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| Traveler Title | L2HE Cavity String Assembly | | | |
| Traveler Abstract | This traveler provides instructions for L2HE Cavity String Assembly with Cleanroom Purge System | | | |
| Traveler ID | L2HE-CLNRM-CST-ASSY | | | |
| Traveler Revision | R5 | | | |
| Traveler Author | Tiffany Ganey | | | |
| Traveler Date | 27-Apr-23 | | | |
| NCR Informative Emails | dreyfuss,ganey | | | |
| NCR Dispositioners | forehand,cheng,kdavis,huque,adamg | | | |
| D3 Emails | forehand,dreyfuss,kdavis,ganey,cheng,powen,adamg | | | |
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| Approval Signatures |  |  |  |  |
| Approval Dates |  |  |  |  |
| Approval Title | Author | Work Center Lead | Group Lead | Project Manager |

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| References | List and Hyperlink all documents related to this traveler. This includes, but is not limited to: safety (THAs, SOPs, etc), drawings, procedures, and facility related documents. | | | |
| [F10023864 - Production Cavity Assembly Drawing](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-240000/Cavity%20Drawing%20Package%20F10023864_rev_M_drawing_package.pdf) | [F10127865 - LCLS-II HE Cavity String Assembly Drawing](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-252642/F10127865_D_DWG1.pdf) | [F10040886 - LCLS-II CM Faraday Window Manifold](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-248684/F10040886_C_DWG1.pdf) | [F10092047 - Faraday Window Cover](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-252116/F10092047--_1-FARADAY%20WINDOW%20COVER.stl) |  |
| [L2HE-PR-CLNRM-GV1SA-ASSY](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-256310/L2HE-PR-CLNRM-GV1SA-ASSY-R3.pdf)  [Upstream Gate Valve Sub-Assembly and Installation](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-256310/L2HE-PR-CLNRM-GV1SA-ASSY-R3.pdf) | [L2HE-PR-CLNRM-GV2SA-ASSY](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-256309/L2HE-PR-CLNRM-GV2SA-ASSY-R2.pdf)  [Downstream Gate Valve / BPM Sub-Assembly and Installation](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-256309/L2HE-PR-CLNRM-GV2SA-ASSY-R2.pdf) | [L2HE-PR-CLNRM-NEG-PREP](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-251396/L2HE-PR-CLNRM-NEG-PREP-R1.pdf)  [Downstream Pump Assembly and NEG Pump Initial Activation](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-251396/L2HE-PR-CLNRM-NEG-PREP-R1.pdf) | [L2HE ROD Cavity Vac for String Build](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-276132/L2HE%20ROD%20Cavity%20Vac%20for%20String%20Build.pdf) |  |
| [SRF-MSPR-CLNRM-TOOL-SPCLMP](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-251184/SRF-MSPR-CLNRM-TOOL-SPCLMP-R1.pdf)  [Nitrile Glove Covering of Spring Clamp](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-251184/SRF-MSPR-CLNRM-TOOL-SPCLMP-R1.pdf) | [SRF-MSPR-CLNRM-LEAK](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-251183/SRF-MSPR-CLNRM-LEAK-R1.pdf)  [Leak testing with an RGA Procedure](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-251183/SRF-MSPR-CLNRM-LEAK-R1.pdf) | [SRF-MSPR-CLNRM-CST-ION](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-270677/SRF-MSPR-CLNRM-CST-ION-R3.pdf)  [Ionized Nitrogen Cleaning Procedure](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-270677/SRF-MSPR-CLNRM-CST-ION-R3.pdf) | [SRF-MSPR-CLNRM-PUMP](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-251963/SRF-MSPR-CLNRM-PUMP-R1.pdf)  [Clean Room Production Pump System Operation](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-251963/SRF-MSPR-CLNRM-PUMP-R1.pdf) |  |

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| Revision Note |  |
| R1 | Initial release of this Traveler. |
| R2 | Major revision to incorporate lessons learned and process improvements from the first cavity string assembly. |
| R3 | Added instructions to verify titanium bellows covers are installed properly; updated definition of Spec 1 to match latest revision of the N2 cleaning procedure. |
| R4 | Updated approvers, NCR, and D3 names to match Work Control Document Register.  Added reference to L2HE-PR-CLNRM-NEG-PREP and updated reference hyperlinks to latest revisions as needed.  Updated bolt hole cleaning process for all flanges with fastener removal, including FPC, GV1SA bellows blank, GV2SA bellows blank, all cavities upstream flange, and all cavities downstream flange.  Revised instructions to verify titanium bellows covers are installed.  Modified list of required cavity string tooling to specify both the Cavity leveling bridge tool and the Magnet flange level tool for the BPM.  Modified purge system configuration for the assembly of GV2SA to the cavity string. Modified when and how the slow pump cart is connected to the cavity string.  Indicated that the -calibrated- leak for the string leak check is Critical MTE Standard Helium Leak Rate and added data fields to track the SN and Calibration Due Date. |
| R5 | Added L2HE ROD Cavity Vac for String Build Record of Decision |

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| Definitions:   |  |  | | --- | --- | | **Ionized Nitrogen (N2) Parts Cleaning Specifications** | | | Spec 1 | Particle counts are to be zero on all scales except 0.3 um, which can be zero or 1 in ten seconds. | | Spec 2 | Particle counts are to be one count per second or less on the 1 um scale. This is equivalent to particle counts </= 10 counts per 10 second cycle on the 1 um scale. | | **Purge System Components** | | | Upstream Purge Line | Connected to the cavity string upstream valve on the Faraday Window Manifold. | | Downstream Purge Line | Moves to each cavity and the GV2SA during assembly to the cavity string. This Line is connected to a pump cart with a turbo only at minimum; a slow pump cart may be used. | | Spool | An elbow with welded VCR fitting or tee with CF flanges that connects to the purge system (vacuum and gas) to the Cavity String Right Angle Valve. | | **Purge Software** | | | Standby | Closes the pneumatic valve and MFC (under the floor), and does not allow gas to flow | | Blowout | Opens the pneumatic valve and opens the MFC fully to allow for gas flow at approximately 7 L/min | | Backfill | Opens the pneumatic valve and opens the MFC to allow for gas flow at approximately 300 SCCM | | Purge | Opens the pneumatic valve and opens MFC to allow for gas flow at approximately 1000 SCCM | | Interlock | 50 mbar above atmosphere (baratron reading = 50 mbar) | | | | |
| **Step No.** | **Instructions** | | **Data Input** |
| 1. | **Prepare for String Assembly**  1. Select the serial number of the cavity string to be assembled. | | [[CMSN]] <<CMSN>> |
| 2. Eight cavities have been qualified in the VTA and are deemed ready for cavity string assembly. The cavities shall be under vacuum with test hardware still installed.   * Verify titanium covers are installed to protect the helium vessel bellows. * Check HOM connectors for electrical shorts. * Verify that all cavities have been cleaned by Chemistry, including removal of all tape residue and wipe down of external surfaces. Pay particular attention to flange areas. * Inspect the cavity for dents and damage. Do not remove the bellows covers after the cavity has been cleaned by Chemistry. | | [[CavitiesPrepped]] <<YESNO>>  [[CavityPrepComment]] <<COMMENT>> |
| 3. Sub-Assemblies are ready:   * An upstream gate valve sub-assembly [GV1SA] is assembled, leak checked, backfilled to atmospheric pressure, and ready for installation on the rail in accordance with L2HE-PR-CLNRM-GV1SA-ASSY. * A BPM magnet sub-assembly [GV2SA] is assembled, leak checked, under vacuum, and staged on the mini-rail in accordance with L2HE-PR-CLNRM-GV2SA-ASSY. | |  |
| 4. Cavity string components of F10127865 have been cleaned and are verified to be ready as needed for completion of the string.   * 8 couplers * All cavity string fasteners and gaskets * 7 inter-cavity bellows | |  |
| 5. Cavity string tooling has been cleaned and setup in the production cleanroom ready for cavity string assembly.   * Cavity leveling bridge tool * Magnet flange level tool for the BPM * Dial indicator tooling for cavity positioning * Coupler holder and adjustable table * Bellows, restraints, holder and adjustable table * Upstream purge holder and adjustable table, if available * Alignment blanks | |  |
| 6. Purge system hardware is cleaned and ready for use as needed.   * 1-1/3 CF fasteners and gasket for GV1SA. * 2-3/4 CF fasteners and gaskets for Cavity and GV2SA. Use large-bore gaskets for all purge system spool assemblies, when available. | |  |
| 7. Purge system is ready for cavity string assembly.   * Verify the purge system is connected to the cleanroom N2 supply. * On the computer/TV, open and run the purge system software. * Ensure 'Crio time' is updating. This indicates an active connection to the cRio controller. * To verify the purge system is running properly, the following steps can be taken:   + On one of the N2 lines, set the flow to 'Blowout'.   + Open the corresponding valves on the purge table. Nitrogen should be flowing out of the opening.   + Partially blocking the opening with a fingertip should cause a rise in baratron pressure. Fully closing the opening should cause the flow to shut off at 300 mbar. * Ensure two turbo pumps are available to follow the cavity assembly along the rail, with connection to a roughing pump outside the cleanroom. | | [[PurgeSystemReady]] <<YESNO>>  [[PurgeSystemComment]] <<COMMENT>> |
| 8. Magnetic hygiene has been completed on components. | | [[MagneticHygieneComplete]] <<YESNO>> |
| 9. Record the date the string prep is complete. | | [[StringPrepComment]] <<COMMENT>>  [[StringPrepCompleteTime]] <<TIMESTAMP>>  [[StringPrepVerificationTech]] <<SRFCVP>> |

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| Step No. | Instructions | Data Input |
| 2. | **Upstream Gate Valve Sub-Assembly [GV1SA] Prep**  1. Record upstream gate valve serial number. | [[AMGVSN1]] <<AMGVSN>> |
| 2. Record upstream bellows serial number. | [[BLBUSN]] <<BLBUSN>> |
| 3. Record Faraday Window Manifold serial number [FWMSN] and Faraday Port Window Serial Number [FPWSN] | [[FWMSN]] <<FWMSN>>  [[FPWSN]] <<FPWSN>> |
| 4. Transfer GV1SA on to the lollipop system.   * Verify that the gate valve handle is facing the power coupler direction and the gate valve flange marked with a triangle is installed on the string side. |  |
| 5. Blow down GV1SA with ionized N2 to Spec 1 in accordance with the Ionized Nitrogen Cleaning Procedure. Verify the Faraday Window Manifold mini valve is closed. |
| 6. Prepare the Upstream Purge Line Spool for assembly to the Faraday Window Manifold right angle valve.   * Set the purge software to "Standby" and verify the baratron is reading approximately 0. * Remove the blank, gasket, and all fasteners from the Spool. * Wipe bolt holes and flange sealing surface with IPA.   **Note**: One technician shall hold the Spool and point opening away from the string, people, and any other critical components such as a cavity bays and prepared / cleaned parts. Angle the opening towards the floor until the Spool is ready to be installed onto the right angle valve. A second technician shall perform the purge system set up and particle counts.   * Set the purge software to "Blowout". * Verify the purge turns on. * Flow N2 through the Spool until Spec 1 is reached for two full cycles. * Set the purge software to "Purge". |
| 7. Install the Upstream Purge Line to the Faraday Window Manifold right angle valve.   * Blow down the Faraday Window Manifold right angle valve, including the flange, bolt holes, and inside the valve up to the valve stem. * Place a new cleaned [Spec 1] gasket on the Upstream Purge Line Spool. * Install two pre-cleaned [Spec 1] studs in a star pattern and snug with a wrench. * Install the four remaining studs continuing the star pattern. * Torque all studs to 53 in-lbs using a standard torque pattern for a round flange. * Repeat the final torque sequence twice and then go around all the studs at least twice or until there is no movement of the nuts. * If the purge system does not shut off, increase torque wrench up to 84 in-lbs or until the flanges go metal-to-metal. * Verify the purge turns off. |
| 8. Slowly open the Faraday Window Manifold right angle valve. The GV1SA is now connected to the purge system.   * Leave the software set to "Purge" for the Upstream Purge Line. | [[GV1SAPrepComment]] <<COMMENT>>  [[GV1SAPrepTime]] <<TIMESTAMP>>  [[GV1SAPrepTech1]] <<SRFCVP>> |

