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Environmental Programs Directorate
Corrective Actions Projects

Standard Operating Procedure

for GROUNDWATER MONITORING WELL DUAL-SCREEN SAMPLING SYSTEM INSTALLATION AND TESTING

Approval Signatures:

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1.0 PURPOSE AND SCOPE

This standard operating procedure (SOP) states the responsibilities and describes the process for installing and testing Baski-style single and dual pump systems in dual-screen groundwater monitoring wells for the Los Alamos National Laboratory (LANL) Environmental Programs (EP) Directorate.

This procedure applies to all LANL EP Directorate personnel and contractor personnel authorized to install or maintain dedicated dual-screen pumping systems, or assist with these tasks.

2.0 BACKGROUND

2.1 Basic Design

Dedicated pumping systems are required to purge monitoring wells for the purpose of sample collection. Dual-screen wells require unique pumping systems that are capable of actively purging each screened interval discretely. Two types of pumping systems are typically specified for LANL dual-screen monitoring wells: dual access port valve (APV) systems sharing a single submersible pump and two-pump systems utilizing a submersible pump and a pneumatic piston type pump. Factors that may impact the choice of system include, but are not limited to: well screen separation length and well screen specific capacities. All dual-screen systems include at least one inflatable packer to isolate each screened interval from the other. LANL has designated dual screen sampling systems ML-3.

- Dual APV systems utilize pneumatically operated valves in order to purge water from the desired screened interval. These systems share a single submersible pump Figure 1 (Attachment 1).

- Two-pump systems utilize a single pump in each screened interval. Pump operation and discharge are independent from one another. The most common two-pump system includes a submersible pump for the lower screened interval and a pneumatic piston-type pump for the upper screened interval Figure 2 (Attachment 2).

This SOP assumes the end user has made appropriate pumping system selection and is not intended as a guide for system selection or system design.

2.2 Pre-installation Requirements

Dual-screen systems are more complicated than typical single pump installations found in single-screen wells. Plumbing components and combinations of components may be elaborate. Precautions to be considered include, but are not limited to the following:

- Perform a complete and thorough well inspection to include: total depth, static composite water level, physical dimensions of the well casing and screen(s), and aquifer pumping tests (one per screen), or review of aquifer test data to determine well screen specific capacities. If aquifer pumping tests are required, discrete static water levels of the respective well screen intervals must be collected. If well screen depths are uncertain or if the well is old, perform video inspection.

- System components should be preassembled at the supplier's point of origin to the degree possible. Preassembled 'modules' save time and reduce possible sources of error and contamination in the field. Examples of modules include submersible pumps preloaded into pump shrouds and preassembling inflatable packers and liquid inflation chambers (LICs).

- If pumping systems are to be stored for any length of time, general precautions should be taken for storage. Components susceptible to ultraviolet light (e.g., packers, PVC pipe, electrical cable) should be covered or stored indoors. Freeze prevention is not necessary as there are no liquids contained within the system before installation. Store all equipment, parts, etc. at a controlled location.

- Dual-screen pumping systems must be inspected and inventoried before starting installation activities. All components of the system must be accounted for, verified, and present onsite.

- Installation crew must take the time to familiarize themselves with system components and installation requirements. All parties (crew, Field Team Leader, and any additional oversight personnel) must be in agreement on order and arrangement of system components before starting installation task.

- Individuals participating in dual-screen well pumping system installations shall be trained to the requirements listed by functional assignment in Table 1 (Attachment 3).

3.0 EQUIPMENT AND TOOLS

- Well construction diagram.
- Sampling system engineering design drawings released for construction.
- Pump hoist capable of lifting pumping system outfitted with typical pump-set equipment and tooling.
- Entire pumping system (receipt inspected, inventoried, and independently checked by two parties for completeness).
- Engineer's measuring tape (measuring in tenths/hundredths of a foot).
- Water level meter of sufficient length to measure water levels and total depth of well.
- Compressed nitrogen cylinder(s).
- Pressure safety manifold (LANL provided).
- Digital pressure gauge(s) capable of measuring in single units of millibars.

4.0 STEP-BY-STEP PROCESS DESCRIPTION

This SOP uses the term 'nitrogen line(s)' and 'control line(s)' in reference to any hard or soft-walled tube that has a pneumatic operational function. All pneumatic operations shall use nitrogen as the compressed gas. These lines utilize fittings for the purpose of splicing and/or terminating. The terms 'drop pipe' and 'pump column' may be used interchangeably. Both terms reference the column of static, hard-walled pipe that the water discharge travels to the surface within.

A completed installation checklist (Attachment 4) shall be used to document the installation procedure and submitted to the Subcontract Technical Representative (STR).

4.1 PERFORMING INVENTORY AND RECEIPT INSPECTIONS

Dual-screen pumping systems are generally outfitted with equipment from more than one manufacturer. Once all shipments have been received, the equipment must be accounted for and verified using invoice receipts and/or packing slips and verified using the design drawings and documented in a receipt inspection report. (See Attachment 5 for example).

Completed receipt inspection report (Attachment 5) shall be submitted to the STR.

4.2 SITE SET-UP

Site set-up involves positioning the pump hoist, associated equipment and tools, and the area where the drop pipe will be laid down in a logical and safe fashion. Upon leveling the pump hoist and raising the derrick, the hoist will need to be approved for work through LANL's Management, Observation, and Verification (MOV) process.

4.3 DECONTAMINATION OF DUAL-SCREEN PUMPING SYSTEMS

4.3.1. All components of the pumping system (i.e., pump shroud, pump(s), liquid inflation chamber, packer, access port valves, drop pipe, tube bundle(s), polyvinyl chloride (PVC) pipe, and fittings) must be decontaminated prior to installation.

For decontamination procedures, follow procedures consistent with "Field Decontamination of Equipment" EP-ERSS-SOP-5061.

New PVC manufactured for supply to the environmental sector is delivered factory cleaned and wrapped in plastic. High quality stainless steel fittings may also be delivered in a similar fashion. The origin of parts and those parts' degree of cleanliness must be verified with the manufacturer or supplier to meet decontamination requirements.

4.3.2. If fittings or nitrogen tubing are pre-attached to the pumping components, the open fittings and/or the end of the tubes must be plugged with compatible pipe plugs to prevent water from entering into the fittings/tubes while decontaminating components.

4.3.3. Project-specific requirements for Quality Assurance/ Quality Control (QA/QC) samples that may be collected (rinsate) from decontaminated permanent pumping hardware can differ. Consult project-specific technical guidance documents (e.g., Drilling Plan, Exhibit D, Statement of Work, etc.) for sample collection requirements. Any QA/QC sample collection must take place after decontamination and before starting assembly.

4.3.4. Before/after decontamination, the main pumping system components must be measured to the hundredth of a foot, and the arrangement of system components must be agreed upon prior to installation.

4.4 INSTALLATION OF DUAL-SCREEN PUMPING SYSTEMS

The installation of a dual-screen pumping system involves wiring pump to pump cable; threading stainless-steel drop pipe and components to one another per pump system design; threading PVC pipe together; banding PVC pipe, nitrogen tubing, and pump cable to stainless-steel drop pipe; pressure testing nitrogen lines after plumbing into fittings; and landing the pump system on top of the stainless-steel well casing. Assembly and testing occur while the system is lowered into the well with the pump hoist.

The nitrogen lines that operate the pneumatic components of these sampling systems, or are a part of the systems themselves, typically require splicing and insertion into a variety of fittings as they routinely are not continuous lines from top to bottom. Typically, the fittings are stainless steel Swagelok brand fittings.

