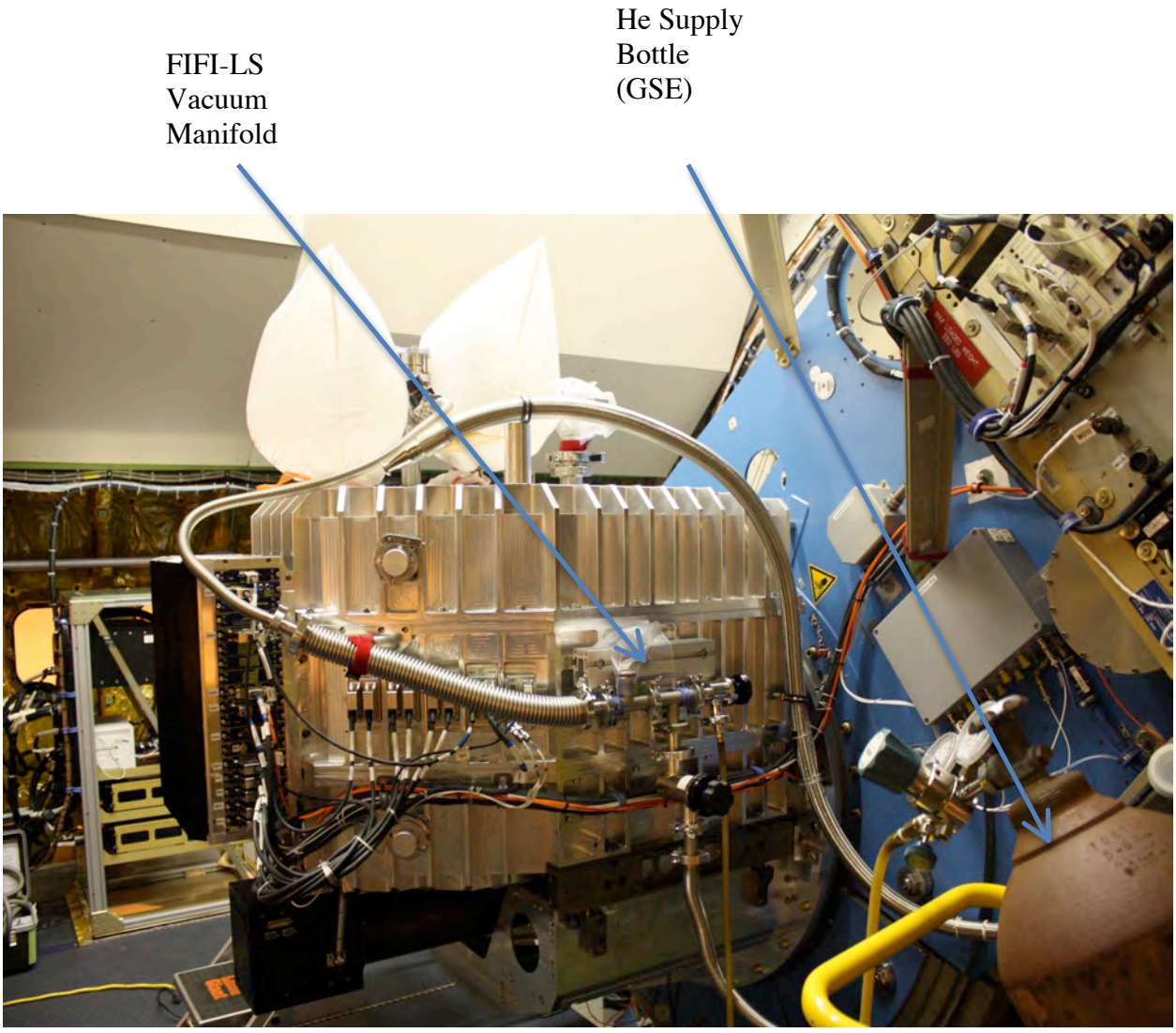



**Figure 5: FIFI-LS backfill manifold**

### 5.4. Connectors

- NW40 KF flanges, hinged clamps, and centering rings for fixation will be used at the CWP.
- SIs shall use KF40 flanges to connect USRA-supplied vacuum lines to the VPS interface described above.
- Connection between the VPS-supplied vacuum lines and the INF will be through one of two KF25 flanges that currently exist on the side of the INF (see TA_SI_02 section 4.5).
- If an SI is utilizing the INF vacuum connection as a feed-through to an SI-provided structure contained in the INF (e.g., a pressure coupler), then the SI shall connect to a SSMO / USRA- provided KF25 adapter to ¾" NPT fitting.
- If an SI is utilizing the VPS bleed / backfill connection(s) to introduce helium or nitrogen to the evacuated system via the VPS vacuum lines, then the SI GSE shall connect to the VPS Bleed / Backfill valves depicted in Figure 4 using ¼ inch hose barb fittings.
- The USRA-supplied KF flange clamps will be able to be pinned in the closed/clamped position.