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| Step No. | Instructions | Data Input |
| 3. | **Cavity 1 Prep**  1. Record Cavity 1 serial number. | [[CAVSN1]] <<CAVSN>> |
| 2. Put the cavity on the rail tooling with the blank flange facing the upstream gate valve sub-assembly [GV1SA] and the FPC facing the southeast corner of the cleanroom. |  |
| **Note: There will be some movement of flange location and/or cavity level every time something is adjusted. Several iterations of the cavity alignment will be required before the cavity will be perfectly level and have both beamline flanges in place.**  **Note**: **The upstream flange of Cavity 1 will dictate the location on all the cavities in the string.**  3. Align the cavity and GV1SA. The cavity shall be aligned with the flange alignment tool to locate the beamline flange in the proper location.   * Verify the location of the flange is near the center of the range of the tooling to accommodate the alignment of all the cavities in the string. * After both flanges of the cavity are in the same position - relative to the rail - set the roll of the cavity level using a precision level on the leveling tool, which is attached to the other set of helium vessel blocks. * Place the upstream bellows flange, which is part of the upstream gate valve sub-assembly [GV1SA], at the same height and location from the rail as that of the cavity flanges. * Level the valve body using the precision level (within 0.25 degrees from level before assembly). Lock the valve lollipop in place with rail locks. |
| 4. Set the roll of the cavity rotationally using the rotational alignment bridge and the "A" frame. Verify all four frame studs and "A" frame studs are tight when finished. |
| 5. Blow down the cavity with ionized N2 in accordance with the Ionized Nitrogen Cleaning Procedure.   * General cavity to Spec 2. * Cavity flange, bolt holes, and inside the right angle valve up to the valve stem to Spec 1. |
| 6. Prepare the Downstream Purge Line Spool for assembly to the cavity right angle valve.   * Set the purge software to "Standby" and verify the baratron is reading approximately 0. * Remove the blank, gasket, and all fasteners from the Spool. * Wipe bolt holes and flange sealing surface with IPA.   **Note**: One technician shall hold the Spool and point opening away from the string, people, and any other critical components such as a cavity bays and prepared / cleaned parts. Angle the opening towards the floor until the Spool is ready to be installed onto the right angle valve. A second technician shall perform the purge system set up and particle counts.   * Set the purge software to "Blowout". * Verify the purge turns on. * Flow N2 through the Spool until Spec 1 is reached for two full cycles. * Set the purge software to "Purge". |
| 7. Install the Downstream Purge Line to the cavity right angle valve.   * Place a new cleaned [Spec 1] gasket on the Spool. Use a large-bore gasket if available. * Install two pre-cleaned [Spec1] studs in a star pattern and snug with wrench. * Install the four remaining studs continuing the star pattern. * Torque all studs using a standard torque pattern for a round flange. * Repeat the final torque sequence twice and then go around all the studs at least twice or until there is no movement of the nuts. Stop if the flanges go metal-to-metal. * Verify the purge turns off. |
| 8. Pump down the purge line to the cavity right angle valve.   * Set the purge software to "Standby" for the Downstream Purge Line. * Pump down the purge header to the closed right angle valve on the cavity. Allow the header to pump to the mid E-5 mbar range. * Close the pump isolation valve. |
| 9. While monitoring the cavity pressure, slowly open the cavity right angle valve. If the cavity pressure reads at the mid E-4 mbar range or higher, notify the cleanroom supervisor. | [[CAV1VacuumOK]] <<YESNO>> |
| 10. Set the purge software to "Backfill" and slowly backfill the cavity. |  |
| 11. When the cavity has been backfilled to the interlock value, change the purge software to "Purge". | [[CAV1PrepComment]] <<COMMENT>>  [[CAV1PrepTime]] <<TIMESTAMP>>  [[CAV1PrepTech]] <<SRFCVP>> |
| 4. | **Cavity 1 FPC Installation**  1. Gather the following components for the connection of the cold end coupler to the cavity. Verify the components are cleaned and ready for installation.   * 1 inspected and accepted FPC body * 1 FPC body flange alignment blank * 2 clean spring clamps * Fasteners * 1 hex seal gasket * Retainer clips * Wrenches |  |
| 2. Record the FPC Serial Number. | [[FPCCSN1]] <<FPCCSN>> |
| 3. Use the FPC body holding tool to hold and spray the FPC to Spec 1.  4. When all the N2 spraying is complete, carefully place the alignment tooling over the probe tip and onto the FPC body flange. Clamp in place with two spring clamps. Open the clamps down and away from the cavity.  5. Install the FPC onto the installation tooling and spray to Spec 1. |  |
| 6. Verify the purge software is set to "Purge" for the Downstream Purge Line.  7. Remove the 4 studs indicated in positions 1, 3, 5, and 7 in the drawing below from the cavity FPC flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure. Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    8. Install 2 pre-cleaned [Spec 1] studs in the open holes at positions 1 and 5 on the cavity and torque to 120 in-lbs.  9. Continue to remove all remaining original studs on the cavity flange in a star pattern, until only the two pre-cleaned studs remain installed.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure. Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  10. Hold the cavity FPC flange and the test coupler flange tight so that there is no movement of the flanges while studs are being removed.  Remove the pre-cleaned stud in position 1 on the cavity coupler flange and then remove the pre-cleaned stud in position 5 on the cavity coupler flange. Pull studs away from the cavity.  Carefully and slowly remove test coupler and gasket away from the cavity.  Verify the purge starts.  11. Install FPC alignment blank on cavity flange with spring clamps. Open the clamps down and away from the cavity. |  |
| 12. Install the FPC alignment table on the lollipop.  13. Align FPC to open holes on alignment blank.  14. Move FPC back as far as possible on the FPC table.  15. Remove the FPC coupler cover.  16. Install the FPC gasket with retaining clips to hold the gasket in place on the FPC. Verify the clips are placed in the horizontal position. |
| 17. Remove the alignment blank from the cavity.  18. Move FPC into place, remove the gasket clips, and install 2 pre-cleaned [Spec 1] studs in a star pattern to secure coupler. Snug studs with wrench.  19. Install 2 additional pre-cleaned [Spec 1] studs continuing the star pattern and snug with wrench.  20. Install remaining 4 studs in pairs continuing the star pattern on FPC flange. |
| 21. Torque all fasteners to 60 in-lbs using a standard torque pattern for a round flange.  22. Increase the torque wrench setting to 120 in-lbs and torque all fasteners using a standard torque pattern for a round flange.  23. Repeat the final torque sequence twice and then go around all the fasteners at least twice or until there is no movement of the nuts. Verify the purge stops. | [[FPC1InstallComment]] <<COMMENT>>  [[FPC1InstallTime]] <<TIMESTAMP>>  [[FPC1InstallTech]] <<SRFCVP>> |
| 24. Remove coupler alignment table from lollipop and install FPC support arm. | [[FPC1SupportArmInstalled]] <<YESNO>> |
| 5. | **Upstream Gate Valve Sub-Assembly to Cavity 1 Assembly**  1. Gather the following components. Verify the components are cleaned and ready for installation.   * 2 bellows flange alignment blanks * 1 beamline gasket * 4 covered spring clamps * Fasteners * Retainer clips * Wrenches |  |
| **Prepare the Upstream Gate Valve Sub-Assembly [GV1SA] Bellows Flange**  2. Verify the purge software is set to "Purge" for the Upstream Purge Line.  3. Remove the 4 studs indicated in the positions 3, 6, 9, and 12 in the drawing below from the GV1SA bellows end flange in a star pattern.  Then remove the studs in positions 2, 5, 8, and 11 from the GV2SA bellows end flange in a star pattern.  The 4 remaining studs shall be located every third hole in the flange.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    4. Install 4 new pre-cleaned [Spec 1] studs in positions 2, 5, 8, and 11 to ensure equal pressure on the gasket. Torque these pre-cleaned studs to 31 ft-lbs.  5. Remove final 4 original studs 2 at a time from the flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  6. Hold the flanges tight so that there is no movement of the flanges while studs are being removed.  Remove the stud in position 5, pulling the stud away from the GV1SA.  Then remove the stud in position 11, pulling the stud away the GV1SA.  Then remove the stud in position 2, pulling the stud away the GV1SA.  Then remove the stud in position 8, pulling the stud away the GV1SA.  Carefully and slowly remove the blank and gasket away from the GV1SA.  Verify the purge starts.  7. Flow purge gas through the GV1SA until Spec 1 is reached for two full cycles.  8. Carefully place an alignment blank onto the bellows flange. Clamp in place with two cleaned spring clamps. Open the clamps down and away from the bellows. |
| **Prepare the Cavity 1 Upstream Flange**  9. Verify the purge software is set to "Purge" for the Downstream Purge Line.  10. Remove the 4 studs indicated in the positions 3, 6, 9, and 12 in the drawing below from the cavity upstream end flange in a star pattern.  Then remove the studs in positions 2, 5, 8, and 11 from the cavity downstream end flange in a star pattern.  The 4 remaining studs shall be located every third hole in the flange.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    11. Install 4 new pre-cleaned [Spec 1] studs in positions 2, 5, 8, and 11 to ensure equal pressure on the gasket. Torque these pre-cleaned studs to 31 ft-lbs.  12. Remove final 4 original studs 2 at a time from the flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  13. Hold the cavity upstream end flange and beamline blank flange tight so that there is no movement of the flanges while studs are being removed.  Remove the stud in position 5, pulling the stud away from the cavity.  Then remove the stud in position 11, pulling the stud away the cavity.  Then remove the stud in position 2, pulling the stud away the cavity.  Then remove the stud in position 8, pulling the stud away the cavity.  Carefully and slowly remove the blank and gasket away from the cavity.  Verify the purge starts.  14. Carefully place an alignment blank on the cavity flange. Verify that the alignment pins on the cavity flange do not line up with the alignment pins on the bellows. Clamp in place with two cleaned spring clamps. Open the clamps down and away from the open cavity flange. |
| **Align GV1SA Bellows and Cavity End Flanges**  15. Slowly slide the cavity towards the bellows to check flange alignment. The nipples on the alignment blanks should move freely into the indents of the flanges. A slight rotation of the bellows flange can be performed if necessary during the alignment process.  16. Move the cavity away from the bellows flange.  17. Carefully remove the alignment blanks from the cavity and bellows. |
| **Install Cavity to GV1SA Bellows**  18. Install the beamline gasket with retaining clips to hold the gasket in place on the bellows flange. Verify the clips are placed in the horizontal position.  19. Slowly slide the cavity back into place against the gasket. Remove the gasket clips.  20. Hold the flanges tightly together, preventing the flanges from rotating or moving away from each other, until the first 4 studs have been snugged tight with a wrench.  21. Place 4 pre-cleaned [Spec 1] studs in a star pattern in the cavity flange and snug them with a wrench.  22. Place the remaining fasteners on the flange continuing the star pattern and snug all of them with a wrench.  23. Verify the level of both the cavity and GV1SA before torquing the fasteners.  24. Torque the fasteners to 15 ft-lbs using a standard torquing pattern for a round flange.  25. Increase the torque and torque all the fasteners to 31 ft-lbs using a standard torquing pattern for a round flange.  26. Repeat the final torque sequence twice and then go around all of the fasteners at least twice or until there is no movement of the nuts. Verify the purge system turns off.  27. Install rail locks on the cavity and valve to lock it in place. | [[GV1SA\_CAV1Comment]] <<COMMENT>>  [[GV1SA\_CAV1Time]] <<TIMESTAMP>>  [[GV1SA\_CAV1Tech1]] <<SRFCVP>>  [[GV1SA\_CAV1Tech2]] <<SRFCVP>> |
| **Remove Purge System Hose from Cavity 1**  28. Verify the purge software is set to "Purge" for the Upstream Purge Line.  29. Set the purge software to "Standby" state for the Downstream Purge Line.  30. Slowly close the cavity right angle valve.  31. Remove the purge system hose from the cavity.  32. Put a blank on the Spool with two studs using the same gasket. |  |

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| Step No. | Instructions | Data Input |
| 6. | **Cavity 2 Prep**  1. Record Cavity 2 serial number. | [[CAVSN2]] <<CAVSN>> |
| 2. Put the cavity on the rail tooling with the blank flange facing the upstream gate valve sub-assembly [GV1SA] and the FPC facing the southeast corner of the cleanroom. |  |
| **Note: There will be some movement of flange location and/or cavity level every time something is adjusted. Several iterations of the cavity alignment will be required before the cavity will be perfectly level and have both beamline flanges in place.**  **Note: The upstream flange of Cavity 1 will dictate the location on all the cavities in the string.**  3. Align Cavity 2 and the upstream flange of Cavity 1. The cavity shall be aligned with the flange alignment tool to locate the beamline flange in the proper location.   * Verify the location of the flange is near the center of the range of the tooling to accommodate the alignment of all the cavities in the string. * After both flanges of the cavity are in the same position - relative to the rail - set the roll of the cavity level using a precision level on the leveling tool, which is attached to the other set of helium vessel blocks. |
| 4. Set the roll of the cavity rotationally using the rotational alignment bridge and the "A" frame. Verify all four frame studs and "A" frame studs are tight when finished. |
| 5. Blow down the cavity with ionized N2 in accordance with the Ionized Nitrogen Cleaning Procedure.   * General cavity to Spec 2. * Cavity flange, bolt holes, and inside the right angle valve up to the valve stem to Spec 1. |
| 6. Prepare the Downstream Purge Line Spool for assembly to the cavity right angle valve.   * Set the purge software to "Standby" and verify the baratron is reading approximately 0. * Remove the blank, gasket, and all fasteners from the Spool. * Wipe bolt holes and flange sealing surface with IPA.   **Note**: One technician shall hold the Spool and point opening away from the string, people, and any other critical components such as a cavity bays and prepared / cleaned parts. Angle the opening towards the floor until the Spool is ready to be installed onto the right angle valve. A second technician shall perform the purge system set up and particle counts.   * Set the purge software to "Blowout". * Verify the purge turns on. * Flow N2 through the Spool until Spec 1 is reached for two full cycles. * Set the purge software to "Purge". |
| 7. Install the Downstream Purge Line to the cavity right angle valve.   * Place a new cleaned [Spec 1] gasket on the Spool. Use a large-bore gasket if available. * Install two pre-cleaned [Spec1] studs in a star pattern and snug with wrench. * Install the four remaining studs continuing the star pattern. * Torque all studs using a standard torque pattern for a round flange. * Repeat the final torque sequence twice and then go around all the studs at least twice or until there is no movement of the nuts. Stop if the flanges go metal-to-metal. * Verify the purge turns off. |
| 8. Pump down the purge line to the cavity right angle valve.   * Set the purge software to "Standby" for the Downstream Purge Line. * Pump down the purge header to the closed right angle valve on the cavity. Allow the header to pump to the mid E-5 mbar range. * Close the pump isolation valve. |
| 9. While monitoring the cavity pressure, slowly open the cavity right angle valve. If the cavity pressure reads at the mid E-4 mbar range or higher, notify the cleanroom supervisor. | [[CAV2VacuumOK]] <<YESNO>> |
| 10. Set the purge software to "Backfill" for the Downstream Purge Line and slowly backfill the cavity. |  |
| 11. When the cavity has been backfilled to the interlock value, change the purge software to "Purge". | [[CAV2PrepComment]] <<COMMENT>>  [[CAV2PrepTime]] <<TIMESTAMP>>  [[CAV2PrepTech]] <<SRFCVP>> |
| 7. | **Cavity 2 FPC Installation**  1. Gather the following components for the connection of the cold end coupler to the cavity. Verify the components are cleaned and ready for installation.   * 1 inspected and accepted FPC body * 1 FPC body flange alignment blank * 2 clean spring clamps * Fasteners * 1 hex seal gasket * Retainer clips * Wrenches |  |
| 2. Record the FPC Serial Number. | [[FPCCSN2]] <<FPCCSN>> |
| 3. Use the FPC body holding tool to hold and spray the FPC to Spec 1.  4. When all the N2 spraying is complete, carefully place the alignment tooling over the probe tip and onto the FPC body flange. Clamp in place with two spring clamps. Open the clamps down and away from the cavity.  5. Install the FPC onto the installation tooling and spray to Spec 1. |  |
| 6. Verify the purge software is set to "Purge" for the Downstream Purge Line.  7. Remove the 4 studs indicated in positions 1, 3, 5, and 7 in the drawing below from the cavity FPC flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure. Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    8. Install 2 pre-cleaned [Spec 1] studs in the open holes at positions 1 and 5 on the cavity and torque to 120 in-lbs.  9. Continue to remove all remaining original studs on the cavity flange in a star pattern, until only the two pre-cleaned studs remain installed.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure. Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  10. Hold the cavity FPC flange and the test coupler flange tight so that there is no movement of the flanges while studs are being removed.  Remove the pre-cleaned stud in position 1 on the cavity coupler flange and then remove the pre-cleaned stud in position 5 on the cavity coupler flange. Pull studs away from the cavity.  Carefully and slowly remove test coupler and gasket away from the cavity.  Verify the purge starts.  11. Install FPC alignment blank on cavity flange with spring clamps. Open the clamps down and away from the cavity. |  |
| 12. Install the FPC alignment table on the lollipop.  13. Align FPC to open holes on alignment blank.  14. Move FPC back as far as possible on the FPC table.  15. Remove the FPC coupler cover.  16. Install the FPC gasket with retaining clips to hold the gasket in place on the FPC. Verify the clips are placed in the horizontal position. |
| 17. Remove the alignment blank from the cavity.  18. Move FPC into place, remove the gasket clips, and install 2 pre-cleaned [Spec 1] studs in a star pattern to secure coupler. Snug studs with wrench.  19. Install 2 additional pre-cleaned [Spec 1] studs continuing the star pattern and snug with wrench.  20. Install remaining 4 studs in pairs continuing the star pattern on FPC flange. |
| 21. Torque all fasteners to 60 in-lbs using a standard torque pattern for a round flange.  22. Increase the torque wrench setting to 120 in-lbs and torque all fasteners using a standard torque pattern for a round flange.  23. Repeat the final torque sequence twice and then go around all the fasteners at least twice or until there is no movement of the nuts. Verify the purge stops. | [[FPC2InstallComment]] <<COMMENT>>  [[FPC2InstallTime]] <<TIMESTAMP>>  [[FPC2InstallTech]] <<SRFCVP>> |
| 24. Remove coupler alignment table from lollipop and install FPC support arm. | [[FPC2SupportArmInstalled]] <<YESNO>> |
| 8. | **Cavity 2 Assembly to Cavity String, including Bellows installation between Cavity 1 and Cavity 2**  1. Gather the following components. Verify the components are cleaned and ready for installation.   * 2 bellows flange alignment blanks * 1 beamline gasket * 4 covered spring clamps * Fasteners * Retainer clips * Wrenches |  |
| **Prepare the Bellows**  2. Place the bellows alignment table on the upstream lollipop for Cavity 2.  3. Place the bellows in the alignment fixture and align the two flanges.  4. Compress the bellows and install the bellows restraint blocks onto the bellows using 2 bolts per restraint. Use Ionized N2 to clean the bellows to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  5. Install the bellows in the alignment fixture. Use Ionized N2 to clean the bellows to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  6. Carefully place an alignment blank on both ends of the bellows. Clamp in place with two covered spring clamps per flange. Open the clamps down and away from the bellows. | [[BLBPSN1\_2]] <<BLBPSN>> |
| **Prepare the Cavity 2 Upstream Flange**  7. Verify the purge software is set to "Purge" for the Downstream Purge Line.  8. Remove the 4 studs indicated in the positions 3, 6, 9, and 12 in the drawing below from the cavity upstream end flange in a star pattern.  Then remove the studs in positions 2, 5, 8, and 11 from the cavity downstream end flange in a star pattern.  The 4 remaining studs shall be located every third hole in the flange.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    9. Install 4 new pre-cleaned [Spec 1] studs in positions 2, 5, 8, and 11 to ensure equal pressure on the gasket. Torque these pre-cleaned studs to 31 ft-lbs.  10. Remove final 4 original studs 2 at a time from the flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  11. Hold the cavity upstream end flange and beamline blank flange tight so that there is no movement of the flanges while studs are being removed.  Remove the stud in position 5, pulling the stud away from the cavity.  Then remove the stud in position 11, pulling the stud away the cavity.  Then remove the stud in position 2, pulling the stud away the cavity.  Then remove the stud in position 8, pulling the stud away the cavity.  Carefully and slowly remove the blank and gasket away from the cavity.  Verify the purge starts.  12. Carefully place an alignment blank on the cavity flange. Verify that the alignment pins on the cavity flange do not line up with the alignment pins on the bellows. Clamp in place with two cleaned spring clamps. Open the clamps down and away from the open cavity flange. |  |
| **Align the Bellows Non-Rotatable Flange and the Cavity 2 Upstream Flanges**  13. Carefully place the cleaned bellows holder with the bellows on the alignment table. The bellows not-rotatable flange shall be facing Cavity 2.  14. Slowly slide the bellows towards Cavity 2 to check flange alignment. The nipples on the alignment blanks should move freely into the indents of the flanges. A slight rotation of the bellows flange can be performed if necessary during the alignment process.  15. Move the cavity away from the bellows flange. |
| **Install the Bellows to Cavity 2**  16. Carefully remove the alignment blanks from the bellows non-rotatable flange and the cavity.  17. Install the beamline gasket with retaining clips to hold the gasket in place on the bellows flange. Verify the clips are placed in the horizontal position.  18. Slowly slide the cavity back into place against the gasket. Remove the gasket clips.  19. Hold the flanges tightly together, preventing the flanges from rotating or moving away from each other, until the first 4 studs have been snugged tight with a wrench.  20. Place 4 pre-cleaned [Spec 1] studs in a star pattern in the cavity flange and snug them with a wrench.  21. Place the remaining fasteners on the flange continuing the star pattern and snug all of them with a wrench.  22. Torque the fasteners to 15 ft-lbs using a standard torquing pattern for a round flange. Do not increase torque at this time. Final torqueing will be performed after both ends of the bellows have been attached to the cavities.  23. Remove the bellows holder and adjustable table from the lollipop. |
| **Prepare Cavity 1 Downstream Flange**  24. Verify the purge software is set to "Purge" for the Upstream Purge Line.  25. Remove the 4 studs indicated in positions 3, 6, 9, and 12 in the drawing below from the cavity downstream end flange in a star pattern.  Then remove the studs in positions 2, 5, 8, and 11 from the cavity downstream end flange in a star pattern.  The 4 remaining studs shall be located every third hole in the flange.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    26. Install 4 new pre-cleaned [Spec 1] studs in positions 2, 5, 8, and 11 in a star pattern to ensure equal pressure on the gasket. Torque these pre-cleaned studs to 31 ft-lbs.  27. Remove final 4 original studs 2 at a time from the flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  28. Hold the cavity downstream end flange and right angle valve sub-assembly flange tight so that there is no movement of the flanges while studs are being removed.  Remove the stud in position 5, pulling the stud away from the cavity.  Then remove the stud in position 11, pulling the stud away the cavity.  Then remove the stud in position 2, pulling the stud away the cavity.  Then remove the stud in position 8, pulling the stud away the cavity.  Carefully and slowly remove the blank and gasket away from the cavity.  Verify the purge starts.  29. Carefully place an alignment blank on the cavity flange. Verify that the alignment pins on the cavity flange do not line up with the alignment pins on the bellows. Clamp in place with two cleaned spring clamps. Open the clamps down and away from the cavity. |  |
| **Align the Bellows Rotatable Flange and Cavity 1 Downstream Flange**  30. Slowly slide Cavity 2 towards Cavity 1 to check bellows rotatable flange alignment. The nipples on the flange alignment covers should move freely into the indents of the flanges. A slight rotation of the bellows flange can be performed if necessary during the alignment process. A bolt on each bellows restraint block can be loosened to allow for the rotatable flange to be adjusted if needed.  31. Move Cavity 2 away from Cavity 1.  32. Carefully remove the alignment covers from the bellows rotatable flange and Cavity 1. |
| **Install the Bellows to Cavity 1**  33. Carefully remove the alignment blanks from the bellows rotatable flange and the cavity.  34. Install the beamline gasket with retaining clips to hold the gasket in place on the bellows flange. Verify the clips are placed in the horizontal position.  35. Slowly slide the cavity back into place against the gasket. Remove the gasket clips.  36. Hold the flanges tightly together, preventing the flanges from rotating or moving away from each other, until the first 4 studs have been snugged tight with a wrench.  37. Place 4 pre-cleaned [Spec 1] studs in a star pattern in the cavity flange and snug them with a wrench.  38. Place the remaining fasteners on the flange continuing the star pattern and snug all of them with a wrench.  39. Torque the fasteners to 15 ft-lbs using a standard torquing pattern for a round flange. |
| **Final Torquing of Bellows Flanges to Cavities**  40. Torque all the fasteners on the Cavity 2 side of the bellows to 31 ft-lbs using a standard torquing pattern for a round flange.  41. Torque all the fasteners on the Cavity 1 side of the bellows to 31 ft-lbs using a standard torquing pattern for a round flange.  42. On the Cavity 2 side, repeat the final torque sequence twice and then go around all of the fasteners at least twice or until there is no movement of the nuts.  43. On the Cavity 1 side, repeat the final torque sequence twice and then go around all of the fasteners at least twice or until there is no movement of the nuts.  44. Verify the purge system turns off.  45. Install rail locks on Cavity 2 to lock it in place. | [[Bellows1\_2\_Comment]] <<COMMENT>>  [[Bellows1\_2\_Time]] <<TIMESTAMP>>  [[Bellows1\_2\_Tech1]] <<SRFCVP>>  [[Bellows1\_2\_Tech2]] <<SRFCVP>> |
| **Remove Purge System Hose from Cavity 2**  46. Set the purge software to "Standby" state for the Downstream Purge Line.  47. Slowly close the cavity right angle valve.  48. Remove the purge system hose from the cavity.  49. Put a blank on the Spool with two studs using the same gasket. |  |