4.4.1. Tubing and Fitting Guidance

Splicing stainless steel nitrogen lines involves cutting the tubing, deburring the tubing, placing a nut and ferrules onto the tubing, inserting the tubing into the stainless steel fitting, and tightening the nut and ferrules onto the fitting body. The most recent revision of the attached specification, CAP-WELLS-SPEC-40 0511 (Attachment 6), must be reviewed prior to making tubing cuts, bends, or fittings. The specification and this procedure can be combined in the field during installation to make successful fitting to tubing connections.

Tube cutting shall be conducted in accordance with CAP-WELLS-SPEC-40 0511. Rushing this procedure will result in poor cuts and excessive cutter wheel wear. It should be noted that tube cutters do not remove material, but push material aside and down. The duller the cutter wheel, the more material is raised at the tube end, increasing tube O.D. This raised material can prevent the tubing from resting firmly on the shoulder of the fitting body, which may cause the fitting to leak. Therefore, sharp cutting wheels should be used at all times.

Both Swagelok and Baski provide procedures for insertion of tubing into stainless steel fittings and tightening the nut and ferrule onto the fitting body, and retightening instructions for tubing fittings with preset ferrules. Both procedures are incorporated into the attached CAP-WELLS-SPEC-40 0511.

According to the Swagelok Tube Fitter's Manual, connections can be disconnected and retightened many times, with the reliable, leak proof seal obtained every time the connection is remade. This, however, has not been observed in the field. Most commonly, fittings are observed to leak. Leaky fittings may be attributable to faulty fittings, nuts, or ferrules, tubing and fittings that may have been exposed to dirt, dust, sand, or other particles, tubing that was not cut precisely, or tubing that was not appropriately deburred, Field crews are tasked with identifying which part(s) of the fitting component is leaking (i.e. nut, ferrule, fitting, or tubing) and needs to be replaced. Therefore, it is necessary for field crews to have extra fitting components and tubing available on site to replace leaky fittings.

4.4.2 Dual APV System

The following describes dual APV systems installed at LANL. The main components of the system include (from first component installed to last component installed, excluding drop pipe details):

- Bull nose plug
- Lower APV
- Inflatable packer
- Liquid Inflation Chamber (LIC)
- Upper APV
- Pump shroud with pre-loaded pump and motor
- Upper and lower water level PVC gauge tubes
- Drop pipe with weep valve
- Wellhead body

4.4.2.1 The bull nose plug terminates the bottom of the typical dual APV system.

4.4.2.2 The lower APV is threaded to the bull nose plug.

The lower APV open control line (when pressurized, the APV screen is 'open' and water from that zone is pumped) is connected to the APV open fitting and passes through the packer and LIC, around the upper APV, and through the pump shroud. The lower APV open control line is continuous above the pump shroud up to the bottom of the wellhead body.

The lower APV close control line (when pressurized, the APV screen is 'closed' and water from that zone is not able to be pumped) is connected to the APV close fitting. The lower APV close control line passes through the packer and LIC and is fitted to a y-block. The y-block has two fittings in the bottom, one connected to the lower APV close control line and one connected to the packer inflation line.

The lower APV is function (pressure) tested before being advanced into the well.

4.4.2.3 Depending on well-specific depths, drop pipe may be threaded together between the lower APV and the packer/LIC assembly.

4.4.2.4 For the purpose of this SOP, the packer and the LIC are considered to be one functional unit. The packer is below the LIC, or first, in order of assembly. The packer inflation line is connected from the top of the packer and fitted to the bottom of the LIC. The LIC is an assembly containing a liquid chamber that is 4.75-in. outside diameter (O.D.), which is filled with distilled water prior to installation (when pressurized, the packer inflates with water via nitrogen pressure supplied to the LIC). The packer inflation line continues from the top of the LIC and is connected to the bottom of the y-block fitting. See Fitting guidance above (Section 4.4.1). The nitrogen line from the top of the y-block passes around the upper APV and is fitted to the bottom of a second y-block located above the upper APV.

The packer/LIC is pressure tested before being advanced into the well.

4.4.2.5 Depending on well-specific depths, drop pipe will be threaded together between the packer/LIC assembly and the upper APV.

The upper APV open control line is connected to the APV open fitting and passes through the pump shroud. The upper APV open control line is continuous above the pump shroud to the bottom of the wellhead body.

The upper APV close control line (when pressurized, the APV screen is 'closed' and water from that zone is not able to be pumped) is connected to the APV close fitting. The upper APV close control line is connected to the bottom of the second y-block located above the upper APV. The nitrogen line fitted to the top of the y-block passes through the pump shroud. Above the pump shroud, the nitrogen line is one continuous line up to the bottom of the landing plate.

The upper APV is function (pressure) tested before being advanced into the well.

4.4.2.6 Depending on well-specific depths, drop pipe will be threaded together between the upper APV and the shrouded pump.

4.4.2.7 A stainless-steel water level line with a screened fitting extends below the packer. A stainless-steel faucet screen with a U.S. mesh size between 25 (0.028-in.) and 80 (0.007-in.) is sandwiched between a male tube connector and a coupling. The terminus of the water level line must be screened in order to prevent debris from plugging the line and rendering it useless. The water level line passes through the packer and LIC, around the upper APV, and through the pump shroud. The water level line is fitted into the end cap of the lower transducer PVC gauge tube. This tube provides lower screen water level measurements. The lower transducer PVC gauge tube is generally placed above the pump shroud. The upper transducer PVC gauge tube, with a slotted screen section and end cap, is placed beside the lower transducer PVC gauge tube above the pump shroud. This tube provides upper screen water level measurements.

4.4.2.8 The PVC gauge tube columns extend to the wellhead body. Both of these columns are comprised of 10-ft long sections of PVC pipe and are assembled by hand (hand-tight) as the system is assembled and advanced into the well.

4.4.2.9 An air-vent line extends from the top of the pump shroud to the bottom of the wellhead body. This line is Nylon as it is not pressurized and serves only as a vent to prevent vapor locking the pump.

4.4.2.10 Electrical service to the pump motor is provided by the pump cable. The wire gauge of the pump cable is selected based on the requirements for the size (horsepower) of the pump motor and the set depth of the pump. Typically, submersible pumps installed with dual-screen sampling systems at LANL have three-phase motors. Three-phase motors require pump cable with four leads. Submersible pump cable is most always double-jacketed; that is, each lead is insulated and the insulated leads are bound together in an all-inclusive outer layer of insulation.

4.4.2.11 The pump cable, PVC pipes, stainless steel nitrogen pressure lines, and nylon vent lines are banded to the stainless-steel pump column. The pump column and all associated hardware running to the surface are assembled one piece at a time as the assembly is lowered into the well. Stainless steel banding and buckles are used to bind all the hardware together. It is recommended that one band be used per each 10-ft piece of PVC (i.e. every ten feet on the drop pipe). Tape of any sort is never to be used due to long term durability and environmental sample quality issues. The PVC gauge tubes, stainless-steel pump column, and pump cable are inserted into the wellhead body, and the nitrogen lines and air vent line are fitted into the bottom of the wellhead body.

4.4.2.12 Near the end (top) of the pump column (i.e. the wellhead body), a riser pipe with a weep valve must be installed. The weep valve is located 3-ft bgs at a minimum. The weep valve allows water in the pump column to drain out after pumping has stopped.