### 5.5. Performance

- The Vacuum Pump System will have connections for two vacuum pumps.
- Each pump (Edwards XDS35i Scroll Pump) provides a maximum displacement of 44 $m^3$/hr with a maximum pumping speed of 35 $m^3$/hr at 5mbar .
- Refer to APP-DA-SPE-SE01-2049, VPS Specification, for further information re: required VPS performance.

### 5.6. Controllability

- The vacuum pumps will be controlled by on/off switches on a control panel near the pumps, and the valves that are connected to the vacuum lines. The on/off switches and valves will be accessible from the cabin area of the aircraft and will be accessible in flight without requiring personnel to cross any safety barriers.
- The system pumping speed will be controllable over the range from 0 to 550 L/min.
- The vacuum line pressures will be measured via VPS provided transducers and displayed both locally and through MCCS housekeeping data.

# APPENDIX A. VACUUM PUMP HARDWARE

Figure 6 along with Tables 1, 2 and 3 list some of the vacuum pump hardware that will be used.

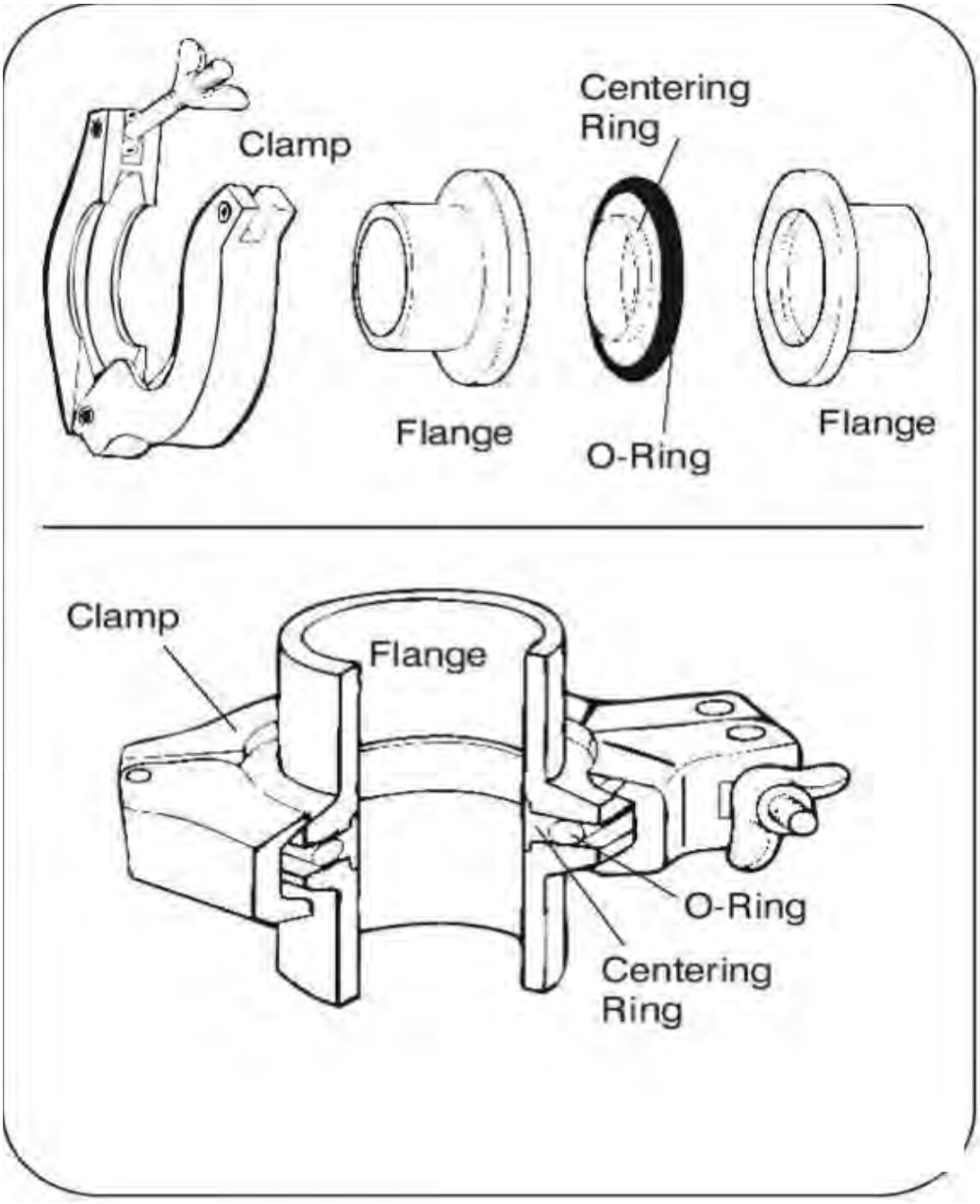
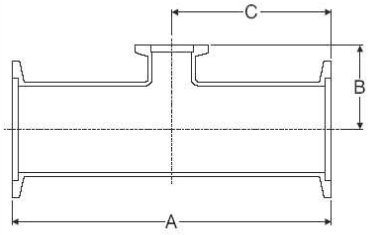