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| Step No. | Instructions | Data Input |
| 9. | **Cavity 3 Prep**  1. Record Cavity 3 serial number. | [[CAVSN3]] <<CAVSN>> |
| 2. Put the cavity on the rail tooling with the blank flange facing the upstream gate valve sub-assembly [GV1SA] and the FPC facing the southeast corner of the cleanroom. |  |
| **Note: There will be some movement of flange location and/or cavity level every time something is adjusted. Several iterations of the cavity alignment will be required before the cavity will be perfectly level and have both beamline flanges in place.**  3. Align Cavity 3 and the upstream flange of Cavity 2. The cavity shall be aligned with the flange alignment tool to locate the beamline flange in the proper location.   * Verify the location of the flange is near the center of the range of the tooling to accommodate the alignment of all the cavities in the string. * After both flanges of the cavity are in the same position - relative to the rail - set the roll of the cavity level using a precision level on the leveling tool, which is attached to the other set of helium vessel blocks. |
| 4. Set the roll of the cavity rotationally using the rotational alignment bridge and the "A" frame. Verify all four frame studs and "A" frame studs are tight when finished. |
| 5. Blow down the cavity with ionized N2 in accordance with the Ionized Nitrogen Cleaning Procedure.   * General cavity to Spec 2. * Cavity flange, bolt holes, and inside the right angle valve up to the valve stem to Spec 1. |
| 6. Prepare the Downstream Purge Line Spool for assembly to the cavity right angle valve.   * Set the purge software to "Standby" and verify the baratron is reading approximately 0. * Remove the blank, gasket, and all fasteners from the Spool. * Wipe bolt holes and flange sealing surface with IPA.   **Note**: One technician shall hold the Spool and point opening away from the string, people, and any other critical components such as a cavity bays and prepared / cleaned parts. Angle the opening towards the floor until the Spool is ready to be installed onto the right angle valve. A second technician shall perform the purge system set up and particle counts.   * Set the purge software to "Blowout". * Verify the purge turns on. * Flow N2 through the Spool until Spec 1 is reached for two full cycles. * Set the purge software to "Purge". |
| 7. Install the Downstream Purge Line to the cavity right angle valve.   * Place a new cleaned [Spec 1] gasket on the Spool. Use a large-bore gasket if available. * Install two pre-cleaned [Spec1] studs in a star pattern and snug with wrench. * Install the four remaining studs continuing the star pattern. * Torque all studs using a standard torque pattern for a round flange. * Repeat the final torque sequence twice and then go around all the studs at least twice or until there is no movement of the nuts. Stop if the flanges go metal-to-metal. * Verify the purge turns off. |
| 8. Pump down the purge line to the cavity right angle valve.   * Set the purge software to "Standby" for the Downstream Purge Line. * Pump down the purge header to the closed right angle valve on the cavity. Allow the header to pump to the mid E-5 mbar range. * Close the pump isolation valve. |
| 9. While monitoring the cavity pressure, slowly open the cavity right angle valve. If the cavity pressure reads at the mid E-4 mbar range or higher, notify the cleanroom supervisor. | [[CAV3VacuumOK]] <<YESNO>> |
| 10. Set the purge software to "Backfill" for the Downstream Purge Line and slowly backfill the cavity. |  |
| 11. When the cavity has been backfilled to the interlock value, change the purge software to "Purge". | [[CAV3PrepComment]] <<COMMENT>>  [[CAV3PrepTime]] <<TIMESTAMP>>  [[CAV3PrepTech]] <<SRFCVP>> |
| 10. | **Cavity 3 FPC Installation**  1. Gather the following components for the connection of the cold end coupler to the cavity. Verify the components are cleaned and ready for installation.   * 1 inspected and accepted FPC body * 1 FPC body flange alignment blank * 2 clean spring clamps * Fasteners * 1 hex seal gasket * Retainer clips * Wrenches |  |
| 2. Record the FPC Serial Number. | [[FPCCSN3]] <<FPCCSN>> |
| 3. Use the FPC body holding tool to hold and spray the FPC to Spec 1.  4. When all the N2 spraying is complete, carefully place the alignment tooling over the probe tip and onto the FPC body flange. Clamp in place with two spring clamps. Open the clamps down and away from the cavity.  5. Install the FPC onto the installation tooling and spray to Spec 1. |  |
| 6. Verify the purge software is set to "Purge" for the Downstream Purge Line.  7. Remove the 4 studs indicated in positions 1, 3, 5, and 7 in the drawing below from the cavity FPC flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure. Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    8. Install 2 pre-cleaned [Spec 1] studs in the open holes at positions 1 and 5 on the cavity and torque to 120 in-lbs.  9. Continue to remove all remaining original studs on the cavity flange in a star pattern, until only the two pre-cleaned studs remain installed.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure. Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  10. Hold the cavity FPC flange and the test coupler flange tight so that there is no movement of the flanges while studs are being removed.  Remove the pre-cleaned stud in position 1 on the cavity coupler flange and then remove the pre-cleaned stud in position 5 on the cavity coupler flange. Pull studs away from the cavity.  Carefully and slowly remove test coupler and gasket away from the cavity.  Verify the purge starts.  11. Install FPC alignment blank on cavity flange with spring clamps. Open the clamps down and away from the cavity. |  |
| 12. Install the FPC alignment table on the lollipop.  13. Align FPC to open holes on alignment blank.  14. Move FPC back as far as possible on the FPC table.  15. Remove the FPC coupler cover.  16. Install the FPC gasket with retaining clips to hold the gasket in place on the FPC. Verify the clips are placed in the horizontal position. |
| 17. Remove the alignment blank from the cavity.  18. Move FPC into place, remove the gasket clips, and install 2 pre-cleaned [Spec 1] studs in a star pattern to secure coupler. Snug studs with wrench.  19. Install 2 additional pre-cleaned [Spec 1] studs continuing the star pattern and snug with wrench.  20. Install remaining 4 studs in pairs continuing the star pattern on FPC flange. |
| 21. Torque all fasteners to 60 in-lbs using a standard torque pattern for a round flange.  22. Increase the torque wrench setting to 120 in-lbs and torque all fasteners using a standard torque pattern for a round flange.  23. Repeat the final torque sequence twice and then go around all the fasteners at least twice or until there is no movement of the nuts. Verify the purge stops. | [[FPC3InstallComment]] <<COMMENT>>  [[FPC3InstallTime]] <<TIMESTAMP>>  [[FPC3InstallTech]] <<SRFCVP>> |
| 24. Remove coupler alignment table from lollipop and install FPC support arm. | [[FPC3SupportArmInstalled]] <<YESNO>> |
| 11. | **Cavity 3 Assembly to Cavity String, including Bellows installation between Cavity 2 and Cavity 3**  1. Gather the following components. Verify the components are cleaned and ready for installation.   * 2 bellows flange alignment blanks * 1 beamline gasket * 4 covered spring clamps * Fasteners * Retainer clips * Wrenches |  |
| **Prepare the Bellows**  2. Place the bellows alignment table on the upstream lollipop for Cavity 3.  3. Place the bellows in the alignment fixture and align the two flanges.  4. Compress the bellows and install the bellows restraint blocks onto the bellows using 2 bolts per restraint. Use Ionized N2 to clean the bellows to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  5. Install the bellows in the alignment fixture. Use Ionized N2 to clean the bellows to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  6. Carefully place an alignment blank on both ends of the bellows. Clamp in place with two covered spring clamps per flange. Open the clamps down and away from the bellows. | [[BLBPSN2\_3]] <<BLBPSN>> |
| **Prepare the Cavity 3 Upstream Flange**  7. Verify the purge software is set to "Purge" for the Downstream Purge Line.  8. Remove the 4 studs indicated in the positions 3, 6, 9, and 12 in the drawing below from the cavity upstream end flange in a star pattern.  Then remove the studs in positions 2, 5, 8, and 11 from the cavity downstream end flange in a star pattern.  The 4 remaining studs shall be located every third hole in the flange.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    9. Install 4 new pre-cleaned [Spec 1] studs in positions 2, 5, 8, and 11 to ensure equal pressure on the gasket. Torque these pre-cleaned studs to 31 ft-lbs.  10. Remove final 4 original studs 2 at a time from the flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  11. Hold the cavity upstream end flange and beamline blank flange tight so that there is no movement of the flanges while studs are being removed.  Remove the stud in position 5, pulling the stud away from the cavity.  Then remove the stud in position 11, pulling the stud away the cavity.  Then remove the stud in position 2, pulling the stud away the cavity.  Then remove the stud in position 8, pulling the stud away the cavity.  Carefully and slowly remove the blank and gasket away from the cavity.  Verify the purge starts.  12. Carefully place an alignment blank on the cavity flange. Verify that the alignment pins on the cavity flange do not line up with the alignment pins on the bellows. Clamp in place with two cleaned spring clamps. Open the clamps down and away from the open cavity flange. |  |
| **Align the Bellows Non-Rotatable Flange and the Cavity 3 Upstream Flanges**  13. Carefully place the cleaned bellows holder with the bellows on the alignment table. The bellows not-rotatable flange shall be facing Cavity 3.  14. Slowly slide the bellows towards Cavity 3 to check flange alignment. The nipples on the alignment blanks should move freely into the indents of the flanges. A slight rotation of the bellows flange can be performed if necessary during the alignment process.  15. Move the cavity away from the bellows flange. |
| **Install the Bellows to Cavity 3**  16. Carefully remove the alignment blanks from the bellows non-rotatable flange and the cavity.  17. Install the beamline gasket with retaining clips to hold the gasket in place on the bellows flange. Verify the clips are placed in the horizontal position.  18. Slowly slide the cavity back into place against the gasket. Remove the gasket clips.  19. Hold the flanges tightly together, preventing the flanges from rotating or moving away from each other, until the first 4 studs have been snugged tight with a wrench.  20. Place 4 pre-cleaned [Spec 1] studs in a star pattern in the cavity flange and snug them with a wrench.  21. Place the remaining fasteners on the flange continuing the star pattern and snug all of them with a wrench.  22. Torque the fasteners to 15 ft-lbs using a standard torquing pattern for a round flange. Do not increase torque at this time. Final torqueing will be performed after both ends of the bellows have been attached to the cavities.  23. Remove the bellows holder and adjustable table from the lollipop. |
| **Prepare Cavity 2 Downstream Flange**  24. Verify the purge software is set to "Purge" for the Upstream Purge Line.  25. Remove the 4 studs indicated in positions 3, 6, 9, and 12 in the drawing below from the cavity downstream end flange in a star pattern.  Then remove the studs in positions 2, 5, 8, and 11 from the cavity downstream end flange in a star pattern.  The 4 remaining studs shall be located every third hole in the flange.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    26. Install 4 new pre-cleaned [Spec 1] studs in positions 2, 5, 8, and 11 in a star pattern to ensure equal pressure on the gasket. Torque these pre-cleaned studs to 31 ft-lbs.  27. Remove final 4 original studs 2 at a time from the flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  28. Hold the cavity downstream end flange and right angle valve sub-assembly flange tight so that there is no movement of the flanges while studs are being removed.  Remove the stud in position 5, pulling the stud away from the cavity.  Then remove the stud in position 11, pulling the stud away the cavity.  Then remove the stud in position 2, pulling the stud away the cavity.  Then remove the stud in position 8, pulling the stud away the cavity.  Carefully and slowly remove the blank and gasket away from the cavity.  Verify the purge starts.  29. Carefully place an alignment blank on the cavity flange. Verify that the alignment pins on the cavity flange do not line up with the alignment pins on the bellows. Clamp in place with two cleaned spring clamps. Open the clamps down and away from the cavity. |  |
| **Align the Bellows Rotatable Flange and Cavity 2 Downstream Flange**  30. Slowly slide Cavity 3 towards Cavity 2 to check bellows rotatable flange alignment. The nipples on the flange alignment covers should move freely into the indents of the flanges. A slight rotation of the bellows flange can be performed if necessary during the alignment process. A bolt on each bellows restraint block can be loosened to allow for the rotatable flange to be adjusted if needed.  31. Move Cavity 3 away from Cavity 2.  32. Carefully remove the alignment covers from the bellows rotatable flange and Cavity 2. |
| **Install the Bellows to Cavity 2**  33. Carefully remove the alignment blanks from the bellows rotatable flange and the cavity.  34. Install the beamline gasket with retaining clips to hold the gasket in place on the bellows flange. Verify the clips are placed in the horizontal position.  35. Slowly slide the cavity back into place against the gasket. Remove the gasket clips.  36. Hold the flanges tightly together, preventing the flanges from rotating or moving away from each other, until the first 4 studs have been snugged tight with a wrench.  37. Place 4 pre-cleaned [Spec 1] studs in a star pattern in the cavity flange and snug them with a wrench.  38. Place the remaining fasteners on the flange continuing the star pattern and snug all of them with a wrench.  39. Torque the fasteners to 15 ft-lbs using a standard torquing pattern for a round flange. |
| **Final Torquing of Bellows Flanges to Cavities**  40. Torque all the fasteners on the Cavity 3 side of the bellows to 31 ft-lbs using a standard torquing pattern for a round flange.  41. Torque all the fasteners on the Cavity 2 side of the bellows to 31 ft-lbs using a standard torquing pattern for a round flange.  42. On the Cavity 3 side, repeat the final torque sequence twice and then go around all of the fasteners at least twice or until there is no movement of the nuts.  43. On the Cavity 2 side, repeat the final torque sequence twice and then go around all of the fasteners at least twice or until there is no movement of the nuts.  44. Verify the purge system turns off.  45. Install rail locks on Cavity 3 to lock it in place. | [[Bellows2\_3\_Comment]] <<COMMENT>>  [[Bellows2\_3\_Time]] <<TIMESTAMP>>  [[Bellows2\_3\_Tech1]] <<SRFCVP>>  [[Bellows2\_3\_Tech2]] <<SRFCVP>> |
| **Remove Purge System Hose from Cavity 3**  46. Set the purge software to "Standby" state for the Downstream Purge Line.  47. Slowly close the cavity right angle valve.  48. Remove the purge system hose from the cavity.  49. Put a blank on the Spool with two studs using the same gasket. |  |