4.4.2.13 The wellhead body is the top piece of the pumping system seen at the top of the well casing. It is also the terminating point for all the various lines and pipes extending to the surface. The wellhead body is commonly referred to as a 'landing plate,' although landing plates are much simpler by comparison. The wellhead bodies typically supplied for LANL dual-screen pumping systems are custom-made units that are very nearly well-specific. The central feature of the wellhead body is the discharge port. The pump column threads into the bottom of the discharge port and a sampling 'tree' threads into the top of the discharge port. On either side of the discharge port are holes for the PVC water level gauge tube columns. The PVC gauge tube columns slide through these holes and are cut off nearly flush with the top of the wellhead body. No mechanical connection exists between the wellhead body and the PVC gauge tubes. Surrounding these three central access holes or ports are smaller, ¼" female national pipe thread (NPT) ports for the ¼" control lines described above. Typically, the wellhead body is supplied with six of these ¼" ports. In the system outlined above, three control lines and one vent line extend to the surface and would occupy four of the six ports. The other two ports are plugged with compatible pipe plugs. The 'finishing' of the wellhead body is accomplished with the installation of a pressure gauge for the packer control line, the installation of the fittings for the APV control lines, the installation of any plugs for any potentially vacant access ports, and the installation of the permanent transducers into the PVC gauge tubes. See Attachments 1 and 2 for typical well head body detail.

4.4.3 Two-Pump System

The following describes the two-pump system. The main components of the system include (from first component installed to last component installed, excluding drop pipe details):

- Submersible pump
- Packer
- LIC
- Pneumatic piston-type pump
- Riser pipe with weep valve
- Wellhead body

The lower water level line and PVC riser pipe columns are fashioned in a similar way as described above for dual APV systems (although the PVC riser pipes would be placed above the largest diameter component, i.e. LIC). The main difference in these systems compared to dual APV systems is the type and location of pumps, discharge lines, and nitrogen lines. There are two discharge lines for the two pumps. The submersible pump will discharge through a stainless-steel pipe column and the pneumatic piston-type pump will be equipped with a tube bundle containing a flexible discharge line. The tube bundle will also be equipped with nitrogen lines for actuation and exhaust.

4.4.3.1 Since the submersible pump is only used to purge one zone and is typically the terminus for the system on the bottom end, only the pump cable and lower water level line pass through the packer and LIC. The submersible pump may or may not be housed in a pump shroud. If no shroud is used, no air vent will be included in the assembly.

4.4.3.2 Depending on well-specific depths, drop pipe will be threaded together between the submersible pump and the packer/LIC assembly.

4.4.3.4 For the purpose of this SOP, the packer and the LIC are considered to be one functional unit. The packer is below the LIC, or first, in order of assembly. The submersible pump is located below the packer and LIC with the pump cable, lower water level tube, and air-vent line (if equipped) passing through the packer and LIC. The packer inflation line is connected from the top of the packer and fitted to the bottom of the LIC. The LIC is an assembly containing a liquid chamber that is 4.75-in. O.D., which is filled with distilled water prior to installation (when pressurized, the packer inflates with water via nitrogen pressure supplied to the LIC). The packer inflation line continues from the top of the LIC and extends to the wellhead body.

The packer/LIC is pressure tested before being advanced into the well.

4.4.3.5 Depending on well-specific depths, drop pipe will be threaded together between the packer/LIC assembly and the upper interval's pump.

4.4.3.6 The upper zone will be purged and sampled with a pneumatic piston-type pump. The placement of this pump must be accommodated during the design phase. A pump 'holder' must be fashioned. The holder must attach the piston pump to the lower zone's pump column and securely hold it in place. By no means shall the upper zone's pump be lowered into place after the lower zone's pump has been set or suspended in the well without attachment to the pumping apparatus in the lower zone.

The piston pump will have a tubing bundle that will contain a Teflon water discharge line, and nitrogen supply and exhaust lines. The tubing bundle is connected to the pump before lowering the pump into the well.

The pneumatic pump is function (pressure) tested before being advanced into the well.

4.4.3.7 The pump cable, PVC pipe, nitrogen pressure lines, and tubing bundle are banded to the stainless-steel pump column.

4.4.3.8 Near the end of the pump column, a riser pipe with a weep valve is installed. The pump cable, PVC pipe, nitrogen pressure lines, and tube bundle are banded to the stainless-steel pump column. The pump column and all associated hardware extending to the surface are assembled one piece at a time as the assembly is lowered into the well. Stainless steel banding and buckles are used to bind all the hardware together. It is recommended that one band be used per each 10-ft piece of PVC (i.e. every ten feet on the drop pipe).

4.4.3.9 The PVC riser pipes, stainless-steel pump column, pump cable, nitrogen lines, and air vent line are inserted into the bottom of the wellhead body. The 'finishing' of the wellhead body is accomplished with the installation of a pressure gauge for the packer control line, the installation of any plugs for any potentially vacant access ports, and the installation of the permanent transducers into the PVC gauge tubes.

4.4.4 General Installation Considerations

4.4.4.1 Wiring pump to pump cable must be performed and tested by qualified individuals.

4.4.4.2 When making threaded connections, an approved pipe dope (e.g. Jet-Lube V-2) must be used. Threads must be compatible. When threading PVC pipe to one another, O-rings must be present. As a further precaution, threads on the submerged sections of the PVC tube for the lower screen zone may be Teflon taped.

4.4.4.3 Stainless steel banding and buckles must be used to attach PVC pipe, nitrogen tubing, vent tubing, and pump cable to the pump column. It is recommended that each piece of PVC is attached to the pump column (i.e. one band every ten feet of drop pipe length). Caution must be used so not to pinch tubing/cables.

4.4.4.4 Pressure testing shall be performed after plumbing nitrogen tubes into any fitting or group of fittings. Pressure testing includes the following:

- The end of nitrogen lines that are being inserted into fittings must have a small application of pipe dope on the end prior to insertion.
- Nitrogen pressure must be exerted on the tubing equal to the operating pressure of the component to which it is attached.

- The amount of time the pressure test is conducted usually depends on the component that is being pressure tested. For example, in the dual access port valve (APV) system, the APV closed sides and packer inflation lines are generally tested at longer intervals than the APV open sides. This is due to the sampling method, in which the APVs will have constant supplied pressure via a nitrogen tank during the sampling event.
- Pressure monitoring can be performed by observing the regulator pressure on the nitrogen supply. When the nitrogen tank is closed, leaks can be detected by reading the gauge on the regulator that is still open to the system.
- If a leak (e.g. audible hissing, bubbles observed when soapy water is applied to the fitting, measured pressure loss above ambient temperature induced fluctuations) is detected, the tubing must be cut and inserted into a new ferrule and/or fitting. Pressure testing must be re-performed.
- Changes in ambient air temperature will affect the pressure gauge readings during pressure testing activities. Therefore, weather/temperature conditions must be observed, noted and incorporated into the interpretation of the pressure testing results to assess whether leaks in the system are present.
- The nitrogen tank(s) and nitrogen tubing coil(s) connected to the system components being tested must be kept out of temperature extremes to avoid overheating or cooling the tubing and causing fluctuations in gauge pressure during pressure testing activities. Tarps or insulating blankets may be used for this purpose.
- Pressure tests are typically conducted at pressures within the range expected to be applied to the system during operation. This requires documenting anticipated packer and APV pressure requirements as presented in Attachment 7.

4.4.4.5 The wellhead body must be manufactured to allow access to all pipe and tubing that are part of the pump system. For dual APV systems, pipe and tubing that may be part of the pump system include stainless-steel drop pipe, PVC pipe, packer inflation line, air-vent line, lower APV open control line, and upper APV open control line. For two-pump systems, pipe and tubing that may be part of the pump system include stainless-steel drop pipe, PVC pipe, packer inflation line, air-vent line, and piston pump discharge and nitrogen lines. The landing plate/wellhead body must be equipped with pipe joints, fittings, and valves compatible with the function of the pipe or tubing (i.e. sampling trees, quick connect fittings, etc.).