**Figure 6. Component Assembly**

**Table 1. ISO-KF Tee, Reducing**

ISO-KF Tee, Reducing — in/(mm)

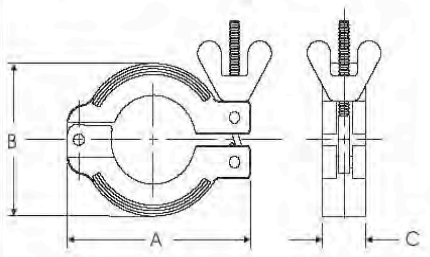



- Stainless Steel type 304
- Same size flanges thru ports

| Flange Size (ISO) | Flange Size (ISO) Tee | A | B | C | Part Number | Price |
|---|---|---|---|---|---|---|
| NW 25 | NW 16 | 3.94 (100) | 1.08 (27) | 1.97 (50) | 100318403 | |
| NW 40 | NW 16 | 5.12 (130) | 1.32 (34) | 2.56 (65) | 100318405 | ← |
| NW 50 | NW 16 | 5.51 (140) | 1.58 (40) | 2.76 (70) | 100318406 | |
| NW 40 | NW 25 | 4.80 (122) | 2.40 (61) | 2.40 (61) | 100319816 | |
| NW 50 | NW 25 | 6.29 (160) | 2.65 (67) | 3.15 (80) | 100319815 | |
| NW 50 | NW 40 | 6.29 (160) | 2.65 (67) | 3.15 (80) | 100319814 | |

**Table 2. Clamps, Wing Nut**

Clamps, Wing Nut — in/(mm)




- Aluminum

| Flange Size (ISO) | Fits Sizes | A | B | C | Part Number | Price |
|---|---|---|---|---|---|---|
| NW 16 | 16/10 | 2.24 (57) | 1.69 (43) | 0.63 (16) | 100312901 | ← |
| NW 25 | 25/20 | 2.76 (70) | 2.17 (55) | 0.63 (16) | 100312903 | |
| NW 40 | 40/32 | 3.39 (86) | 2.76 (70) | 0.63 (16) | 100312905 | ← |
| NW 50 | 50 | 4.33 (110) | 3.70 (94) | 0.79 (20) | 100312906 | |

**Table 3. Seal, Centering Ring Assembly, Stainless Steel/Viton**

| Seal, Centering Ring Assembly, Stainless Steel/Viton® | | | | | | | in/(mm) |
|---|---|---|---|---|---|---|---|
|  | Flange Size (ISO) | | | | | Part Number | Price |
| | NW 10 | | | | | 100312700 | |
| | NW 16 | | | | | 100312701 | ⬅ |
| | NW 25 | | | | | 100312703 | |
| | NW 40 | | | | | 100312705 | ⬅ |
| | NW 50 | | | | | 100312706 | |
| • 180°C Max. | NW 80 | | | | | 100760508 | |
| • Replaceable O-Ring | NW 100 | | | | | 100760510 | |
| • NW 80/100 include aluminum spacer ring | | | | | | | |