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| Step No. | Instructions | Data Input |
| 12. | **Cavity 4 Prep**  1. Record Cavity 4 serial number. | [[CAVSN4]] <<CAVSN>> |
| 2. Put the cavity on the rail tooling with the blank flange facing the upstream gate valve sub-assembly [GV1SA] and the FPC facing the southeast corner of the cleanroom. |  |
| **Note: There will be some movement of flange location and/or cavity level every time something is adjusted. Several iterations of the cavity alignment will be required before the cavity will be perfectly level and have both beamline flanges in place.**  3. Align Cavity 4 and the upstream flange of Cavity 3. The cavity shall be aligned with the flange alignment tool to locate the beamline flange in the proper location.   * Verify the location of the flange is near the center of the range of the tooling to accommodate the alignment of all the cavities in the string. * After both flanges of the cavity are in the same position - relative to the rail - set the roll of the cavity level using a precision level on the leveling tool, which is attached to the other set of helium vessel blocks. |
| 4. Set the roll of the cavity rotationally using the rotational alignment bridge and the "A" frame. Verify all four frame studs and "A" frame studs are tight when finished. |
| 5. Blow down the cavity with ionized N2 in accordance with the Ionized Nitrogen Cleaning Procedure.   * General cavity to Spec 2. * Cavity flange, bolt holes, and inside the right angle valve up to the valve stem to Spec 1. |
| 6. Prepare the Downstream Purge Line Spool for assembly to the cavity right angle valve.   * Set the purge software to "Standby" for and verify the baratron is reading approximately 0. * Remove the blank, gasket, and all fasteners from the Spool. * Wipe bolt holes and flange sealing surface with IPA.   **Note**: One technician shall hold the Spool and point opening away from the string, people, and any other critical components such as a cavity bays and prepared / cleaned parts. Angle the opening towards the floor until the Spool is ready to be installed onto the right angle valve. A second technician shall perform the purge system set up and particle counts.   * Set the purge software to "Blowout". * Verify the purge turns on. * Flow N2 through the Spool until Spec 1 is reached for two full cycles. * Set the purge software to "Purge". |
| 7. Install the Downstream Purge Line to the cavity right angle valve.   * Place a new cleaned [Spec 1] gasket on the Spool. Use a large-bore gasket if available. * Install two pre-cleaned [Spec1] studs in a star pattern and snug with wrench. * Install the four remaining studs continuing the star pattern. * Torque all studs using a standard torque pattern for a round flange. * Repeat the final torque sequence twice and then go around all the studs at least twice or until there is no movement of the nuts. Stop if the flanges go metal-to-metal. * Verify the purge turns off. |
| 8. Pump down the purge line to the cavity right angle valve.   * Set the purge software to "Standby" for the Downstream Purge Line. * Pump down the purge header to the closed right angle valve on the cavity. Allow the header to pump to the mid E-5 mbar range. * Close the pump isolation valve. |
| 9. While monitoring the cavity pressure, slowly open the cavity right angle valve. If the cavity pressure reads at the mid E-4 mbar range or higher, notify the cleanroom supervisor. | [[CAV4VacuumOK]] <<YESNO>> |
| 10. Set the purge software to "Backfill" for the Downstream Purge Line and slowly backfill the cavity. |  |
| 11. When the cavity has been backfilled to the interlock value, change the purge software to "Purge". | [[CAV4PrepComment]] <<COMMENT>>  [[CAV4PrepTime]] <<TIMESTAMP>>  [[CAV4PrepTech]] <<SRFCVP>> |
| 13. | **Cavity 4 FPC Installation**  1. Gather the following components for the connection of the cold end coupler to the cavity. Verify the components are cleaned and ready for installation.   * 1 inspected and accepted FPC body * 1 FPC body flange alignment blank * 2 clean spring clamps * Fasteners * 1 hex seal gasket * Retainer clips * Wrenches |  |
| 2. Record the FPC Serial Number. | [[FPCCSN4]] <<FPCCSN>> |
| 3. Use the FPC body holding tool to hold and spray the FPC to Spec 1.  4. When all the N2 spraying is complete, carefully place the alignment tooling over the probe tip and onto the FPC body flange. Clamp in place with two spring clamps. Open the clamps down and away from the cavity.  5. Install the FPC onto the installation tooling and spray to Spec 1. |  |
| 6. Verify the purge software is set to "Purge" for the Downstream Purge Line.  7. Remove the 4 studs indicated in positions 1, 3, 5, and 7 in the drawing below from the cavity FPC flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure. Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    8. Install 2 pre-cleaned [Spec 1] studs in the open holes at positions 1 and 5 on the cavity and torque to 120 in-lbs.  9. Continue to remove all remaining original studs on the cavity flange in a star pattern, until only the two pre-cleaned studs remain installed.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure. Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  10. Hold the cavity FPC flange and the test coupler flange tight so that there is no movement of the flanges while studs are being removed.  Remove the pre-cleaned stud in position 1 on the cavity coupler flange and then remove the pre-cleaned stud in position 5 on the cavity coupler flange. Pull studs away from the cavity.  Carefully and slowly remove test coupler and gasket away from the cavity.  Verify the purge starts.  11. Install FPC alignment blank on cavity flange with spring clamps. Open the clamps down and away from the cavity. |  |
| 12. Install the FPC alignment table on the lollipop.  13. Align FPC to open holes on alignment blank.  14. Move FPC back as far as possible on the FPC table.  15. Remove the FPC coupler cover.  16. Install the FPC gasket with retaining clips to hold the gasket in place on the FPC. Verify the clips are placed in the horizontal position. |
| 17. Remove the alignment blank from the cavity.  18. Move FPC into place, remove the gasket clips, and install 2 pre-cleaned [Spec 1] studs in a star pattern to secure coupler. Snug studs with wrench.  19. Install 2 additional pre-cleaned [Spec 1] studs continuing the star pattern and snug with wrench.  20. Install remaining 4 studs in pairs continuing the star pattern on FPC flange. |
| 21. Torque all fasteners to 60 in-lbs using a standard torque pattern for a round flange.  22. Increase the torque wrench setting to 120 in-lbs and torque all fasteners using a standard torque pattern for a round flange.  23. Repeat the final torque sequence twice and then go around all the fasteners at least twice or until there is no movement of the nuts. Verify the purge stops. | [[FPC4InstallComment]] <<COMMENT>>  [[FPC4InstallTime]] <<TIMESTAMP>>  [[FPC4InstallTech]] <<SRFCVP>> |
| 24. Remove coupler alignment table from lollipop and install FPC support arm. | [[FPC4SupportArmInstalled]] <<YESNO>> |
| 14. | **Cavity 4 Assembly to Cavity String, including Bellows installation between Cavity 3 and Cavity 4**  1. Gather the following components. Verify the components are cleaned and ready for installation.   * 2 bellows flange alignment blanks * 1 beamline gasket * 4 covered spring clamps * Fasteners * Retainer clips * Wrenches |  |
| **Prepare the Bellows**  2. Place the bellows alignment table on the upstream lollipop for Cavity 4.  3. Place the bellows in the alignment fixture and align the two flanges.  4. Compress the bellows and install the bellows restraint blocks onto the bellows using 2 bolts per restraint. Use Ionized N2 to clean the bellows to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  5. Install the bellows in the alignment fixture. Use Ionized N2 to clean the bellows to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  6. Carefully place an alignment blank on both ends of the bellows. Clamp in place with two covered spring clamps per flange. Open the clamps down and away from the bellows. | [[BLBPSN3\_4]] <<BLBPSN>> |
| **Prepare the Cavity 4 Upstream Flange**  7. Verify the purge software is set to "Purge" for the Downstream Purge Line.  8. Remove the 4 studs indicated in the positions 3, 6, 9, and 12 in the drawing below from the cavity upstream end flange in a star pattern.  Then remove the studs in positions 2, 5, 8, and 11 from the cavity downstream end flange in a star pattern.  The 4 remaining studs shall be located every third hole in the flange.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    9. Install 4 new pre-cleaned [Spec 1] studs in positions 2, 5, 8, and 11 to ensure equal pressure on the gasket. Torque these pre-cleaned studs to 31 ft-lbs.  10. Remove final 4 original studs 2 at a time from the flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  11. Hold the cavity upstream end flange and beamline blank flange tight so that there is no movement of the flanges while studs are being removed.  Remove the stud in position 5, pulling the stud away from the cavity.  Then remove the stud in position 11, pulling the stud away the cavity.  Then remove the stud in position 2, pulling the stud away the cavity.  Then remove the stud in position 8, pulling the stud away the cavity.  Carefully and slowly remove the blank and gasket away from the cavity.  Verify the purge starts.  12. Carefully place an alignment blank on the cavity flange. Verify that the alignment pins on the cavity flange do not line up with the alignment pins on the bellows. Clamp in place with two cleaned spring clamps. Open the clamps down and away from the open cavity flange. |  |
| **Align the Bellows Non-Rotatable Flange and the Cavity 4 Upstream Flanges**  13. Carefully place the cleaned bellows holder with the bellows on the alignment table. The bellows not-rotatable flange shall be facing Cavity 4.  14. Slowly slide the bellows towards Cavity 4 to check flange alignment. The nipples on the alignment blanks should move freely into the indents of the flanges. A slight rotation of the bellows flange can be performed if necessary during the alignment process.  15. Move the cavity away from the bellows flange. |
| **Install the Bellows to Cavity 4**  16. Carefully remove the alignment blanks from the bellows non-rotatable flange and the cavity.  17. Install the beamline gasket with retaining clips to hold the gasket in place on the bellows flange. Verify the clips are placed in the horizontal position.  18. Slowly slide the cavity back into place against the gasket. Remove the gasket clips.  19. Hold the flanges tightly together, preventing the flanges from rotating or moving away from each other, until the first 4 studs have been snugged tight with a wrench.  20. Place 4 pre-cleaned [Spec 1] studs in a star pattern in the cavity flange and snug them with a wrench.  21. Place the remaining fasteners on the flange continuing the star pattern and snug all of them with a wrench.  22. Torque the fasteners to 15 ft-lbs using a standard torquing pattern for a round flange. Do not increase torque at this time. Final torqueing will be performed after both ends of the bellows have been attached to the cavities.  23. Remove the bellows holder and adjustable table from the lollipop. |
| **Prepare Cavity 3 Downstream Flange**  24. Verify the purge software is set to "Purge" for the Upstream Purge Line.  25. Remove the 4 studs indicated in positions 3, 6, 9, and 12 in the drawing below from the cavity downstream end flange in a star pattern.  Then remove the studs in positions 2, 5, 8, and 11 from the cavity downstream end flange in a star pattern.  The 4 remaining studs shall be located every third hole in the flange.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    26. Install 4 new pre-cleaned [Spec 1] studs in positions 2, 5, 8, and 11 in a star pattern to ensure equal pressure on the gasket. Torque these pre-cleaned studs to 31 ft-lbs.  27. Remove final 4 original studs 2 at a time from the flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  28. Hold the cavity downstream end flange and right angle valve sub-assembly flange tight so that there is no movement of the flanges while studs are being removed.  Remove the stud in position 5, pulling the stud away from the cavity.  Then remove the stud in position 11, pulling the stud away the cavity.  Then remove the stud in position 2, pulling the stud away the cavity.  Then remove the stud in position 8, pulling the stud away the cavity.  Carefully and slowly remove the blank and gasket away from the cavity.  Verify the purge starts.  29. Carefully place an alignment blank on the cavity flange. Verify that the alignment pins on the cavity flange do not line up with the alignment pins on the bellows. Clamp in place with two cleaned spring clamps. Open the clamps down and away from the cavity. |  |
| **Align the Bellows Rotatable Flange and Cavity 3 Downstream Flange**  30. Slowly slide Cavity 4 towards Cavity 3 to check bellows rotatable flange alignment. The nipples on the flange alignment covers should move freely into the indents of the flanges. A slight rotation of the bellows flange can be performed if necessary during the alignment process. A bolt on each bellows restraint block can be loosened to allow for the rotatable flange to be adjusted if needed.  31. Move Cavity 4 away from Cavity 3.  32. Carefully remove the alignment covers from the bellows rotatable flange and Cavity 3. |
| **Install the Bellows to Cavity 3**  33. Carefully remove the alignment blanks from the bellows rotatable flange and the cavity.  34. Install the beamline gasket with retaining clips to hold the gasket in place on the bellows flange. Verify the clips are placed in the horizontal position.  35. Slowly slide the cavity back into place against the gasket. Remove the gasket clips.  36. Hold the flanges tightly together, preventing the flanges from rotating or moving away from each other, until the first 4 studs have been snugged tight with a wrench.  37. Place 4 pre-cleaned [Spec 1] studs in a star pattern in the cavity flange and snug them with a wrench.  38. Place the remaining fasteners on the flange continuing the star pattern and snug all of them with a wrench.  39. Torque the fasteners to 15 ft-lbs using a standard torquing pattern for a round flange. |
| **Final Torquing of Bellows Flanges to Cavities**  40. Torque all the fasteners on the Cavity 4 side of the bellows to 31 ft-lbs using a standard torquing pattern for a round flange.  41. Torque all the fasteners on the Cavity 3 side of the bellows to 31 ft-lbs using a standard torquing pattern for a round flange.  42. On the Cavity 4 side, repeat the final torque sequence twice and then go around all of the fasteners at least twice or until there is no movement of the nuts.  43. On the Cavity 3 side, repeat the final torque sequence twice and then go around all of the fasteners at least twice or until there is no movement of the nuts.  44. Verify the purge system turns off.  45. Install rail locks on Cavity 4 to lock it in place. | [[Bellows3\_4\_Comment]] <<COMMENT>>  [[Bellows3\_4\_Time]] <<TIMESTAMP>>  [[Bellows3\_4\_Tech1]] <<SRFCVP>>  [[Bellows3\_4\_Tech2]] <<SRFCVP>> |
| **Remove Purge System Hose from Cavity 4**  46. Set the purge software to "Standby" state for the Downstream Purge Line.  47. Slowly close the cavity right angle valve.  48. Remove the purge system hose from the cavity.  49. Put a blank on the Spool with two studs using the same gasket. |  |