4.4.4.6 Once the system is landed (i.e. landing plate rested on top of well casing), final pressure tests must be conducted. Dual APV system components that must be tested include packer inflation line/lower and upper APV close control line and lower and upper APV open control lines. Two-pump system components that must be tested includes packer inflation line and piston pump nitrogen lines.

4.4.4.7 The PVC gauge tube(s) must be measured to compare with manual measurements.

4.5 TESTING AND MONITORING DUAL-SCREEN PUMPING SYSTEMS

4.5.1 After the pump system is landed and final pressure tests have been performed, the pumping system must be tested. This involves installing transducers, inflating/deflating the packer, monitoring water levels, pumping, etc., until the pumping system is observed to be operating to its specifications.

4.5.1.1 Manually measure water levels in each 1-inch PVC to determine the depth to water for each screen zone using a clean, calibrated water level probe.

4.5.1.2 Measure the bottom depth of each PVC tube as a QC check on the documented installation depths. Install transducers to begin monitoring water levels electronically.

4.5.1.3 Monitor the water level trend in each zone and adjust for the transient water level offset between the time the level was measured manually and time that electronic monitoring began. Use this information to convert water depths to actual groundwater elevations.

4.5.1.4 Using the above information, determine the current head difference between the two screen zones.

4.5.1.5 Program both upper and lower transducers for temporary dense data collection (10-second intervals) to monitor transient water level response and set up In-Situ software for real-time water level monitoring during system checkout.

4.5.1.6 Sequentially, open and close each APV while monitoring water levels in both zones. Look for any water level anomalies, such as a water level response in one or both zones when opening the lower APV, which can indicate a hydraulic leak in the pump shroud. Initial valve actuation can trigger anomalous water level responses. If an anomalous water level response is observed, sequentially open and close each valve to see if the anomaly is repeated or absent. If the anomaly persists, document condition and notify STR.

4.5.1.7 Using well component installation details, water levels and well geometry, compute the purge volume associated with each screen zone.

4.5.1.8 Pump each screen zone. Open the appropriate APV and wait for stable water level conditions. Start the pump to begin the testing process. Note the time it takes for water to reach the surface. Measure the discharge rate several times using a bucket and stopwatch.

4.5.1.9 Pump a minimum of three purge volumes for the zone being tested, unless otherwise directed by an STR. (This will simulate a sampling event.)

4.5.1.10 Once a sufficient volume has been pumped, shut the pump off and begin observing recovery data. After several minutes, the APV may be closed as recovery continues.

NOTE: Monitor the water level in the drop pipe to see if it is dropping. This provides a check on the frost-protection weep valve, allowing a determination of whether or not the valve is working (letting water drain). In this regard, examine pumping water level data to verify that the valve did not leak during testing. If the data suggest a possible leak, operate the pump again while applying artificial backpressure to the discharge in order to seat the check ball. Retest the zone to see if the valve has seated and no longer leaks while pumping.

4.5.1.11 Using the observed drawdown data, determine the specific capacity of the screen zone. Combine this information with data from the original extended aquifer test to extrapolate the estimated specific capacity applicable to extended cross flow that would have occurred during the sampling system installation.

4.5.1.12 Once data are available from both zones, use the collected information (zone specific capacities and head difference) to determine the cross flow rate and total cross flow volume associated with the sampling system installation. Provide this information to LANL so decisions can be made regarding purging out the appropriate water volume. See Attachment 8 for cross flow calculation.

4.5.1.13 Following completion of the testing procedures, download the transducer data files and reprogram the transducers to the standard data collection protocol (1-hr intervals).

4.5.2 Post Installation 24-hour and 7-day Tests including acceptance criteria.

After the pump system is landed, final pressure tests have been performed, and the system has been tested, the packer pressures shall be monitored for 8 days. Acceptable pressure drops are less than 5 psi in the first 24 hours, and less than 5 psi over the 7 days following the 24 hour period.

4.6 REPORTING

4.6.1 Sampling System Test Report

After testing, a sampling system test report shall be prepared and submitted. The report must include the following:

- Summary of testing conducted
- A brief summary of well completion details and packer information
- Pressure requirements for operating the system
- Groundwater level data, including:
    1. Baseline groundwater level data collected prior to system testing
    2. Groundwater level data collected during system testing
- APV operation, including actuation pressures and response times
- Cross flow information during installation, including:
    1. Estimated cross flow during system installation
    2. Parameters used to calculate cross flow volumes
    3. Summary of pumping operations to remove calculated cross flow volume
- Summary of purge volume requirements
- Identification of any water level response anomalies that may have been observed
- New Mexico Professional Engineer stamped As-built drawings
- Receipt inspection report, including pump column Material Test Report and retrofitted submersible pump documentation.
- Installation checklist
- Results of post installation 24 hour and 7 day tests.

4.6.2 Well Construction and Sampling System Information

A Well Construction and Sampling System Information sheet shall be prepared following sampling system installation and testing. The sheet shall be a stand-alone document that will provide the following information:

- Summary of the well location
- Summary of the well completion type, including a description of screen locations
- Special instructions, including pumping rate limitations for each screen
- Table showing well construction information
- Table showing estimated purge volumes for each screen
- Table showing pressure requirements for operation of the system, including minimum, action, target, and maximum pressure requirements for the packer, and pressure requirements for the APVs.
- Labeled photograph and/or sketch of the top of the wellhead body

4.7 MONITORING

For monitoring the system after installation, follow procedures outlined in “Pressure Monitoring of Packer Systems in Monitoring Wells” SOP-5260**.**

4.8 RECORDS MANAGMENT

Maintain and submit records and/or documents generated to the Records Processing Facility according to EP-DIR-AP-10003, Records Management Procedure for ADEP Employees.

- Sampling system receipt inspection report
- Sampling system test report
- Well construction and sampling system information sheet
- Installation Checklist
- As-built drawings, NM PE stamped including electronic files in native format (e.g.dwg for Autocad)
- Field logs, logbooks, field reports, etc.

5.0 DEFINITIONS

N/A

6.0 PROCESS FLOWCHART

N/A

7.0 ATTACHMENTS

Attachment 1 Figure 1 – Sampling System Installation Diagram

Attachment 2 Figure 2 – Dual Pump Sampling System Installation Diagram

Attachment 3 Table 1 - Training Requirements

Attachment 4 Installation Checklist

Attachment 5 Receipt Inspection Report

Attachment 6 Specifications

Attachment 7 Packer and APV Pressure Requirements

Attachment 8 Cross Flow Calculation

REVISION HISTORY

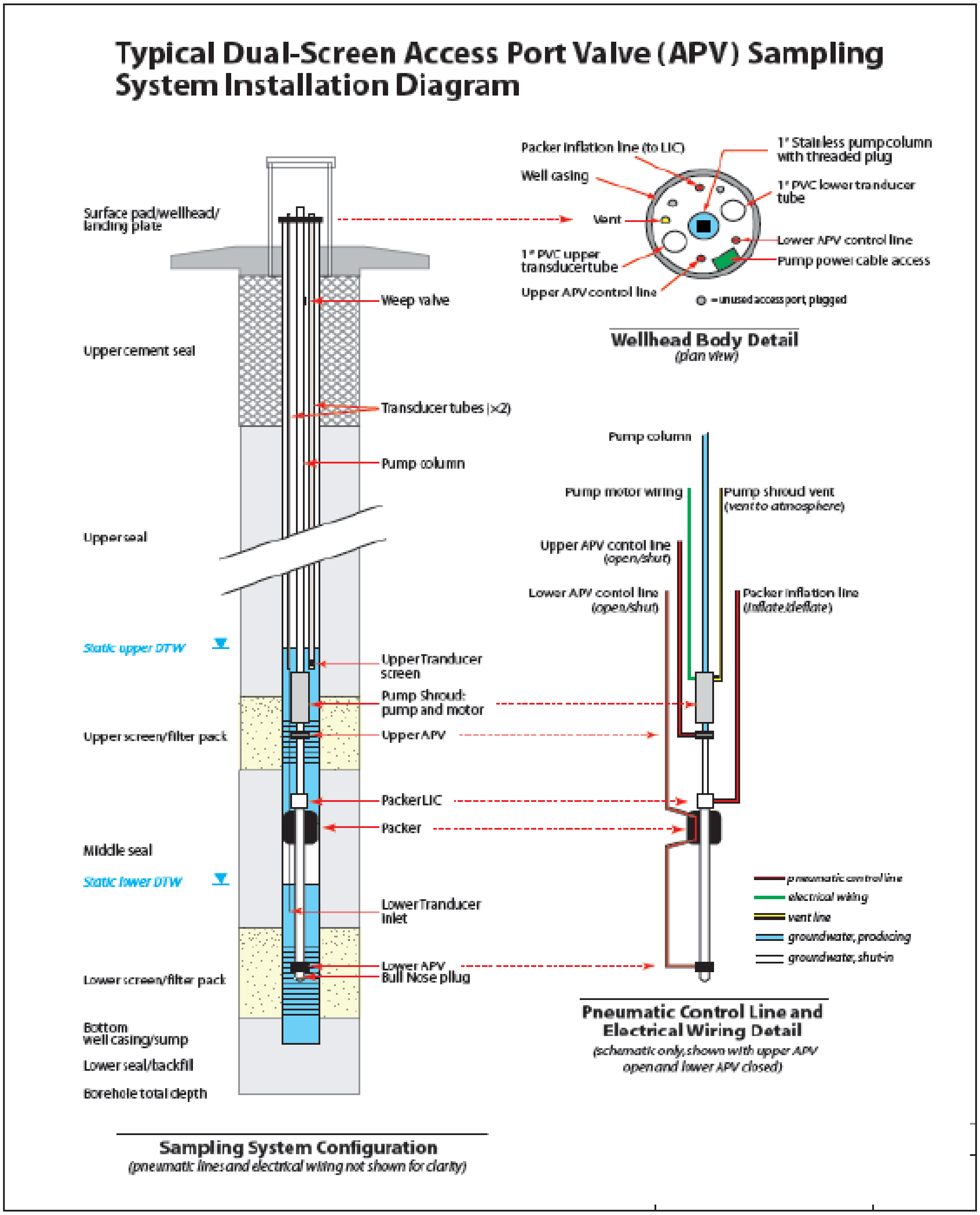
Revision No. *[Enter current revision number, beginning with Rev.0]*	**Effective Date** *[DCC inserts effective date for revision]*	**Description of Changes** *[List specific changes made since the previous revision]*	**Type of Change** *[Technical (T) or Editorial (E)]*
0		New document.	T/E
0 IPC-1		Changes to Attachment 6: updated references in Section 1.2.C4 & 1.2C5; and changed maximum Rockwell hardness in Section 2.2.	T

Click here for "Required Read" credit.

If you don't have A-level access, contact creichelt@lanl.gov.

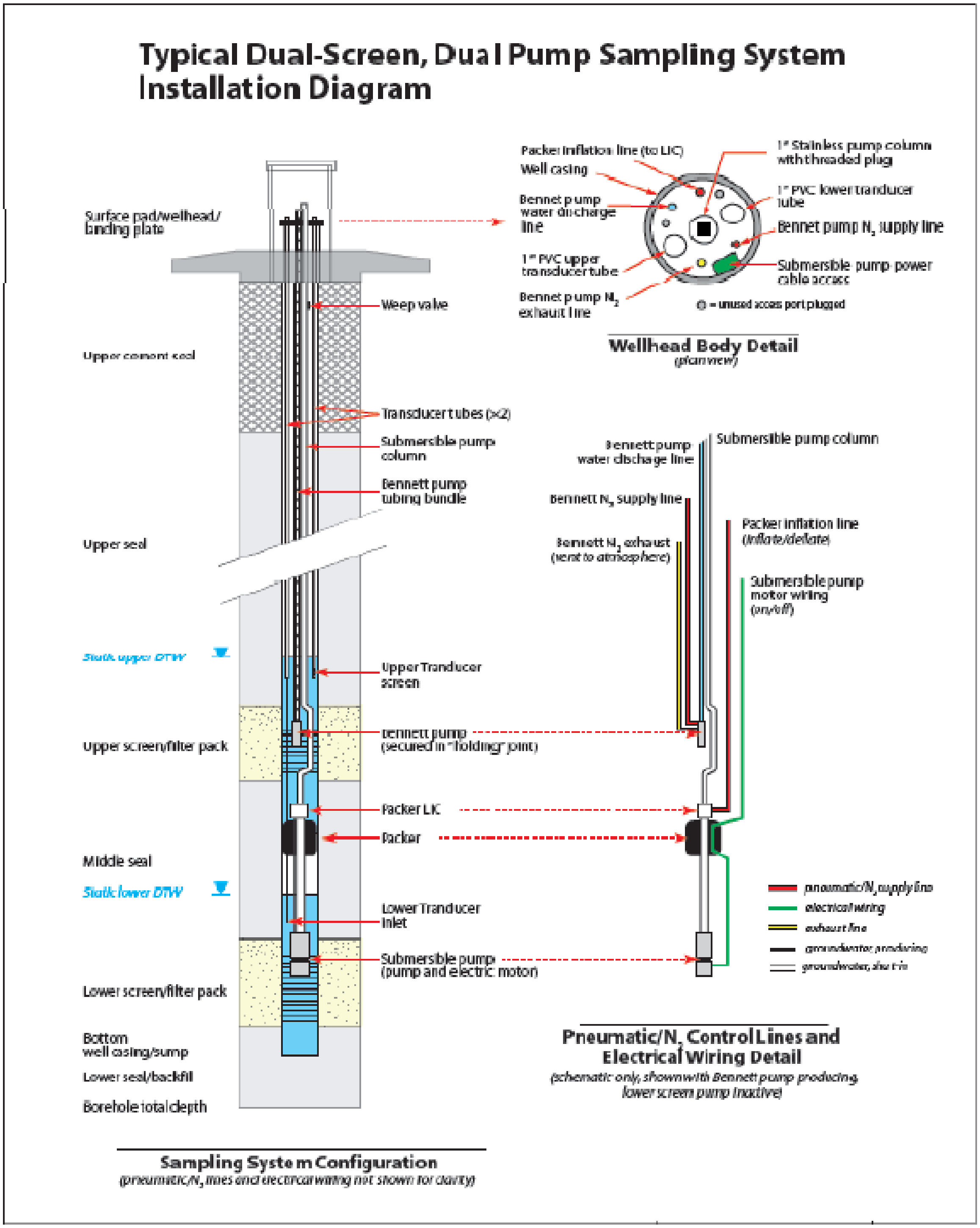
ATTACHMENT 1

FIGURE -1



ATTACHMENT 2

FIGURE -2



ATTACHMENT 3

TABLE 1 - TRAINING REQUIREMENTS

GROUNDWATER MONITORING WELL DUAL-SCREEN SAMPLING SYSTEM INSTALLATION

TITLE	OJT	SOP	NGWA Certification	Swagelok Fitting Instructions	Baski Fitting Instructions	Electrical Training Requirements/ NEC
Installation Foreman/Rig Operator		X	X	X	X	X
Foreman Helper		X		X	X	
Field Team Leader/Site Geologist	X	X		X	X	
Installation Specialist	X	X		X	X	