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| Step No. | Instructions | Data Input |
| 15. | **Cavity 5 Prep**  1. Record Cavity 5 serial number. | [[CAVSN5]] <<CAVSN>> |
| 2. Put the cavity on the rail tooling with the blank flange facing the upstream gate valve sub-assembly [GV1SA] and the FPC facing the southeast corner of the cleanroom. |  |
| **Note: There will be some movement of flange location and/or cavity level every time something is adjusted. Several iterations of the cavity alignment will be required before the cavity will be perfectly level and have both beamline flanges in place.**  3. Align Cavity 5 and the upstream flange of Cavity 4. The cavity shall be aligned with the flange alignment tool to locate the beamline flange in the proper location.   * Verify the location of the flange is near the center of the range of the tooling to accommodate the alignment of all the cavities in the string. * After both flanges of the cavity are in the same position - relative to the rail - set the roll of the cavity level using a precision level on the leveling tool, which is attached to the other set of helium vessel blocks. |
| 4. Set the roll of the cavity rotationally using the rotational alignment bridge and the "A" frame. Verify all four frame studs and "A" frame studs are tight when finished. |
| 5. Blow down the cavity with ionized N2 in accordance with the Ionized Nitrogen Cleaning Procedure.   * General cavity to Spec 2. * Cavity flange, bolt holes, and inside the right angle valve up to the valve stem to Spec 1. |
| 6. Prepare the Downstream Purge Line Spool for assembly to the cavity right angle valve.   * Set the purge software to "Standby" and verify the baratron is reading approximately 0. * Remove the blank, gasket, and all fasteners from the Spool. * Wipe bolt holes and flange sealing surface with IPA.   **Note:** One technician shall hold the Spool and point opening away from the string, people, and any other critical components such as a cavity bays and prepared / cleaned parts. Angle the opening towards the floor until the Spool is ready to be installed onto the right angle valve. A second technician shall perform the purge system set up and particle counts.   * Set the purge software to "Blowout". * Verify the purge turns on. * Flow N2 through the Spool until Spec 1 is reached for two full cycles. * Set the purge software to "Purge". |
| 7. Install the Downstream Purge Line to the cavity right angle valve.   * Place a new cleaned [Spec 1] gasket on the Spool. Use a large-bore gasket if available. * Install two pre-cleaned [Spec1] studs in a star pattern and snug with wrench. * Install the four remaining studs continuing the star pattern. * Torque all studs using a standard torque pattern for a round flange. * Repeat the final torque sequence twice and then go around all the studs at least twice or until there is no movement of the nuts. Stop if the flanges go metal-to-metal. * Verify the purge turns off. |
| 8. Pump down the purge line to the cavity right angle valve.   * Set the purge software to "Standby" for the Downstream Purge Line. * Pump down the purge header to the closed right angle valve on the cavity. Allow the header to pump to the mid E-5 mbar range. * Close the pump isolation valve. |
| 9. While monitoring the cavity pressure, slowly open the cavity right angle valve. If the cavity pressure reads at the mid E-4 mbar range or higher, notify the cleanroom supervisor. | [[CAV5VacuumOK]] <<YESNO>> |
| 10. Set the purge software to "Backfill" for the Downstream Purge Line and slowly backfill the cavity. |  |
| 11. When the cavity has been backfilled to the interlock value, change the purge software to "Purge". | [[CAV5PrepComment]] <<COMMENT>>  [[CAV5PrepTime]] <<TIMESTAMP>>  [[CAV5PrepTech]] <<SRFCVP>> |
| 16. | **Cavity 5 FPC Installation**  1. Gather the following components for the connection of the cold end coupler to the cavity. Verify the components are cleaned and ready for installation.   * 1 inspected and accepted FPC body * 1 FPC body flange alignment blank * 2 clean spring clamps * Fasteners * 1 hex seal gasket * Retainer clips * Wrenches |  |
| 2. Record the FPC Serial Number. | [[FPCCSN5]] <<FPCCSN>> |
| 3. Use the FPC body holding tool to hold and spray the FPC to Spec 1.  4. When all the N2 spraying is complete, carefully place the alignment tooling over the probe tip and onto the FPC body flange. Clamp in place with two spring clamps. Open the clamps down and away from the cavity.  5. Install the FPC onto the installation tooling and spray to Spec 1. |  |
| 6. Verify the purge software is set to "Purge" for the Downstream Purge Line.  7. Remove the 4 studs indicated in positions 1, 3, 5, and 7 in the drawing below from the cavity FPC flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure. Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    8. Install 2 pre-cleaned [Spec 1] studs in the open holes at positions 1 and 5 on the cavity and torque to 120 in-lbs.  9. Continue to remove all remaining original studs on the cavity flange in a star pattern, until only the two pre-cleaned studs remain installed.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure. Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  10. Hold the cavity FPC flange and the test coupler flange tight so that there is no movement of the flanges while studs are being removed.  Remove the pre-cleaned stud in position 1 on the cavity coupler flange and then remove the pre-cleaned stud in position 5 on the cavity coupler flange. Pull studs away from the cavity.  Carefully and slowly remove test coupler and gasket away from the cavity.  Verify the purge starts.  11. Install FPC alignment blank on cavity flange with spring clamps. Open the clamps down and away from the cavity. |  |
| 12. Install the FPC alignment table on the lollipop.  13. Align FPC to open holes on alignment blank.  14. Move FPC back as far as possible on the FPC table.  15. Remove the FPC coupler cover.  16. Install the FPC gasket with retaining clips to hold the gasket in place on the FPC. Verify the clips are placed in the horizontal position. |
| 17. Remove the alignment blank from the cavity.  18. Move FPC into place, remove the gasket clips, and install 2 pre-cleaned [Spec 1] studs in a star pattern to secure coupler. Snug studs with wrench.  19. Install 2 additional pre-cleaned [Spec 1] studs continuing the star pattern and snug with wrench.  20. Install remaining 4 studs in pairs continuing the star pattern on FPC flange. |
| 21. Torque all fasteners to 60 in-lbs using a standard torque pattern for a round flange.  22. Increase the torque wrench setting to 120 in-lbs and torque all fasteners using a standard torque pattern for a round flange.  23. Repeat the final torque sequence twice and then go around all the fasteners at least twice or until there is no movement of the nuts. Verify the purge stops. | [[FPC5InstallComment]] <<COMMENT>>  [[FPC5InstallTime]] <<TIMESTAMP>>  [[FPC5InstallTech]] <<SRFCVP>> |
| 24. Remove coupler alignment table from lollipop and install FPC support arm. | [[FPC5SupportArmInstalled]] <<YESNO>> |
| 17. | **Cavity 5 Assembly to Cavity String, including Bellows installation between Cavity 4 and Cavity 5**  1. Gather the following components. Verify the components are cleaned and ready for installation.   * 2 bellows flange alignment blanks * 1 beamline gasket * 4 covered spring clamps * Fasteners * Retainer clips * Wrenches |  |
| **Prepare the Bellows**  2. Place the bellows alignment table on the upstream lollipop for Cavity 5.  3. Place the bellows in the alignment fixture and align the two flanges.  4. Compress the bellows and install the bellows restraint blocks onto the bellows using 2 bolts per restraint. Use Ionized N2 to clean the bellows to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  5. Install the bellows in the alignment fixture. Use Ionized N2 to clean the bellows to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  6. Carefully place an alignment blank on both ends of the bellows. Clamp in place with two covered spring clamps per flange. Open the clamps down and away from the bellows. | [[BLBPSN4\_5]] <<BLBPSN>> |
| **Prepare the Cavity 5 Upstream Flange**  7. Verify the purge software is set to "Purge" for the Downstream Purge Line.  8. Remove the 4 studs indicated in the positions 3, 6, 9, and 12 in the drawing below from the cavity upstream end flange in a star pattern.  Then remove the studs in positions 2, 5, 8, and 11 from the cavity downstream end flange in a star pattern.  The 4 remaining studs shall be located every third hole in the flange.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    9. Install 4 new pre-cleaned [Spec 1] studs in positions 2, 5, 8, and 11 to ensure equal pressure on the gasket. Torque these pre-cleaned studs to 31 ft-lbs.  10. Remove final 4 original studs 2 at a time from the flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  11. Hold the cavity upstream end flange and beamline blank flange tight so that there is no movement of the flanges while studs are being removed.  Remove the stud in position 5, pulling the stud away from the cavity.  Then remove the stud in position 11, pulling the stud away the cavity.  Then remove the stud in position 2, pulling the stud away the cavity.  Then remove the stud in position 8, pulling the stud away the cavity.  Carefully and slowly remove the blank and gasket away from the cavity.  Verify the purge starts.  12. Carefully place an alignment blank on the cavity flange. Verify that the alignment pins on the cavity flange do not line up with the alignment pins on the bellows. Clamp in place with two cleaned spring clamps. Open the clamps down and away from the open cavity flange. |  |
| **Align the Bellows Non-Rotatable Flange and the Cavity 5 Upstream Flanges**  13. Carefully place the cleaned bellows holder with the bellows on the alignment table. The bellows not-rotatable flange shall be facing Cavity 5.  14. Slowly slide the bellows towards Cavity 5 to check flange alignment. The nipples on the alignment blanks should move freely into the indents of the flanges. A slight rotation of the bellows flange can be performed if necessary during the alignment process.  15. Move the cavity away from the bellows flange. |
| **Install the Bellows to Cavity 5**  16. Carefully remove the alignment blanks from the bellows non-rotatable flange and the cavity.  17. Install the beamline gasket with retaining clips to hold the gasket in place on the bellows flange. Verify the clips are placed in the horizontal position.  18. Slowly slide the cavity back into place against the gasket. Remove the gasket clips.  19. Hold the flanges tightly together, preventing the flanges from rotating or moving away from each other, until the first 4 studs have been snugged tight with a wrench.  20. Place 4 pre-cleaned [Spec 1] studs in a star pattern in the cavity flange and snug them with a wrench.  21. Place the remaining fasteners on the flange continuing the star pattern and snug all of them with a wrench.  22. Torque the fasteners to 15 ft-lbs using a standard torquing pattern for a round flange. Do not increase torque at this time. Final torqueing will be performed after both ends of the bellows have been attached to the cavities.  23. Remove the bellows holder and adjustable table from the lollipop. |
| **Prepare Cavity 4 Downstream Flange**  24. Verify the purge software is set to "Purge" for the Upstream Purge Line.  25. Remove the 4 studs indicated in positions 3, 6, 9, and 12 in the drawing below from the cavity downstream end flange in a star pattern.  Then remove the studs in positions 2, 5, 8, and 11 from the cavity downstream end flange in a star pattern.  The 4 remaining studs shall be located every third hole in the flange.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    26. Install 4 new pre-cleaned [Spec 1] studs in positions 2, 5, 8, and 11 in a star pattern to ensure equal pressure on the gasket. Torque these pre-cleaned studs to 31 ft-lbs.  27. Remove final 4 original studs 2 at a time from the flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  28. Hold the cavity downstream end flange and right angle valve sub-assembly flange tight so that there is no movement of the flanges while studs are being removed.  Remove the stud in position 5, pulling the stud away from the cavity.  Then remove the stud in position 11, pulling the stud away the cavity.  Then remove the stud in position 2, pulling the stud away the cavity.  Then remove the stud in position 8, pulling the stud away the cavity.  Carefully and slowly remove the blank and gasket away from the cavity.  Verify the purge starts.  29. Carefully place an alignment blank on the cavity flange. Verify that the alignment pins on the cavity flange do not line up with the alignment pins on the bellows. Clamp in place with two cleaned spring clamps. Open the clamps down and away from the cavity. |  |
| **Align the Bellows Rotatable Flange and Cavity 4 Downstream Flange**  30. Slowly slide Cavity 5 towards Cavity 4 to check bellows rotatable flange alignment. The nipples on the flange alignment covers should move freely into the indents of the flanges. A slight rotation of the bellows flange can be performed if necessary during the alignment process. A bolt on each bellows restraint block can be loosened to allow for the rotatable flange to be adjusted if needed.  31. Move Cavity 5 away from Cavity 4.  32. Carefully remove the alignment covers from the bellows rotatable flange and Cavity 4. |
| **Install the Bellows to Cavity 4**  33. Carefully remove the alignment blanks from the bellows rotatable flange and the cavity.  34. Install the beamline gasket with retaining clips to hold the gasket in place on the bellows flange. Verify the clips are placed in the horizontal position.  35. Slowly slide the cavity back into place against the gasket. Remove the gasket clips.  36. Hold the flanges tightly together, preventing the flanges from rotating or moving away from each other, until the first 4 studs have been snugged tight with a wrench.  37. Place 4 pre-cleaned [Spec 1] studs in a star pattern in the cavity flange and snug them with a wrench.  38. Place the remaining fasteners on the flange continuing the star pattern and snug all of them with a wrench.  39. Torque the fasteners to 15 ft-lbs using a standard torquing pattern for a round flange. |
| **Final Torquing of Bellows Flanges to Cavities**  40. Torque all the fasteners on the Cavity 5 side of the bellows to 31 ft-lbs using a standard torquing pattern for a round flange.  41. Torque all the fasteners on the Cavity 4 side of the bellows to 31 ft-lbs using a standard torquing pattern for a round flange.  42. On the Cavity 5 side, repeat the final torque sequence twice and then go around all of the fasteners at least twice or until there is no movement of the nuts.  43. On the Cavity 4 side, repeat the final torque sequence twice and then go around all of the fasteners at least twice or until there is no movement of the nuts.  44. Verify the purge system turns off.  45. Install rail locks on Cavity 5 to lock it in place. | [[Bellows4\_5\_Comment]] <<COMMENT>>  [[Bellows4\_5\_Time]] <<TIMESTAMP>>  [[Bellows4\_5\_Tech1]] <<SRFCVP>>  [[Bellows4\_5\_Tech2]] <<SRFCVP>> |
| **Remove Purge System Hose from Cavity 5**  46. Set the purge software to "Standby" state for the Downstream Purge Line.  47. Slowly close the cavity right angle valve.  48. Remove the purge system hose from the cavity.  49. Put a blank on the Spool with two studs using the same gasket. |  |

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| Step No. | Instructions | Data Input |
| 18. | **Cavity 6 Prep**  1. Record Cavity 6 serial number. | [[CAVSN6]] <<CAVSN>> |
| 2. Put the cavity on the rail tooling with the blank flange facing the upstream gate valve sub-assembly [GV1SA] and the FPC facing the southeast corner of the cleanroom. |  |
| **Note: There will be some movement of flange location and/or cavity level every time something is adjusted. Several iterations of the cavity alignment will be required before the cavity will be perfectly level and have both beamline flanges in place.**  3. Align Cavity 6 and the upstream flange of Cavity 5. The cavity shall be aligned with the flange alignment tool to locate the beamline flange in the proper location.   * Verify the location of the flange is near the center of the range of the tooling to accommodate the alignment of all the cavities in the string. * After both flanges of the cavity are in the same position - relative to the rail - set the roll of the cavity level using a precision level on the leveling tool, which is attached to the other set of helium vessel blocks. |
| 4. Set the roll of the cavity rotationally using the rotational alignment bridge and the "A" frame. Verify all four frame studs and "A" frame studs are tight when finished. |
| 5. Blow down the cavity with ionized N2 in accordance with the Ionized Nitrogen Cleaning Procedure.   * General cavity to Spec 2. * Cavity flange, bolt holes, and inside the right angle valve up to the valve stem to Spec 1. |
| 6. Prepare the Downstream Purge Line Spool for assembly to the cavity right angle valve.   * Set the purge software to "Standby" and verify the baratron is reading approximately 0. * Remove the blank, gasket, and all fasteners from the Spool. * Wipe bolt holes and flange sealing surface with IPA.   **Note:** One technician shall hold the Spool and point opening away from the string, people, and any other critical components such as a cavity bays and prepared / cleaned parts. Angle the opening towards the floor until the Spool is ready to be installed onto the right angle valve. A second technician shall perform the purge system set up and particle counts.   * Set the purge software to "Blowout". * Verify the purge turns on. * Flow N2 through the Spool until Spec 1 is reached for two full cycles. * Set the purge software to "Purge". |
| 7. Install the Downstream Purge Line to the cavity right angle valve.   * Place a new cleaned [Spec 1] gasket on the Spool. Use a large-bore gasket if available. * Install two pre-cleaned [Spec1] studs in a star pattern and snug with wrench. * Install the four remaining studs continuing the star pattern. * Torque all studs using a standard torque pattern for a round flange. * Repeat the final torque sequence twice and then go around all the studs at least twice or until there is no movement of the nuts. Stop if the flanges go metal-to-metal. * Verify the purge turns off. |
| 8. Pump down the purge line to the cavity right angle valve.   * Set the purge software to "Standby" for the Downstream Purge Line. * Pump down the purge header to the closed right angle valve on the cavity. Allow the header to pump to the mid E-5 mbar range. * Close the pump isolation valve. |
| 9. While monitoring the cavity pressure, slowly open the cavity right angle valve. If the cavity pressure reads at the mid E-4 mbar range or higher, notify the cleanroom supervisor. | [[CAV6VacuumOK]] <<YESNO>> |
| 10. Set the purge software to "Backfill" for the Downstream Purge Line and slowly backfill the cavity. |  |
| 11. When the cavity has been backfilled to the interlock value, change the purge software to "Purge". | [[CAV6PrepComment]] <<COMMENT>>  [[CAV6PrepTime]] <<TIMESTAMP>>  [[CAV6PrepTech]] <<SRFCVP>> |
| 19. | **Cavity 6 FPC Installation**  1. Gather the following components for the connection of the cold end coupler to the cavity. Verify the components are cleaned and ready for installation.   * 1 inspected and accepted FPC body * 1 FPC body flange alignment blank * 2 clean spring clamps * Fasteners * 1 hex seal gasket * Retainer clips * Wrenches |  |
| 2. Record the FPC Serial Number. | [[FPCCSN6]] <<FPCCSN>> |
| 3. Use the FPC body holding tool to hold and spray the FPC to Spec 1.  4. When all the N2 spraying is complete, carefully place the alignment tooling over the probe tip and onto the FPC body flange. Clamp in place with two spring clamps. Open the clamps down and away from the cavity.  5. Install the FPC onto the installation tooling and spray to Spec 1. |  |
| 6. Verify the purge software is set to "Purge" for the Downstream Purge Line.  7. Remove the 4 studs indicated in positions 1, 3, 5, and 7 in the drawing below from the cavity FPC flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure. Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    8. Install 2 pre-cleaned [Spec 1] studs in the open holes at positions 1 and 5 on the cavity and torque to 120 in-lbs.  9. Continue to remove all remaining original studs on the cavity flange in a star pattern, until only the two pre-cleaned studs remain installed.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure. Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  10. Hold the cavity FPC flange and the test coupler flange tight so that there is no movement of the flanges while studs are being removed.  Remove the pre-cleaned stud in position 1 on the cavity coupler flange and then remove the pre-cleaned stud in position 5 on the cavity coupler flange. Pull studs away from the cavity.  Carefully and slowly remove test coupler and gasket away from the cavity.  Verify the purge starts.  11. Install FPC alignment blank on cavity flange with spring clamps. Open the clamps down and away from the cavity. |  |
| 12. Install the FPC alignment table on the lollipop.  13. Align FPC to open holes on alignment blank.  14. Move FPC back as far as possible on the FPC table.  15. Remove the FPC coupler cover.  16. Install the FPC gasket with retaining clips to hold the gasket in place on the FPC. Verify the clips are placed in the horizontal position. |
| 17. Remove the alignment blank from the cavity.  18. Move FPC into place, remove the gasket clips, and install 2 pre-cleaned [Spec 1] studs in a star pattern to secure coupler. Snug studs with wrench.  19. Install 2 additional pre-cleaned [Spec 1] studs continuing the star pattern and snug with wrench.  20. Install remaining 4 studs in pairs continuing the star pattern on FPC flange. |
| 21. Torque all fasteners to 60 in-lbs using a standard torque pattern for a round flange.  22. Increase the torque wrench setting to 120 in-lbs and torque all fasteners using a standard torque pattern for a round flange.  23. Repeat the final torque sequence twice and then go around all the fasteners at least twice or until there is no movement of the nuts. Verify the purge stops. | [[FPC6InstallComment]] <<COMMENT>>  [[FPC6InstallTime]] <<TIMESTAMP>>  [[FPC6InstallTech]] <<SRFCVP>> |
| 24. Remove coupler alignment table from lollipop and install FPC support arm. | [[FPC6SupportArmInstalled]] <<YESNO>> |
| 20. | **Cavity 6 Assembly to Cavity String, including Bellows installation between Cavity 5 and Cavity 6**  1. Gather the following components. Verify the components are cleaned and ready for installation.   * 2 bellows flange alignment blanks * 1 beamline gasket * 4 covered spring clamps * Fasteners * Retainer clips * Wrenches |  |
| **Prepare the Bellows**  2. Place the bellows alignment table on the upstream lollipop for Cavity 6.  3. Place the bellows in the alignment fixture and align the two flanges.  4. Compress the bellows and install the bellows restraint blocks onto the bellows using 2 bolts per restraint. Use Ionized N2 to clean the bellows to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  5. Install the bellows in the alignment fixture. Use Ionized N2 to clean the bellows to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  6. Carefully place an alignment blank on both ends of the bellows. Clamp in place with two covered spring clamps per flange. Open the clamps down and away from the bellows. | [[BLBPSN5\_6]] <<BLBPSN>> |
| **Prepare the Cavity 6 Upstream Flange**  7. Verify the purge software is set to "Purge" for the Downstream Purge Line.  8. Remove the 4 studs indicated in the positions 3, 6, 9, and 12 in the drawing below from the cavity upstream end flange in a star pattern.  Then remove the studs in positions 2, 5, 8, and 11 from the cavity downstream end flange in a star pattern.  The 4 remaining studs shall be located every third hole in the flange.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    9. Install 4 new pre-cleaned [Spec 1] studs in positions 2, 5, 8, and 11 to ensure equal pressure on the gasket. Torque these pre-cleaned studs to 31 ft-lbs.  10. Remove final 4 original studs 2 at a time from the flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  11. Hold the cavity upstream end flange and beamline blank flange tight so that there is no movement of the flanges while studs are being removed.  Remove the stud in position 5, pulling the stud away from the cavity.  Then remove the stud in position 11, pulling the stud away the cavity.  Then remove the stud in position 2, pulling the stud away the cavity.  Then remove the stud in position 8, pulling the stud away the cavity.  Carefully and slowly remove the blank and gasket away from the cavity.  Verify the purge starts.  12. Carefully place an alignment blank on the cavity flange. Verify that the alignment pins on the cavity flange do not line up with the alignment pins on the bellows. Clamp in place with two cleaned spring clamps. Open the clamps down and away from the open cavity flange. |  |
| **Align the Bellows Non-Rotatable Flange and the Cavity 6 Upstream Flanges**  13. Carefully place the cleaned bellows holder with the bellows on the alignment table. The bellows not-rotatable flange shall be facing Cavity 6.  14. Slowly slide the bellows towards Cavity 6 to check flange alignment. The nipples on the alignment blanks should move freely into the indents of the flanges. A slight rotation of the bellows flange can be performed if necessary during the alignment process.  15. Move the cavity away from the bellows flange. |
| **Install the Bellows to Cavity 6**  16. Carefully remove the alignment blanks from the bellows non-rotatable flange and the cavity.  17. Install the beamline gasket with retaining clips to hold the gasket in place on the bellows flange. Verify the clips are placed in the horizontal position.  18. Slowly slide the cavity back into place against the gasket. Remove the gasket clips.  19. Hold the flanges tightly together, preventing the flanges from rotating or moving away from each other, until the first 4 studs have been snugged tight with a wrench.  20. Place 4 pre-cleaned [Spec 1] studs in a star pattern in the cavity flange and snug them with a wrench.  21. Place the remaining fasteners on the flange continuing the star pattern and snug all of them with a wrench.  22. Torque the fasteners to 15 ft-lbs using a standard torquing pattern for a round flange. Do not increase torque at this time. Final torqueing will be performed after both ends of the bellows have been attached to the cavities.  23. Remove the bellows holder and adjustable table from the lollipop. |
| **Prepare Cavity 5 Downstream Flange**  24. Verify the purge software is set to "Purge" for the Upstream Purge Line.  25. Remove the 4 studs indicated in positions 3, 6, 9, and 12 in the drawing below from the cavity downstream end flange in a star pattern.  Then remove the studs in positions 2, 5, 8, and 11 from the cavity downstream end flange in a star pattern.  The 4 remaining studs shall be located every third hole in the flange.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    26. Install 4 new pre-cleaned [Spec 1] studs in positions 2, 5, 8, and 11 in a star pattern to ensure equal pressure on the gasket. Torque these pre-cleaned studs to 31 ft-lbs.  27. Remove final 4 original studs 2 at a time from the flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  28. Hold the cavity downstream end flange and right angle valve sub-assembly flange tight so that there is no movement of the flanges while studs are being removed.  Remove the stud in position 5, pulling the stud away from the cavity.  Then remove the stud in position 11, pulling the stud away the cavity.  Then remove the stud in position 2, pulling the stud away the cavity.  Then remove the stud in position 8, pulling the stud away the cavity.  Carefully and slowly remove the blank and gasket away from the cavity.  Verify the purge starts.  29. Carefully place an alignment blank on the cavity flange. Verify that the alignment pins on the cavity flange do not line up with the alignment pins on the bellows. Clamp in place with two cleaned spring clamps. Open the clamps down and away from the cavity. |  |
| **Align the Bellows Rotatable Flange and Cavity 5 Downstream Flange**  30. Slowly slide Cavity 6 towards Cavity 5 to check bellows rotatable flange alignment. The nipples on the flange alignment covers should move freely into the indents of the flanges. A slight rotation of the bellows flange can be performed if necessary during the alignment process. A bolt on each bellows restraint block can be loosened to allow for the rotatable flange to be adjusted if needed.  31. Move Cavity 6 away from Cavity 5.  32. Carefully remove the alignment covers from the bellows rotatable flange and Cavity 5. |
| **Install the Bellows to Cavity 5**  33. Carefully remove the alignment blanks from the bellows rotatable flange and the cavity.  34. Install the beamline gasket with retaining clips to hold the gasket in place on the bellows flange. Verify the clips are placed in the horizontal position.  35. Slowly slide the cavity back into place against the gasket. Remove the gasket clips.  36. Hold the flanges tightly together, preventing the flanges from rotating or moving away from each other, until the first 4 studs have been snugged tight with a wrench.  37. Place 4 pre-cleaned [Spec 1] studs in a star pattern in the cavity flange and snug them with a wrench.  38. Place the remaining fasteners on the flange continuing the star pattern and snug all of them with a wrench.  39. Torque the fasteners to 15 ft-lbs using a standard torquing pattern for a round flange. |
| **Final Torquing of Bellows Flanges to Cavities**  40. Torque all the fasteners on the Cavity 6 side of the bellows to 31 ft-lbs using a standard torquing pattern for a round flange.  41. Torque all the fasteners on the Cavity 5 side of the bellows to 31 ft-lbs using a standard torquing pattern for a round flange.  42. On the Cavity 6 side, repeat the final torque sequence twice and then go around all of the fasteners at least twice or until there is no movement of the nuts.  43. On the Cavity 5 side, repeat the final torque sequence twice and then go around all of the fasteners at least twice or until there is no movement of the nuts.  44. Verify the purge system turns off.  45. Install rail locks on Cavity 6 to lock it in place. | [[Bellows5\_6\_Comment]] <<COMMENT>>  [[Bellows5\_6\_Time]] <<TIMESTAMP>>  [[Bellows5\_6\_Tech1]] <<SRFCVP>>  [[Bellows5\_6\_Tech2]] <<SRFCVP>> |
| **Remove Purge System Hose from Cavity 6**  46. Set the purge software to "Standby" state for the Downstream Purge Line.  47. Slowly close the cavity right angle valve.  48. Remove the purge system hose from the cavity.  49. Put a blank on the Spool with two studs using the same gasket. |  |