ATTACHMENT 4

Installation Checklist

No.	Inspection Attribute	SAT/UNSAT
1.	Verify formal receipt inspection completed. RIR #:	
2.	All major components of the pumping system [i.e. pump shroud, pump(s), liquid inflation chamber, packer, access port valves, drop pipe] decontaminated prior to installation. a. If fittings or nitrogen tubing are pre-attached to the pumping components, the open fittings and/or the ends of the tubes should be plugged to prevent water from entering into the fittings/tubes b. Verify pump model is the same as model specified on design drawings.	
3.	Before/after decontamination, the main pumping system components measured to the hundredth of a foot, and the arrangement of system components agreed upon prior to installation.	
4.	Assembled per engineering drawing approved for construction a. Verify weep hole located below local frost line (at least 3-ft below ground surface). b. Upper screen interval PVC transducer tube equipped with a 0.010-in. slot screen with a threaded end cap at the bottom of the tube. c. Lower screen interval PVC transducer tube equipped with a flexible nylon tube that extends from a threaded end cap at the bottom of the PVC tube.	
5.	Wiring of pump to pump cable inspected and approved by qualified individuals once wiring complete and before installation.	
6.	Stainless steel banding and buckles used to attach PVC pipe, nitrogen tubing, and pump cable to the pump column do not pinch tubing/cables.	
7.	Pressure tests performed after plumbing nitrogen tubes into any fittings that pressurize the packer do not indicate a leak. (Pressure tests conducted at pressures within the range expected to be applied to the system during operation.)	
8.	Pump(s) tested after installation. Discharge rate calculated and pump performs to specifications.	
9.	Final APV and packer pressure tests conducted following installation.	
10.	Packer pressure maintained 24 hours after installation within 5 psi.	
11.	Packer pressure maintained seven days after installation within 5 psi.	

ATTACHMENT 5

RECEIPT INSPECTION REPORT

Attribute	Specific Attribute Inspected	Sat	Unsat	Not Observed
1	Visually inspect all material and verify that items have not been damaged during shipment			
2	Verify that all items received are as identified and described on the Dual-Screen Well Pumping Assembly Design Drawings			
3	Verify pump column constructed of non-annealed, pickled, passivated stainless steel pipe as certified by a Material Test Report			
4	Verify that submersible pump is environmentally retrofitted as certified with documentation from supplier, including modified pump curve			

Inspected By:

____

(Print name/signature/date inspection completed)

☐ **See attached pages**

ATTACHMENT 6
(17 pages)

CAP WELLS SPECIFICATIONS 40_0511

CAP-WELLS-SPEC-40_0511

COMPRESSION FITTINGS ON STAINLESS STEEL TUBING

PART 1 GENERAL

1.1 PURPOSE

A. The purpose of this specification is to provide a safe and correct method for installation and remake of Swagelok fittings on stainless steel tubing up to a maximum OD of 1 inch.

1.2 DESCRIPTION

A. Definitions

1. Compression Fitting: A tube fitting consisting of two ferrules, a nut and the fitting body. The tubing is utilized to provide one of the sealing joints in the assembly.
2. Hex Flat: This describes 1/6 turn on a 6-sided Swagelok compression fitting or 60 degrees revolution with 360 degrees being one complete revolution.

B. Acronyms

1. ASME – American Society of Mechanical Engineers
2. ASTM – American Society of Testing Materials
3. B&PV – Boiler and Pressure Vessel
4. DOT – Department of Transportation
5. ID – Inner Diameter
6. LIR – Laboratory Implementation Requirements
7. MAWP – Maximum Allowable Working Pressure
8. OD – Outside Diameter
9. SS – Stainless Steel
10. TB – Technical Bulletin

C. References and Related Sections

1. ASME B31.1 – Power Piping
2. ASME B31.3 – Process Piping
3. ASME B31.9 – Building Services Piping
4. LANL Engineering Standards Manual PD342 - Chapter 17, Pressure Safety http://www.lanl.gov/orgs/eng/engstandards/ESM_Chapters.shtml#esm17
5. P101-34 - Pressure Safety https://policy.lanl.gov/pods/policies.nsf/MainFrameset?ReadForm&DocNum=P101-34&FileName=P101-34.pdf IPC-1
6. 22 0529 - Hangers and Support for Plumbing Piping and Equipment

7. 22 0554, Identification for Plumbing, HVAC, and Fire Piping and Equipment
8. 22 0813-- Testing Piping Systems

1.3 STORAGE AND HANDLING

A. Deliver tubing material and fittings to site in clean, degreased, and dry condition.

B. Inspect components and documentation to ensure components are as ordered and suitable for use. Store in a controlled area prior to use.

C. Maintain end seals and covers to physically protect parts and preserve cleanliness.

D. Remove end seals and covers only for cleaning, fabrication, erection, or inspection.

E. Exercise care in the handling and storage of materials and pre-fabrications to ensure that contamination by foreign material does not occur.

F. Do not drag tubing off trucks or rack (causes longitudinal scratches).

1.4 PREREQUISITES

A. Installers of compression fittings shall be one-time trained on their assembly by the manufacturer or an authorized distributor, or through a formal LANL course for the following applications:

- intermediate and high pressure systems (defined here as 150 psi gas/1500 psi liquid and 3000 psi gas/5000 psi liquid max allowable operating pressures, respectively).

Acceptable Courses:

- Course 30831, Compression Fitting Assembly
- Swagelok Safety Seminar (*approx 4 hours, taught by Albuquerque Valve and Fitting info@albuquerque.swagelok.com*)

B. Review drawings, details, manuals, and other material required for instrument or process tubing and fitting installation.

C. Use the following guidelines during the performance of this specification:

1. Fitting Removal
   a. If applicable, verify piping system has been properly isolated, drained, and tagged.
   b. Tube caps and fittings should not be used to bleed or vent any instrument/process lines at normal system pressures. This is an unsafe act that may result in serious injury or contamination.

PART 2 PRODUCTS

2.1 EQUIPMENT REQUIRED

A. Swagelok Tube Fitting Gap Inspection Gages for initial installation (See Attachment 4.4, Table 4.4-1)

B. Special Tools

1. Tube benders (with bend radius as required by Attachment 4.2, Table 4.2-1)
2. Tube cutter (see Attachment 4.1)
3. Tube deburring tool or equivalent

C. Additional Equipment/Tools

1. Applicable personal protective equipment
2. 6-inch ruler
3. Scribe (for marking fittings) or equivalent (indelible pen or felt tip marker – low chloride if on stainless steel)
4. Open end wrenches (as required for application)
5. Tubing, as applicable for work to be done
6. Fittings and fitting components, as applicable for work to be done

2.2 TUBING MATERIAL

All selected tubing must be annealed with a Rockwell hardness of less than 90 (Rb 90) for success in fitting makeup. For guidance refer to Swagelok Tubing Data Catalog MS-01 and Stainless Steel Tubing: ASTM A269, annealed, Type 316. IPC-1

PART 3 - EXECUTION

3.1 INSTALLATION

A. Follow Attachments 4.1 through 4.8 for proper installation, remake, and maintenance of Swagelok compression fittings.

3.2 PARTS REPLACEMENT

A. Do not connect, mix, or interchange parts (caps, plugs, ferrules, bodies, etc.) of tube fittings made by different manufacturers (such as Parker to Swagelok). Improper fitting seal, DAMAGE, or INJURIES may result.