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| Step No. | Instructions | Data Input |
| 21. | **Cavity 7 Prep**  1. Record Cavity 7 serial number. | [[CAVSN7]] <<CAVSN>> |
| 2. Put the cavity on the rail tooling with the blank flange facing the upstream gate valve sub-assembly [GV1SA] and the FPC facing the southeast corner of the cleanroom. |  |
| **Note: There will be some movement of flange location and/or cavity level every time something is adjusted. Several iterations of the cavity alignment will be required before the cavity will be perfectly level and have both beamline flanges in place.**  3. Align Cavity 7 and the upstream flange of Cavity 6. The cavity shall be aligned with the flange alignment tool to locate the beamline flange in the proper location.   * Verify the location of the flange is near the center of the range of the tooling to accommodate the alignment of all the cavities in the string. * After both flanges of the cavity are in the same position - relative to the rail - set the roll of the cavity level using a precision level on the leveling tool, which is attached to the other set of helium vessel blocks. |
| 4. Set the roll of the cavity rotationally using the rotational alignment bridge and the "A" frame. Verify all four frame studs and "A" frame studs are tight when finished. |
| 5. Blow down the cavity with ionized N2 in accordance with the Ionized Nitrogen Cleaning Procedure.   * General cavity to Spec 2. * Cavity flange, bolt holes, and inside the right angle valve up to the valve stem to Spec 1. |
| 6. Prepare the Downstream Purge Line Spool for assembly to the cavity right angle valve.   * Set the purge software to "Standby" and verify the baratron is reading approximately 0. * Remove the blank, gasket, and all fasteners from the Spool. * Wipe bolt holes and flange sealing surface with IPA.   **Note:** One technician shall hold the Spool and point opening away from the string, people, and any other critical components such as a cavity bays and prepared / cleaned parts. Angle the opening towards the floor until the Spool is ready to be installed onto the right angle valve. A second technician shall perform the purge system set up and particle counts.   * Set the purge software to "Blowout". * Verify the purge turns on. * Flow N2 through the Spool until Spec 1 is reached for two full cycles. * Set the purge software to "Purge". |
| 7. Install the Downstream Purge Line to the cavity right angle valve.   * Place a new cleaned [Spec 1] gasket on the Spool. Use a large-bore gasket if available. * Install two pre-cleaned [Spec1] studs in a star pattern and snug with wrench. * Install the four remaining studs continuing the star pattern. * Torque all studs using a standard torque pattern for a round flange. * Repeat the final torque sequence twice and then go around all the studs at least twice or until there is no movement of the nuts. Stop if the flanges go metal-to-metal. * Verify the purge turns off. |
| 8. Pump down the purge line to the cavity right angle valve.   * Set the purge software to "Standby" for the Downstream Purge Line. * Pump down the purge header to the closed right angle valve on the cavity. Allow the header to pump to the mid E-5 mbar range. * Close the pump isolation valve. |
| 9. While monitoring the cavity pressure, slowly open the cavity right angle valve. If the cavity pressure reads at the mid E-4 mbar range or higher, notify the cleanroom supervisor. | [[CAV7VacuumOK]] <<YESNO>> |
| 10. Set the purge software to "Backfill" for the Downstream Purge Line and slowly backfill the cavity. |  |
| 11. When the cavity has been backfilled to the interlock value, change the purge software to "Purge". | [[CAV7PrepComment]] <<COMMENT>>  [[CAV7PrepTime]] <<TIMESTAMP>>  [[CAV7PrepTech]] <<SRFCVP>> |
| 22. | **Cavity 7 FPC Installation**  1. Gather the following components for the connection of the cold end coupler to the cavity. Verify the components are cleaned and ready for installation.   * 1 inspected and accepted FPC body * 1 FPC body flange alignment blank * 2 clean spring clamps * Fasteners * 1 hex seal gasket * Retainer clips * Wrenches |  |
| 2. Record the FPC Serial Number. | [[FPCCSN7]] <<FPCCSN>> |
| 3. Use the FPC body holding tool to hold and spray the FPC to Spec 1.  4. When all the N2 spraying is complete, carefully place the alignment tooling over the probe tip and onto the FPC body flange. Clamp in place with two spring clamps. Open the clamps down and away from the cavity.  5. Install the FPC onto the installation tooling and spray to Spec 1. |  |
| 6. Verify the purge software is set to "Purge" for the Downstream Purge Line.  7. Remove the 4 studs indicated in positions 1, 3, 5, and 7 in the drawing below from the cavity FPC flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure. Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    8. Install 2 pre-cleaned [Spec 1] studs in the open holes at positions 1 and 5 on the cavity and torque to 120 in-lbs.  9. Continue to remove all remaining original studs on the cavity flange in a star pattern, until only the two pre-cleaned studs remain installed.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure. Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  10. Hold the cavity FPC flange and the test coupler flange tight so that there is no movement of the flanges while studs are being removed.  Remove the pre-cleaned stud in position 1 on the cavity coupler flange and then remove the pre-cleaned stud in position 5 on the cavity coupler flange. Pull studs away from the cavity.  Carefully and slowly remove test coupler and gasket away from the cavity.  Verify the purge starts.  11. Install FPC alignment blank on cavity flange with spring clamps. Open the clamps down and away from the cavity. |  |
| 12. Install the FPC alignment table on the lollipop.  13. Align FPC to open holes on alignment blank.  14. Move FPC back as far as possible on the FPC table.  15. Remove the FPC coupler cover.  16. Install the FPC gasket with retaining clips to hold the gasket in place on the FPC. Verify the clips are placed in the horizontal position. |
| 17. Remove the alignment blank from the cavity.  18. Move FPC into place, remove the gasket clips, and install 2 pre-cleaned [Spec 1] studs in a star pattern to secure coupler. Snug studs with wrench.  19. Install 2 additional pre-cleaned [Spec 1] studs continuing the star pattern and snug with wrench.  20. Install remaining 4 studs in pairs continuing the star pattern on FPC flange. |
| 21. Torque all fasteners to 60 in-lbs using a standard torque pattern for a round flange.  22. Increase the torque wrench setting to 120 in-lbs and torque all fasteners using a standard torque pattern for a round flange.  23. Repeat the final torque sequence twice and then go around all the fasteners at least twice or until there is no movement of the nuts. Verify the purge stops. | [[FPC7InstallComment]] <<COMMENT>>  [[FPC7InstallTime]] <<TIMESTAMP>>  [[FPC7InstallTech]] <<SRFCVP>> |
| 24. Remove coupler alignment table from lollipop and install FPC support arm. | [[FPC7SupportArmInstalled]] <<YESNO>> |
| 23. | **Cavity 7 Assembly to Cavity String, including Bellows installation between Cavity 6 and Cavity 7**  1. Gather the following components. Verify the components are cleaned and ready for installation.   * 2 bellows flange alignment blanks * 1 beamline gasket * 4 covered spring clamps * Fasteners * Retainer clips * Wrenches |  |
| **Prepare the Bellows**  2. Place the bellows alignment table on the upstream lollipop for Cavity 7.  3. Place the bellows in the alignment fixture and align the two flanges.  4. Compress the bellows and install the bellows restraint blocks onto the bellows using 2 bolts per restraint. Use Ionized N2 to clean the bellows to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  5. Install the bellows in the alignment fixture. Use Ionized N2 to clean the bellows to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  6. Carefully place an alignment blank on both ends of the bellows. Clamp in place with two covered spring clamps per flange. Open the clamps down and away from the bellows. | [[BLBPSN6\_7]] <<BLBPSN>> |
| **Prepare the Cavity 7 Upstream Flange**  7. Verify the purge software is set to "Purge" for the Downstream Purge Line.  8. Remove the 4 studs indicated in the positions 3, 6, 9, and 12 in the drawing below from the cavity upstream end flange in a star pattern.  Then remove the studs in positions 2, 5, 8, and 11 from the cavity downstream end flange in a star pattern.  The 4 remaining studs shall be located every third hole in the flange.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    9. Install 4 new pre-cleaned [Spec 1] studs in positions 2, 5, 8, and 11 to ensure equal pressure on the gasket. Torque these pre-cleaned studs to 31 ft-lbs.  10. Remove final 4 original studs 2 at a time from the flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  11. Hold the cavity upstream end flange and beamline blank flange tight so that there is no movement of the flanges while studs are being removed.  Remove the stud in position 5, pulling the stud away from the cavity.  Then remove the stud in position 11, pulling the stud away the cavity.  Then remove the stud in position 2, pulling the stud away the cavity.  Then remove the stud in position 8, pulling the stud away the cavity.  Carefully and slowly remove the blank and gasket away from the cavity.  Verify the purge starts.  12. Carefully place an alignment blank on the cavity flange. Verify that the alignment pins on the cavity flange do not line up with the alignment pins on the bellows. Clamp in place with two cleaned spring clamps. Open the clamps down and away from the open cavity flange. |  |
| **Align the Bellows Non-Rotatable Flange and the Cavity 7 Upstream Flanges**  13. Carefully place the cleaned bellows holder with the bellows on the alignment table. The bellows not-rotatable flange shall be facing Cavity 7.  14. Slowly slide the bellows towards Cavity 7 to check flange alignment. The nipples on the alignment blanks should move freely into the indents of the flanges. A slight rotation of the bellows flange can be performed if necessary during the alignment process.  15. Move the cavity away from the bellows flange. |
| **Install the Bellows to Cavity 7**  16. Carefully remove the alignment blanks from the bellows non-rotatable flange and the cavity.  17. Install the beamline gasket with retaining clips to hold the gasket in place on the bellows flange. Verify the clips are placed in the horizontal position.  18. Slowly slide the cavity back into place against the gasket. Remove the gasket clips.  19. Hold the flanges tightly together, preventing the flanges from rotating or moving away from each other, until the first 4 studs have been snugged tight with a wrench.  20. Place 4 pre-cleaned [Spec 1] studs in a star pattern in the cavity flange and snug them with a wrench.  21. Place the remaining fasteners on the flange continuing the star pattern and snug all of them with a wrench.  22. Torque the fasteners to 15 ft-lbs using a standard torquing pattern for a round flange. Do not increase torque at this time. Final torqueing will be performed after both ends of the bellows have been attached to the cavities.  23. Remove the bellows holder and adjustable table from the lollipop. |
| **Prepare Cavity 6 Downstream Flange**  24. Verify the purge software is set to "Purge" for the Upstream Purge Line.  25. Remove the 4 studs indicated in positions 3, 6, 9, and 12 in the drawing below from the cavity downstream end flange in a star pattern.  Then remove the studs in positions 2, 5, 8, and 11 from the cavity downstream end flange in a star pattern.  The 4 remaining studs shall be located every third hole in the flange.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    26. Install 4 new pre-cleaned [Spec 1] studs in positions 2, 5, 8, and 11 in a star pattern to ensure equal pressure on the gasket. Torque these pre-cleaned studs to 31 ft-lbs.  27. Remove final 4 original studs 2 at a time from the flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  28. Hold the cavity downstream end flange and right angle valve sub-assembly flange tight so that there is no movement of the flanges while studs are being removed.  Remove the stud in position 5, pulling the stud away from the cavity.  Then remove the stud in position 11, pulling the stud away the cavity.  Then remove the stud in position 2, pulling the stud away the cavity.  Then remove the stud in position 8, pulling the stud away the cavity.  Carefully and slowly remove the blank and gasket away from the cavity.  Verify the purge starts.  29. Carefully place an alignment blank on the cavity flange. Verify that the alignment pins on the cavity flange do not line up with the alignment pins on the bellows. Clamp in place with two cleaned spring clamps. Open the clamps down and away from the cavity. |  |
| **Align the Bellows Rotatable Flange and Cavity 6 Downstream Flange**  30. Slowly slide Cavity 7 towards Cavity 6 to check bellows rotatable flange alignment. The nipples on the flange alignment covers should move freely into the indents of the flanges. A slight rotation of the bellows flange can be performed if necessary during the alignment process. A bolt on each bellows restraint block can be loosened to allow for the rotatable flange to be adjusted if needed.  31. Move Cavity 7 away from Cavity 6.  32. Carefully remove the alignment covers from the bellows rotatable flange and Cavity 6. |
| **Install the Bellows to Cavity 6**  33. Carefully remove the alignment blanks from the bellows rotatable flange and the cavity.  34. Install the beamline gasket with retaining clips to hold the gasket in place on the bellows flange. Verify the clips are placed in the horizontal position.  35. Slowly slide the cavity back into place against the gasket. Remove the gasket clips.  36. Hold the flanges tightly together, preventing the flanges from rotating or moving away from each other, until the first 4 studs have been snugged tight with a wrench.  37. Place 4 pre-cleaned [Spec 1] studs in a star pattern in the cavity flange and snug them with a wrench.  38. Place the remaining fasteners on the flange continuing the star pattern and snug all of them with a wrench.  39. Torque the fasteners to 15 ft-lbs using a standard torquing pattern for a round flange. |
| **Final Torquing of Bellows Flanges to Cavities**  40. Torque all the fasteners on the Cavity 7 side of the bellows to 31 ft-lbs using a standard torquing pattern for a round flange.  41. Torque all the fasteners on the Cavity 6 side of the bellows to 31 ft-lbs using a standard torquing pattern for a round flange.  42. On the Cavity 7 side, repeat the final torque sequence twice and then go around all of the fasteners at least twice or until there is no movement of the nuts.  43. On the Cavity 6 side, repeat the final torque sequence twice and then go around all of the fasteners at least twice or until there is no movement of the nuts.  44. Verify the purge system turns off.  45. Install rail locks on Cavity 7 to lock it in place. | [[Bellows6\_7\_Comment]] <<COMMENT>>  [[Bellows6\_7\_Time]] <<TIMESTAMP>>  [[Bellows6\_7\_Tech1]] <<SRFCVP>>  [[Bellows6\_7\_Tech2]] <<SRFCVP>> |
| **Remove Purge System Hose from Cavity 7**  46. Set the purge software to "Standby" state for the Downstream Purge Line.  47. Slowly close the cavity right angle valve.  48. Remove the purge system hose from the cavity.  49. Put a blank on the Spool with two studs using the same gasket. |  |

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| Step No. | Instructions | Data Input |
| 24. | **Cavity 8 Prep**  1. Record Cavity 8 serial number. | [[CAVSN8]] <<CAVSN>> |
| 2. Put the cavity on the rail tooling with the blank flange facing the upstream gate valve sub-assembly [GV1SA] and the FPC facing the southeast corner of the cleanroom. |  |
| **Note: There will be some movement of flange location and/or cavity level every time something is adjusted. Several iterations of the cavity alignment will be required before the cavity will be perfectly level and have both beamline flanges in place.**  3. Align Cavity 8 and the upstream flange of Cavity 7. The cavity shall be aligned with the flange alignment tool to locate the beamline flange in the proper location.   * Verify the location of the flange is near the center of the range of the tooling to accommodate the alignment of all the cavities in the string. * After both flanges of the cavity are in the same position - relative to the rail - set the roll of the cavity level using a precision level on the leveling tool, which is attached to the other set of helium vessel blocks. |
| 4. Set the roll of the cavity rotationally using the rotational alignment bridge and the "A" frame. Verify all four frame studs and "A" frame studs are tight when finished. |
| 5. Blow down the cavity with ionized N2 in accordance with the Ionized Nitrogen Cleaning Procedure.   * General cavity to Spec 2. * Cavity flange, bolt holes, and inside the right angle valve up to the valve stem to Spec 1. |
| 6. Prepare the Downstream Purge Line Spool for assembly to the cavity right angle valve.   * Set the purge software to "Standby" and verify the baratron is reading approximately 0. * Remove the blank, gasket, and all fasteners from the Spool. * Wipe bolt holes and flange sealing surface with IPA.   **Note:** One technician shall hold the Spool and point opening away from the string, people, and any other critical components such as a cavity bays and prepared / cleaned parts. Angle the opening towards the floor until the Spool is ready to be installed onto the right angle valve. A second technician shall perform the purge system set up and particle counts.   * Set the purge software to "Blowout". * Verify the purge turns on. * Flow N2 through the Spool until Spec 1 is reached for two full cycles. * Set the purge software to "Purge". |
| 7. Install the Downstream Purge Line to the cavity right angle valve.   * Place a new cleaned [Spec 1] gasket on the Downstream Purge Line Spool. Use a large-bore gasket if available. * Install two pre-cleaned [Spec1] studs in a star pattern and snug with wrench. * Install the four remaining studs continuing the star pattern. * Torque all studs using a standard torque pattern for a round flange. * Repeat the final torque sequence twice and then go around all the studs at least twice or until there is no movement of the nuts. Stop if the flanges go metal-to-metal. * Verify the purge turns off. |
| 8. Pump down the purge line to the cavity right angle valve.   * Set the purge software to "Standby" for the Downstream Purge Line. * Pump down the purge header to the closed right angle valve on the cavity. Allow the header to pump to the mid E-5 mbar range. * Close the pump isolation valve. |
| 9. While monitoring the cavity pressure, slowly open the cavity right angle valve. If the cavity pressure reads at the mid E-4 mbar range or higher, notify the cleanroom supervisor. | [[CAV8VacuumOK]] <<YESNO>> |
| 10. Set the purge software to "Backfill" for the Downstream Purge Line and slowly backfill the cavity. |  |
| 11. When the cavity has been backfilled to the interlock value, change the purge software to "Purge". | [[CAV8PrepComment]] <<COMMENT>>  [[CAV8PrepTime]] <<TIMESTAMP>>  [[CAV8PrepTech]] <<SRFCVP>> |
| 25. | **Cavity 8 FPC Installation**  1. Gather the following components for the connection of the cold end coupler to the cavity. Verify the components are cleaned and ready for installation.   * 1 inspected and accepted FPC body * 1 FPC body flange alignment blank * 2 clean spring clamps * Fasteners * 1 hex seal gasket * Retainer clips * Wrenches |  |
| 2. Record the FPC Serial Number. | [[FPCCSN8]] <<FPCCSN>> |
| 3. Use the FPC body holding tool to hold and spray the FPC to Spec 1.  4. When all the N2 spraying is complete, carefully place the alignment tooling over the probe tip and onto the FPC body flange. Clamp in place with two spring clamps. Open the clamps down and away from the cavity.  5. Install the FPC onto the installation tooling and spray to Spec 1. |  |
| 6. Verify the purge software is set to "Purge" for the Downstream Purge Line.  7. Remove the 4 studs indicated in positions 1, 3, 5, and 7 in the drawing below from the cavity FPC flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure. Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    8. Install 2 pre-cleaned [Spec 1] studs in the open holes at positions 1 and 5 on the cavity and torque to 120 in-lbs.  9. Continue to remove all remaining original studs on the cavity flange in a star pattern, until only the two pre-cleaned studs remain installed.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure. Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  10. Hold the cavity FPC flange and the test coupler flange tight so that there is no movement of the flanges while studs are being removed.  Remove the pre-cleaned stud in position 1 on the cavity coupler flange and then remove the pre-cleaned stud in position 5 on the cavity coupler flange. Pull studs away from the cavity.  Carefully and slowly remove test coupler and gasket away from the cavity.  Verify the purge starts.  11. Install FPC alignment blank on cavity flange with spring clamps. Open the clamps down and away from the cavity. |  |
| 12. Install the FPC alignment table on the lollipop.  13. Align FPC to open holes on alignment blank.  14. Move FPC back as far as possible on the FPC table.  15. Remove the FPC coupler cover.  16. Install the FPC gasket with retaining clips to hold the gasket in place on the FPC. Verify the clips are placed in the horizontal position. |
| 17. Remove the alignment blank from the cavity.  18. Move FPC into place, remove the gasket clips, and install 2 pre-cleaned [Spec 1] studs in a star pattern to secure coupler. Snug studs with wrench.  19. Install 2 additional pre-cleaned [Spec 1] studs continuing the star pattern and snug with wrench.  20. Install remaining 4 studs in pairs continuing the star pattern on FPC flange. |
| 21. Torque all fasteners to 60 in-lbs using a standard torque pattern for a round flange.  22. Increase the torque wrench setting to 120 in-lbs and torque all fasteners using a standard torque pattern for a round flange.  23. Repeat the final torque sequence twice and then go around all the fasteners at least twice or until there is no movement of the nuts. Verify the purge stops. | [[FPC8InstallComment]] <<COMMENT>>  [[FPC8InstallTime]] <<TIMESTAMP>>  [[FPC8InstallTech]] <<SRFCVP>> |
| 24. Remove coupler alignment table from lollipop and install FPC support arm. | [[FPC8SupportArmInstalled]] <<YESNO>> |
| 26. | **Cavity 8 Assembly to Cavity String, including Bellows installation between Cavity 7 and Cavity 8**  1. Gather the following components. Verify the components are cleaned and ready for installation.   * 2 bellows flange alignment blanks * 1 beamline gasket * 4 covered spring clamps * Fasteners * Retainer clips * Wrenches |  |
| **Prepare the Bellows**  2. Place the bellows alignment table on the upstream lollipop for Cavity 8.  3. Place the bellows in the alignment fixture and align the two flanges.  4. Compress the bellows and install the bellows restraint blocks onto the bellows using 2 bolts per restraint. Use Ionized N2 to clean the bellows to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  5. Install the bellows in the alignment fixture. Use Ionized N2 to clean the bellows to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  6. Carefully place an alignment blank on both ends of the bellows. Clamp in place with two covered spring clamps per flange. Open the clamps down and away from the bellows. | [[BLBPSN7\_8]] <<BLBPSN>> |
| **Prepare the Cavity 8 Upstream Flange**  7. Verify the purge software is set to "Purge" for the Downstream Purge Line.  8. Remove the 4 studs indicated in the positions 3, 6, 9, and 12 in the drawing below from the cavity upstream end flange in a star pattern.  Then remove the studs in positions 2, 5, 8, and 11 from the cavity downstream end flange in a star pattern.  The 4 remaining studs shall be located every third hole in the flange.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    9. Install 4 new pre-cleaned [Spec 1] studs in positions 2, 5, 8, and 11 to ensure equal pressure on the gasket. Torque these pre-cleaned studs to 31 ft-lbs.  10. Remove final 4 original studs 2 at a time from the flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  11. Hold the cavity upstream end flange and beamline blank flange tight so that there is no movement of the flanges while studs are being removed.  Remove the stud in position 5, pulling the stud away from the cavity.  Then remove the stud in position 11, pulling the stud away the cavity.  Then remove the stud in position 2, pulling the stud away the cavity.  Then remove the stud in position 8, pulling the stud away the cavity.  Carefully and slowly remove the blank and gasket away from the cavity.  Verify the purge starts.  12. Carefully place an alignment blank on the cavity flange. Verify that the alignment pins on the cavity flange do not line up with the alignment pins on the bellows. Clamp in place with two cleaned spring clamps. Open the clamps down and away from the open cavity flange. |  |
| **Align the Bellows Non-Rotatable Flange and the Cavity 8 Upstream Flanges**  13. Carefully place the cleaned bellows holder with the bellows on the alignment table. The bellows not-rotatable flange shall be facing Cavity 8.  14. Slowly slide the bellows towards Cavity 8 to check flange alignment. The nipples on the alignment blanks should move freely into the indents of the flanges. A slight rotation of the bellows flange can be performed if necessary during the alignment process.  15. Move the cavity away from the bellows flange. |
| **Install the Bellows to Cavity 8**  16. Carefully remove the alignment blanks from the bellows non-rotatable flange and the cavity.  17. Install the beamline gasket with retaining clips to hold the gasket in place on the bellows flange. Verify the clips are placed in the horizontal position.  18. Slowly slide the cavity back into place against the gasket. Remove the gasket clips.  19. Hold the flanges tightly together, preventing the flanges from rotating or moving away from each other, until the first 4 studs have been snugged tight with a wrench.  20. Place 4 pre-cleaned [Spec 1] studs in a star pattern in the cavity flange and snug them with a wrench.  21. Place the remaining fasteners on the flange continuing the star pattern and snug all of them with a wrench.  22. Torque the fasteners to 15 ft-lbs using a standard torquing pattern for a round flange. Do not increase torque at this time. Final torqueing will be performed after both ends of the bellows have been attached to the cavities.  23. Remove the bellows holder and adjustable table from the lollipop. |
| **Prepare Cavity 7 Downstream Flange**  24. Verify the purge software is set to "Purge" for the Upstream Purge Line.  25. Remove the 4 studs indicated in positions 3, 6, 9, and 12 in the drawing below from the cavity downstream end flange in a star pattern.  Then remove the studs in positions 2, 5, 8, and 11 from the cavity downstream end flange in a star pattern.  The 4 remaining studs shall be located every third hole in the flange.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    26. Install 4 new pre-cleaned [Spec 1] studs in positions 2, 5, 8, and 11 in a star pattern to ensure equal pressure on the gasket. Torque these pre-cleaned studs to 31 ft-lbs.  27. Remove final 4 original studs 2 at a time from the flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  28. Hold the cavity downstream end flange and right angle valve sub-assembly flange tight so that there is no movement of the flanges while studs are being removed.  Remove the stud in position 5, pulling the stud away from the cavity.  Then remove the stud in position 11, pulling the stud away the cavity.  Then remove the stud in position 2, pulling the stud away the cavity.  Then remove the stud in position 8, pulling the stud away the cavity.  Carefully and slowly remove the blank and gasket away from the cavity.  Verify the purge starts.  29. Carefully place an alignment blank on the cavity flange. Verify that the alignment pins on the cavity flange do not line up with the alignment pins on the bellows. Clamp in place with two cleaned spring clamps. Open the clamps down and away from the cavity. |  |
| **Align the Bellows Rotatable Flange and Cavity 7 Downstream Flange**  30. Slowly slide Cavity 8 towards Cavity 7 to check bellows rotatable flange alignment. The nipples on the flange alignment covers should move freely into the indents of the flanges. A slight rotation of the bellows flange can be performed if necessary during the alignment process. A bolt on each bellows restraint block can be loosened to allow for the rotatable flange to be adjusted if needed.  31. Move Cavity 8 away from Cavity 7.  32. Carefully remove the alignment covers from the bellows rotatable flange and Cavity 7. |
| **Install the Bellows to Cavity 7**  33. Carefully remove the alignment blanks from the bellows rotatable flange and the cavity.  34. Install the beamline gasket with retaining clips to hold the gasket in place on the bellows flange. Verify the clips are placed in the horizontal position.  35. Slowly slide the cavity back into place against the gasket. Remove the gasket clips.  36. Hold the flanges tightly together, preventing the flanges from rotating or moving away from each other, until the first 4 studs have been snugged tight with a wrench.  37. Place 4 pre-cleaned [Spec 1] studs in a star pattern in the cavity flange and snug them with a wrench.  38. Place the remaining fasteners on the flange continuing the star pattern and snug all of them with a wrench.  39. Torque the fasteners to 15 ft-lbs using a standard torquing pattern for a round flange. |
| **Final Torquing of Bellows Flanges to Cavities**  40. Torque all the fasteners on the Cavity 8 side of the bellows to 31 ft-lbs using a standard torquing pattern for a round flange.  41. Torque all the fasteners on the Cavity 7 side of the bellows to 31 ft-lbs using a standard torquing pattern for a round flange.  42. On the Cavity 8 side, repeat the final torque sequence twice and then go around all of the fasteners at least twice or until there is no movement of the nuts.  43. On the Cavity 7 side, repeat the final torque sequence twice and then go around all of the fasteners at least twice or until there is no movement of the nuts.  44. Verify the purge system turns off.  45. Install rail locks on Cavity 8 to lock it in place. | [[Bellows7\_8\_Comment]] <<COMMENT>>  [[Bellows7\_8\_Time]] <<TIMESTAMP>>  [[Bellows7\_8\_Tech1]] <<SRFCVP>>  [[Bellows7\_8\_Tech2]] <<SRFCVP>> |
| **Remove Purge System Hose from Cavity 8**  46. Set the purge software to "Standby" state for the Downstream Purge Line.  47. Slowly close the cavity right angle valve.  48. Remove the purge system hose from the cavity.  49. Put a blank on the Spool with two studs using the same gasket. |  |