B. Use all SS fittings and ferrules on SS tubing.

3.3 POST INSTALLATION INSPECTION AND TESTING

A. Inspection

1. Ensure lines are terminated correctly by performing visual continuity checks on each tubing run.
2. Ensure tubing and fittings are of the type and size specified.
3. Ensure tubing is free of wrinkles, flats, axial scratches, gouges, and humps.
4. Ensure tubing is properly supported and protected from damage.
5. Ensure threads are mostly or fully covered by fitting nut.
6. Check for proper pull up of the fitting with appropriate size no-go gage.

NOTE: Some fittings (e.g., bulkhead fittings) are not gageable.

B. Leak Test

1. Test to determine the integrity of the component and related equipment to perform their intended functions. Pressure test all new piping and overall system, and any pressure system that has been modified or repaired, shall be pressure-tested before operating. Testing must conform to the conditions of the relevant codes and standards (e.g., B&PV, B31, or DOT).

   Note: Systems greater than 15 PSIG require adherence to LIR 402-1200-01.

2. On pressure systems, perform a pressure test in accordance with an appropriate ASME B&PV Code, the appropriate section of B31 piping codes (see LIR 402-1200-01) or testing per Section 22 0813, Testing Piping Systems.

PART 4 ATTACHMENTS

4.1 Tube Cutting

4.2 Tube Bending

4.3 Tubing Installation

4.4 Swagelok Fitting Initial Installation

4.5 Tube Fitting Tightening Due to Leaking Fitting

4.6 Tube Fitting Removal and Reconnection

END OF SECTION

FOR LANL USE ONLY

This project specification is based on LANL Master Specification 40 0511 Rev. 1, dated July 17, 2008.

Attachment 4.1

Tube Cutting

CAUTION: When cutting, ensure tubing does not get hot. Heat hardening of tubing may cause fitting failure.

Tube cutters used for SS up to 1" OD must be specially designed to avoid work hardening.

Due to the possibility of introducing foreign particles internal to tubing, ensure tubing is clean and deburred after cuts (hacksaw use is highly discouraged).

NOTE: Tubing shall be cut using tools designed and maintained (sharp cutting surfaces) specifically for that purpose.

4.1.1 Tube Cutters

A. Using tube cutters, cut tubing squarely with gradually applied force. Use 1/8 turn of cutter knob for every two revolutions on steel or stainless steel. Use 1/8 turn of cutter knob for each revolution when cutting copper tubing.

B. Deburr ID of tubing.

C. Clean as necessary.

4.1.2 Hacksaw (hacksaw use is highly discouraged)

A. When using a hacksaw to cut tubing, use tube sawing guide instead of a vise to ensure a square cut and to keep tubing from flattening out.

B. Hacksaw blade should have 24 teeth per inch minimum.

C. For proper entry into fitting and to prevent system contamination and/or restricted flow, deburr both ID and OD of tubing.

D. Clean as necessary.

Attachment 4.2
Tube Bending

NOTES: **1.** Tubing minimum bending radius shall be based on the applicable tubing OD (tube fittings shall be used whenever smaller bending radii are required).

2. Tube bending will result in wall thinning and the need to derate the tubing design pressure per ASME (e.g., ANSI/ASME B31.9 Section 102.4.5).

4.2.1 Use table 4.2-1 to determine minimum tubing bend radius.

Table 4.2-1 Minimum Bending Radius for Tubing (requires derating)

	For Tube Bend $\leq 180^0$		
Tubing OD (inch)	Min Bend Radius (inch)	Calculated Bend Radius (diameters)	Resulting Wall Thinning (%)
1/8	3/8	3	22
1/4	9/16	2.25	31
1/4	3/4	3	22
3/8	15/16	2.5	27
1/2	1-1/2	3	22
5/8	2-1/4	3.6	19
3/4	3	4	17
1	4	4	17

NOTE: 1. All tube bends shall be made using tools designed specifically for that purpose. Caution shall be exercised to ensure a smooth, even bend with minimal flattening, wrinkles, humps, or other damage to tubing.

2. Tube benders vary, but requirements for minimum bend radius shall be met.

3. Actual bend radius can be greater than required minimum.

4.2.2 Select tube bender that meets the minimum bend radius requirements from Step 4.2.1 (Table 4.2-1).

4.2.3 Bend tubing as follows:

A. Ensure even bends with no flattening or other damage to tubing.

B. Bend tubing so that deformed section at bend does not enter fitting. See dimension L on Figure 4.2-1 and Table 4.2-2.

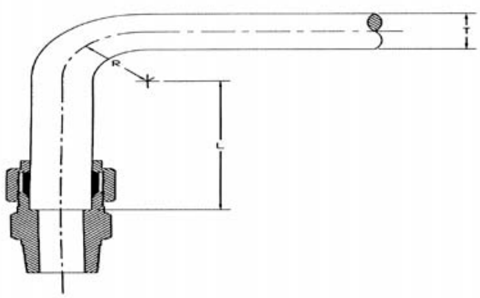


Figure 4.2-1 Guidance for Determining Length Between Tube Bend and Fitting

Table 4.2-2 Determining Length Between Tube Bend and Fitting

T (inch)	Tubing OD	1/8	1/4	3/8	1/2	5/8	3/4	1
L (inch) Length of Straight Tube	Recommended	3/4	13/16	15/16	1 3/16	1 1/4	1 1/4	1 1/2
	Absolute Minimum	5/8	11/16	3/4	1	1 1/6	1 1/16	1 5/16

CAUTION:	Do not spring tubing into position in fitting as this can result in excessive stress on tubing and connections leading to leakage.

C. Tube line fabrication (bend angles and measured lengths) must be accurate so that the tube end easily enters the fitting in proper alignment.

D. When a section of bent tubing is being connected, ensure that tubing is in proper alignment with fitting before tightening.

E. Use bends where practical instead of fittings.

4.2.4 Verify and document based on applicable Project Quality Management Plan.

Attachment 4.3
Tubing Installation

4.3.1 Flush or blow down tubing and fitting(s), where practical.

4.3.2 Ensure that visible internal surfaces of tubing are clean of any foreign matter. Remove all filings, chips, and grit before attachment of fittings. Cover ends until final installation.

4.3.3 Use related attachments with this one as necessary.

A. Tube Cutting (Attachment 4.1)

B. Tube Bending (Attachment 4.2)

C. Swagelok Fitting Installation (Attachment 4.4)

4.3.4 Plan tubing layout to ensure:

A. Tubing does not block access to equipment that needs to be accessed for maintenance.

B. When attaching tubing to an item that may occasionally be removed for repair or maintenance, ensure method of connecting and running tubing allows easy removal.

C. Ensure tubing is kept clear of controls and does not impede operator's access to controls.

D. Ensure tubing is appropriately supported. Refer to LANL Specification Section 22 0529 Hangers and Supports for Plumbing Piping and Equipment.

E. Ensure valves or other devices that require torque to be executed in their operation are mounted so that a twisting movement is not applied to tubing. Normally this would require valves or other devices to be mounted using a bracket to hold it in place.

F. Ensure fittings are staggered and offset when making multiple runs to provide easier installation and conserve space.

NOTE: Straight runs between two fixed fittings should be avoided. This does not allow for expansion and or for tubing to be properly bottomed in fitting when being made up.