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| Step No. | Instructions | Data Input |
| 27. | **Downstream Gate Valve Sub-Assembly [GV2SA] Prep**  1. Record downstream gate valve serial number. | [[AMGVSN2]] <<AMGVSN>>  [[Lookup the AMGVSN provided in this traveler against AMGVSN in L2HE-CLNRM-GV2SA-ASSY traveler, and auto populate the following fields in this traveler:   |  |  | | --- | --- | | L2HE-CLNRM-CST-ASSY data field name | L2HE-CLNRM-GV2SA-ASSY data field name | | BLBSSN | BellowsSN | | BPMSN | BPMSN | | BPMFTSN1 | BPMFTSN1 | | BPMFTSN2 | BPMFTSN2 | | BPMFTSN3 | BPMFTSN3 | | BPMFTSN4 | BPMFTSN4 | | BLXDSN | BLXDSN |   ]] <<NOTE>> |
| 2. Record downstream bellows serial number. | [[BLBSSN]] <<BLBSSN>> |
| 3. Record BPM serial numbers. | [[BPMSN]] <<BPMSN>>  [[BPMFTSN1]] <<BPMFTSN>>  [[BPMFTSN2]] <<BPMFTSN>>  [[BPMFTSN3]] <<BPMFTSN>>  [[BPMFTSN4]] <<BPMFTSN>>  [[BLXDSN]] <<BLXDSN>> |
| 4. Transfer GV2SA on to the lollipop system. Verify that the gate valve handle is facing the power coupler direction. |  |
| 5. Perform an alignment of GV2SA.   * Align the magnet flange to the cavities using the magnet flange leveling tool. * Lock GV2SA in place with the leveling studs of the gate valve holder. |
| 6. Blow down GV2SA with ionized N2 to Spec 2 in accordance with the Ionized Nitrogen Cleaning Procedure. |
| 7. Prepare the Downstream Purge Line Spool for assembly to the GV2SA right angle valve.   * Set the purge software to "Standby" and verify the baratron is reading approximately 0. * Remove the blank, gasket, and all fasteners from the Spool. * Wipe bolt holes and flange sealing surface with IPA.   **Note:** One technician shall hold the Spool and point opening away from the string, people, and any other critical components such as a cavity bays and prepared / cleaned parts. Angle the opening towards the floor until the Spool is ready to be installed onto the right angle valve. A second technician shall perform the purge system set up and particle counts.   * Set the purge software to "Blowout". * Verify the purge turns on. * Flow N2 through the Spool until Spec 1 is reached for two full cycles. * Set the purge software to "Purge". |
| 8. Install the Downstream Purge Line to the NEG Manifold right angle valve.   * Blow down the NEG Manifold right angle valve, including the flange, bolt holes, and inside the valve up to the valve stem. * Place a new cleaned [Spec 1] gasket on the Purge Line Spool. * Install two pre-cleaned [Spec 1] studs in a star pattern and snug with a wrench. * Install the four remaining studs continuing the star pattern. * Torque all studs using a standard torque pattern for a round flange. * Repeat the final torque sequence twice and then go around all the studs at least twice or until there is no movement of the nuts. Stop if the flanges go metal-to-metal. * Verify the purge turns off. |
| 9. Pump down the purge line to GV2SA right angle valve.   * Set the purge software to "Standby". * Pump down the purge header to the closed right angle valve on GV2SA. Allow the header to pump to the mid E-5 mbar range. * Close the pump isolation valve. |  |
| 10. While monitoring the GV2SA pressure, slowly open GV2SA right angle valve. If the GV2SA pressure reads at the mid E-4 mbar range or higher, notify the cleanroom supervisor. | [[GV2SA\_VacuumOK]] <<YESNO>> |
| 11. Set the purge software to "Backfill" and slowly backfill GV2SA. |  |
| 12. When GV2SA has been backfilled to the interlock value, change the purge software to "Purge". | [[GV2SAPrepComment]] <<COMMENT>>  [[GV2SAPrepTime]] <<TIMESTAMP>>  [[GV2SAPrepTech1]] <<SRFCVP>> |
| 28. | **Downstream Gate Valve Sub-Assembly to Cavity 8 Assembly**  1. Gather the following components. Verify the components are cleaned and ready for installation.   * 2 bellows flange alignment blanks * 1 beamline gasket * 4 covered spring clamps * Fasteners * Retainer clips * Wrenches |  |
| **Prepare the Downstream Gate Valve Sub-Assembly (GV2SA) Bellows Flange**  2. Verify the purge software is set to "Purge".  3. Remove the 4 studs indicated in the positions 3, 6, 9, and 12 in the drawing below from the GV2SA bellows end flange in a star pattern.  Then remove the studs in positions 2, 5, 8, and 11 from the GV2SA bellows end flange in a star pattern.  The 4 remaining studs shall be located every third hole in the flange.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    4. Install 4 new pre-cleaned [Spec 1] studs in positions 2, 5, 8, and 11 to ensure equal pressure on the gasket. Torque these pre-cleaned studs to 31 ft-lbs.  5. Remove final 4 original studs 2 at a time from the flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  6. Hold the GV2SA bellows end flange and bellows blank flange tight so that there is no movement of the flanges while studs are being removed.  Remove the stud in position 5, pulling the stud away from the GV2SA.  Then remove the stud in position 11, pulling the stud away the GV2SA.  Then remove the stud in position 2, pulling the stud away the GV2SA.  Then remove the stud in position 8, pulling the stud away the GV2SA.  Carefully and slowly remove the blank and gasket away from the GV2SA.  Verify the purge starts.  7. Carefully place an alignment blank on the bellows flange. Clamp in place with two cleaned spring clamps. Open the clamps down and away from the open cavity flange. |
| **Prepare the Cavity 8 Downstream Flange**  8. Verify the purge software is set to "Purge" for the Upstream Purge Line.  9. Remove the 4 studs indicated in positions 3, 6, 9, and 12 in the drawing below from the cavity downstream end flange in a star pattern.  Then remove the studs in positions 2, 5, 8, and 11 from the cavity downstream end flange in a star pattern.  The 4 remaining studs shall be located every third hole in the flange.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.    10. Install 4 new pre-cleaned [Spec 1] studs in positions 2, 5, 8, and 11 in a star pattern to ensure equal pressure on the gasket. Torque these pre-cleaned studs to 31 ft-lbs.  11. Remove final 4 original studs 2 at a time from the flange in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure.  Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  12. Hold the cavity downstream end flange and right angle valve sub-assembly flange tight so that there is no movement of the flanges while studs are being removed.  Remove the stud in position 5, pulling the stud away from the cavity.  Then remove the stud in position 11, pulling the stud away the cavity.  Then remove the stud in position 2, pulling the stud away the cavity.  Then remove the stud in position 8, pulling the stud away the cavity.  Carefully and slowly remove the blank and gasket away from the cavity.  Verify the purge starts.  13. Carefully place an alignment blank on the cavity flange. Verify that the alignment pins on the cavity flange do not line up with the alignment pins on the bellows. Clamp in place with two cleaned spring clamps. Open the clamps down and away from the cavity. |
| **Align GV2SA Bellows and Cavity End Flange**  14. Slowly slide GV2SA towards the cavity to check flange alignment. The nipples on the alignment blanks should move freely into the indents of the flanges. A slight rotation of the bellows flange can be performed if necessary during the alignment process.  15. Move GV2SA away from the cavity flange.  16. Carefully remove the alignment blanks from the cavity and bellows. |
| **Install Cavity to GV2SA Bellows**  17. Install the beamline gasket with retaining clips to hold the gasket in place on the bellows flange. Verify the clips are placed in the horizontal position.  18. Slowly slide the cavity back into place against the gasket. Remove the clips.  19. Hold the flanges tightly together, preventing the flanges from rotating or moving away from each other, until the first 4 studs have been snugged tight with a wrench.  20. Place 4 pre-cleaned [Spec 1] studs in a star pattern in the cavity flange and snug them with a wrench.  21. Place the remaining fasteners on the flange continuing the star pattern and snug all of them with a wrench.  22. Torque the fasteners to 15 ft-lbs using a standard torquing pattern for a round flange.  23. Increase the torque and torque all the fasteners to 31 ft-lbs using a standard torquing pattern for a round flange.  24. Repeat the final torque sequence twice and then go around all of the fasteners at least twice or until there is no movement of the nuts. Verify the purge system turns off.  25. Install rail locks on the cavity and valve to lock them in place. | [[CAV8\_GV2SAComment]] <<COMMENT>>  [[CAV8\_GV2SATimeStamp]] <<TIMESTAMP>>  [[CAV8\_GV2SATech1]] <<SRFCVP>>  [[CAV8\_GV2SATech2]] <<SRFCVP>> |

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| Step No. | Instructions | Data Input |
| 29. | **Remove Downstream Purge Line**  1. Verify the Upstream Purge Line is set to "Purge"  2. Set the downstream purge software to "Standby" state for the Purge Line connected to the GV2SA.  3. Close the Downstream Purge Line Spool valve.  4. Slowly close the GV2SA right angle valve. Leave the downstream gate valve open.  5. Remove the purge system hose from GV2SA.  6. Put a blank on the Spool using the same gasket and all of the fasteners. | [[GV2SA\_RAV\_PurgeLine\_Closed]] <<YESNO>>  [[DownstreamHoseRemoved]] <<YESNO>> |
| 30. | **Install NEG Pump**  If the NEG is not already installed on the GV2SA, then install the NEG with the following steps. A blank should be installed on the GV2SA at the location where the NEG shall be installed.  1. Verify the NEG has already been conditioned and had two activation cycles in accordance with L2HE-PR-CLNRM-NEG-PREP.  2. Verify the purge software is set to "Purge" for the Upstream Purge Line.  3. Remove 4 studs from the blank flange where the NEG will be installed in a star pattern.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure. Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  8. Install 2 pre-cleaned [Spec 1] studs in open holes and torque to 120 in-lbs.  9. Continue to remove all remaining original studs on the blank flange in a star pattern, until only the two pre-cleaned studs remain installed.  Prepare an IPA dipped Q-tip and remove excess liquid from the Q-tip before cleaning the bolt holes. Clean bolt holes with the IPA dipped Q-tip.  Use ionized N2 to spray open bolt holes from both directions to Spec 1 in accordance with the Ionized N2 Parts Cleaning Procedure. Repeat using ionized N2 to spray open bolt holes from both directions two additional times to Spec 1 to ensure cleanliness before proceeding.  10. Hold the flanges tight so that there is no movement of the flanges while studs are being removed.  Remove the pre-cleaned studs one at a time. Pull studs away from the GV2SA.  Carefully and slowly remove the blank and gasket away from the GV2SA.  Verify the purge starts.  11. Install the gasket with retaining clips to hold the gasket in place. Verify the clips are placed in the horizontal position.  12. Align the NEG pump to the GV2SA flange with the capped sensor port on the NEG pump facing "down" with reference to beamline installation as shown in the image below. This is a known and acceptable deviation from the drawing F10127865 Rev. B Detail D.    13. Slowly move the NEG pump into place, and remove the gasket clips and install 2 pre-cleaned [Spec 1] studs in a star pattern to secure the NEG pump. Hold the flanges tight to prevent motion of the flanges while installing the studs. Snug studs with a wrench.  14. Install remaining 4 studs in pairs continuing the star pattern and snug with wrench.  15. Torque all fasteners to 60 in-lbs using a standard torque pattern for a round flange.  16. Increase the torque wrench setting to 120 in-lbs and torque all fasteners using a standard torque pattern for a round flange.  17. Repeat the final torque sequence twice and then go around all the fasteners at least twice or until there is no movement of the nuts. Verify the purge stops. | [[NEGPumpInstalled]] <<YESNO>>  [[NEGPumpComment]] <<COMMENT>> |

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| Step No. | Instructions | Data Input |
| 31. | **Cavity String Final Torque**  All fasteners on the string shall be re-torqued to the following torque values:   * Beamline fasteners: 31 ft-lbs * FPC flange fasteners: 120 in-lbs * Field Probe and HOM fasteners: 40 in-lbs | [[FinalTorqueComment]] <<COMMENT>>  [[FinalTorqueTimeStamp]] <<TIMESTAMP>>  [[FinalTorqueTech1]] <<SRFCVP>>  [[FinalTorqueTech2]] <<SRFCVP>> |
| 32. | **Cavity String Final Flange Alignment and Lock Lollipops**  1. Verify the cavity flange alignment on all cavities.  2. Verify the distance between cavities using the alignment tooling that rests on the cavity FPC flanges. Nominal distance is 1384.3 mm.  3. Set the lollipop locking turnbuckles and lock them in place with the lock nut.  4. Place rail brakes in several locations to prevent the carriages from moving in either direction. | [[FinalAlignComment]] <<COMMENT>>  [[FinalAlignTimeStamp]] <<TIMESTAMP>>  [[FinalAlignTech1]] <<SRFCVP>>  [[FinalAlignTech2]] <<SRFCVP>> |
| 33. | **Remove Upstream Purge Line**  1. Set the purge software to "Standby" state for the Upstream Purge Line.  2. Close the Upstream Purge Line Spool valve.  3. Slowly close the GV1SA right angle valve. Leave the upstream gate valve open.  4. Remove the purge system hose from GV1SA.  5. Put a blank on the Spool using the same gasket and all of the fasteners.  6. If available, install filter (F10040886, part number 4) on the Faraday Window Manifold right angle valve. If the filter is not available, install a blank. Use a new gasket and pre-cleaned [Spec 2] fasteners. | [[GV1SA\_RAV\_Closed]] <<YESNO>>  [[Faraday\_RAV\_Cover]] {{Filter,Blank,Other}} <<SELECT>>  [[Faraday\_RAV\_Other]] <<COMMENT>>  [[UpstreamHoseRemoved]] <<YESNO>> |
| 34. | **Connect the Slow Pump Down Cart and Slow Pump the Cavity String from Downstream End**  1. Verify the slow pump cart is bled up.  2. Remove any blank on the slow pump cart. Wipe the bolt holes and flanges sealing surface on the slow pump cart.  3. Blow down the GV2SA right angle valve flange, bolt holes, and inside the right angle up to the valve stem to Spec 1.  4. Install the slow pump hose to the GV2SA right angle valve:   * Place a new cleaned [Spec 1] gasket on the slow pump hose. * Install two pre-cleaned [Spec 1] studs in a star pattern and snug with a wrench. * Install the four remaining studs continuing the star pattern. * Torque all studs using a standard torque pattern for a round flange. * Repeat the final torque sequence twice and then go around all the studs at least twice or until there is no movement of the nuts. Stop if the flanges go metal-to-metal.   5. Verify that both VAT string isolation gate valves are open.  6. On the slow pump cart, open the isolation valve to the RGA.  7. Over pressurize the slow pump cart to match the cavity string pressure.  8. Use of CRITICAL MTE is required. Verify that the Critical MTE Standard Helium Leak Rate is open before pumping. Record the F-tag (or Serial No.) and Cal DUE date for the Critical MTE Standard Helium Leak Rate.  9. Slowly open the GV2SA right angle valve. The cavity string is now open to the slow pump cart.  10. Start slow-pumping process in accordance with [the Clean Room Slow Pump Cart Procedure](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-251963/SRF-MSPR-CLNRM-PUMP-R1.pdf). | [[CalibratedLeakOpen]] <<YESNO>>  [[CriticalSHLR\_SN]] <<SN>>  [[CriticalSHLR\_DueDate]] <<COMMENT>>  [[SlowPumpStartTime]] <<TIMESTAMP>>  [[SlowPumpComment]] <<COMMENT>>  [[SlowPumpTech1]] <<SRFCVP>> |
| 35. | **Bag Cavity String for Leak Check**  While the string is pumping, place one large leak check bag around every joint between each set of cavities and include the FPC.   * Place a bag around the upstream gate valve sub-assembly [GV1SA] and Cavity 1. * Place a bag around the downstream gate valve sub-assembly [GV2SA] connection to Cavity 8. * Place a bag around the entire pump manifold and GV2SA right angle valve connection. |  |

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| Step No. | Instructions | Data Input |
| 36. | **Turn on RGA**  1. Allow the string to pump approximately 48 hours after starting the turbomolecular pump, or until the vacuum reading at the pump cart gauge is a minimum of 2E-7 mbar before turning on the filament and the electron multiplier of the RGA.  2. Allow the filament to warm up for a minimum of 20 minutes before starting the trace.  3. Allow the trace to run for approximately 15 minutes.  4. Close the Critical MTE Helium Standard Leak Rate. | [[RGAComment]] <<COMMENT>>  [[RGAStartTime]] <<TIMESTAMP>>  [[RGATech1]] <<SRFCVP>> |
| 37. | **Cavity String Leak Check**  1. Set up the RGA and perform the cavity string leak check in accordance with SRF-MSPR-CLNRM-LEAK.  2. Begin leak checking each bag, starting at the upstream end of the string (furthest away from pump).  3. Watch the trace as He is placed into each bag.  4. Record the trace time when each bag begins to be filled with He. The trace time is located on the x-axis of the trace.  5. Allow 10 minutes before filling the next bag in Line.  6. If a leak is detected in any bag:   * Place a nitrogen purge in that bag until the trace recovers, and then continue the leak check. * Initiate a D3 to record troubleshooting actions and leak check file.   7. After troubleshooting is complete, purge all of the bags with N2 and start a new trace. Begin the leak check process again from the beginning.  8. Attach the leak check files. | [[Bag1StartTime]] <<FLOAT>>  [[Bag2StartTime]] <<FLOAT>>  [[Bag3StartTime]] <<FLOAT>>  [[Bag4StartTime]] <<FLOAT>>  [[Bag5StartTime]] <<FLOAT>>  [[Bag6StartTime]] <<FLOAT>>  [[Bag7StartTime]] <<FLOAT>>  [[Bag8StartTime]] <<FLOAT>>  [[Bag9StartTime]] <<FLOAT>>  [[Bag10StartTime]] <<FLOAT>>  [[StringLeakCheck]] <<FILEUPLOAD>>  [[Bag1StartTimeA]] <<FLOAT>>  [[Bag2StartTimeA]] <<FLOAT>>  [[Bag3StartTimeA]] <<FLOAT>>  [[Bag4StartTimeA]] <<FLOAT>>  [[Bag5StartTimeA]] <<FLOAT>>  [[Bag6StartTimeA]] <<FLOAT>>  [[Bag7StartTimeA]] <<FLOAT>>  [[Bag8StartTimeA]] <<FLOAT>>  [[Bag9StartTimeA]] <<FLOAT>>  [[Bag10AStartTime]] <<FLOAT>>  [[StringLeakCheckA]] <<FILEUPLOAD>>  [[LeakCheckComment]] <<COMMENT>>  [[StringLeakTight]] <<YESNO>>  [[LkCheckTech1]] <<SRFCVP>>  [[LkCheckTech2]] <<SRFCVP>>  [[LeakCheckTime]] <<TIMESTAMP>> |
| 38. | **Initial Beamline Vacuum**  Pump the beamline to the 1E-8 Torr range. Record the beamline vacuum level achieved. | [[InitialBeamlineVacuum\_Torr]] <<SCINOT>> (Torr)  [[InitialBeamlineVacuum\_Time]] <<TIMESTAMP>>  [[InitialBeamlineVacuum\_Tech]] <<SRFCVP>> |

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| Step No. | Instructions | Data Input |
| 39. | **Final NEG Pump Activation**  **Note**: Steps and References in L2HE-PR-CLNRM-NEG-PREP can be used as a guide for NEG pump activation. The [SIP POWER ION Pump Controller User Manual](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-249701/SIP%20POWER%20User%20Manual%5b1%5d.pdf) and [NEXTorr Z200 Pump Operating Instructions](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-249702/operating%20instructions%20NEXTorr%20Z200.pdf) are available in DocuShare.  1. Record the beamline pressure. | [[NegActivation\_InitBLPress]] <<FLOAT>> |
| 2. Close the downstream gate valve.  3. Connect the NEG POWERMINI power supply and the SIP POWER ION pump power supply to the NEG. Do not start activation yet.  4. Verify the pressure at the NEG Pump Assembly is in the 3E-6 Torr range. The turbo pump is kept actively pumping throughout the activation process.  5. Turn on the NEG POWER MINI power supply. The power supply should be set as shown. Note: the "Pump temp" will not show any readings.  **Vout = 12.0 V, Trise = 30, Thold = 180**  Graphical user interface  Description automatically generated  6. Once the power supply is ready, press the start/stop button to begin activation. Activation should take about an hour. During this time, the NEG pump and spool will reach high temperatures. Be careful not to burn yourself. Do not touch the pump, spool, or flanges during an activation cycle. | [[NegActivationCycle1Comp]] <<TIMESTAMP>> |
| 7. Pump the NEG Pump Assembly until the pressure is at least the beamline pressure recorded above.  8. Close the GV2SA right angle valve.  9. Slowly open the downstream gate valve.  10. Turn on the Ion Pump. | [[GV2SA\_RAV\_Closed]] <<YESNO>>  [[NegActivationTech1]] <<SRFCVP>> |
| 40. | **Backfill FPC Tophat with N2**  1. For each FPC tophat, slightly unscrew the SMA connector and backfill the space under the cap with dry, filtered nitrogen.    2. Tighten the SMA connector to seal the space. | [[FPC\_TophatsBackfilled]] <<YESNO>> |
| 41. | **Final Beamline Vacuum**  Pump the beamline to the 1E-8 Torr range. Record the beamline vacuum level achieved and then turn off the Ion Pump. | [[FinalBeamlineVacuum\_Torr]] <<SCINOT>> (Torr)  [[FinalBeamlineVacuum\_Time]] <<TIMESTAMP>>  [[FinalBeamlineVacuum\_Tech]] <<SRFCVP>> |
| 42. | **The Cavity String is now ready for rollout.** | [[CST\_ReadyForRollout]] <<TIMESTAMP>> |