J. If necessary, use expansion loops in tubing to allow for thermal growth.

K. If necessary, make layout sketch of tubing runs by measuring distances with a flexible steel rule. Some suggestions to consider:

1. Consult fitting vendor catalog to determine distance to end point of tubing. (See Attachment 4.2 on bending tubing)

2. Measure all dimensions to and from centerline of tubing.

3. For clearances, it is necessary to allow for one-half tubing OD to clear obstructions to prevent rubbing.

4. Tube bends can be measured square and excess tubing trimmed from end after bending. For more accurate tube length measurement, length of tubing in a bend can be calculated using Table 4.3-1 and the equation below:

Table 4.3-1 Bend Angle Cross Reference To Bend Factor

Degrees of Bend	30^0	45^0	60^0	90^0	180^0
Bend Factor	0.52	0.78	1.04	1.57	3.14

Required Tube Length = **Bend** $\left[\textbf{Bend Factor}\right]$ **X** $\left[\textbf{Bend Radius}\right]$

NOTE: Example: For a 90^0 bend with a bend radius of 2 inches:

Required Tube Length = (1.57) x (2 inches) = 3.14 inches

4.3.5 Label piping system including wellhead connections and pressure system identification and certification tag.

4.3.6 Verify and document based on applicable Project Quality Management Plan.

Attachment 4.4
Swagelok Fitting Initial Installation

4.4.1 Refer to the following for:

- Tube Cutting (Attachment 4.1)
- Tube Bending (Attachment 4.2)

4.4.2 Flush or blow down tubing / fitting(s), where practical.

4.4.3 Ensure that visible internal and external surfaces of tubing and fitting(s) are clean of any foreign matter.

NOTE: Tubing surface finish is very important to proper sealing. Tubing with any depression, scratch, raised portion, or other surface defect will be difficult to seal.

4.4.4 Ensure:

- No axial scratches along tubing where ferrule seats
- Ferrule(s) are not scratched or deformed
- Fittings components are of proper type
- Parts are not mixed or interchanged with another manufacturer
- No damaged threads on fitting bodies and nuts

NOTES:

- The small tapered end of ferrule goes into fitting body.
- Swagelok fittings have a two piece ferrule: front ferrule (large piece) and back ferrule (small piece).
- Do not use Teflon tape on tube end of fitting body threads. A small amount of low-chloride lubricant on stainless steel threads can be used to minimize galling (do not get inside the process; (Swagelok Silver- or High Purity-Goop are acceptable).
- You may apply a thin coat of approved Jet Lube V-2 to the O.D. of the tubing (over the last inch where the ferrules will eventually sit) and the O.D. of the ferrule. Be careful not to get any thread compound inside the tubing.

4.4.5 Makeup nut and ferrule(s) on tubing. See Figure 4.4-1:

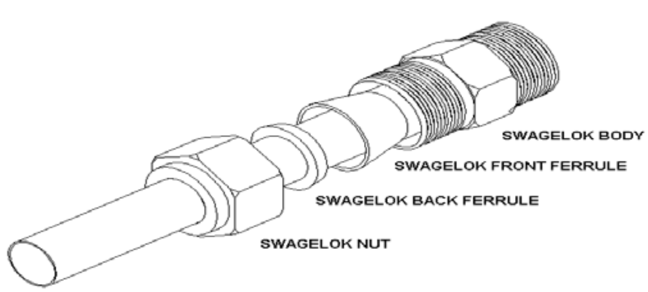


Figure 4.4-1 Swagelok Fitting Exploded View Showing Ferrules Orientation

NOTE: Fittings are not normally disassembled prior to use as contaminants may enter fitting or ferrules may be lost.

4.4.6 Align tubing with fitting so that tubing end easily enters fitting in proper alignment.

4.4.7 Insert tubing end until it bottoms against shoulder in fitting body. While holding tube end against shoulder in fitting body, tighten nut finger tight. This is necessary to prevent movement of the tube while the nut forces the ferrule to grip the tube and to seal through any minor imperfections that may exist on the outside of the surface.

NOTE:

- If unexpected resistance is felt when threading nut to finger tight, then fitting should be cleaned or replaced, as applicable.
- Do not force an improperly fitted tube line into the fittings. If tubing is oval or will not easily fit through fitting nuts, ferrules, and bodies, do not force tubing into fittings.
- Tightening fittings finger tight means manually, with no tools.

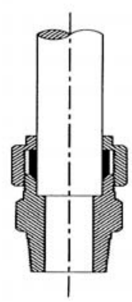


Figure 4.4-2 Swagelok Fitting Cutaway View

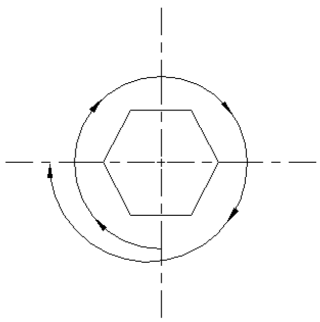
4.4.8 Scribe fitting at 6 o'clock position. Use a tool capable of scratching the fitting, DO NOT use indelible pen or felt tip marker. If desired, fitting body may also be marked temporarily to verify number of turns in the following step.

NOTE: When scribing nut and fitting body on fittings where scribe reference on body may be used for more than one nut (e.g., union, elbow, etc.), ensure that scribe marks relating to each nut are distinguishable.

4.4.9 While holding fitting body steady with backup wrench:

A. For tubing OD ≥ 1/4 inch: Tighten nut 1-1/4 turns (as shown in Figure 4.4-3 below left) to swage ferrule. (Nut mark should be at 9 o'clock position).

B. For tubing OD < 1/4 inch: Tighten nut 3/4 turn (as shown in Figure 4.4-4 below right) to swage ferrule. (Nut mark should be at 3 o'clock position).



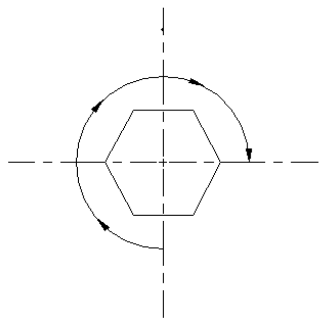


Figure 4.4-3 Tightening Nut 1 1/4 Turns (for tubing OD ≥ 1/4 inch)

Figure 4.4.-4 Tightening Nut 3/4 Turn (for tubing OD < 1/4 inch)

CAUTION:

- Never permit the fitting body to rotate during tube end make-up. **Two wrenches must be used.** Assemble port connectors to components first and hold with wrench while making up the tube joint. All types of union bodies must be held while each of the tube ends is makeup.
- Never attempt to makeup by torque or feel. Always turn the nut the prescribed amount (listed above) regardless of torque required.

NOTE:

- A gap inspection gage is used with Swagelok fittings to verify proper swaging and pull up.
- Gap inspection gages should be used unless physical makeup of fitting prevents their use.
- Gap inspection gage is not required on jam nut of Bulkhead Union Fitting or other fittings without shoulders. Step 4.4.10 provides alternative inspection method.
- During initial installation using gap inspection gage, Swagelok fittings do not require disassembly and visual inspection if made up to manufacturer's instructions.

Table 4.4-1 Swagelok Gap Double-Ended Inspection Gages

Tubing OD (inch)	1/8	1/4	5/16	3/8	1/2	5/8	3/4	1
Swagelok Gage Series	200	400	500	600	810	1010	1210	1610

NOTE: Only the following Swagelok Gap Inspection Gage ends are to be used in this procedure:

For tubing OD ≥ 1/4 in.: Use 1-1/4 TURNS FROM FINGER TIGHT end

For tubing OD < 1/4 in.: Use 3/4 TURNS FROM FINGER TIGHT end

C. Attempt to insert gap inspection gage between fitting nut and body hex.

- For tubing OD ≥ 1/4 inch: Use 1-1/4 TURNS from FINGER TIGHT end
- For tubing OD < 1/4 inch: Use 3/4 TURN from FINGER TIGHT end

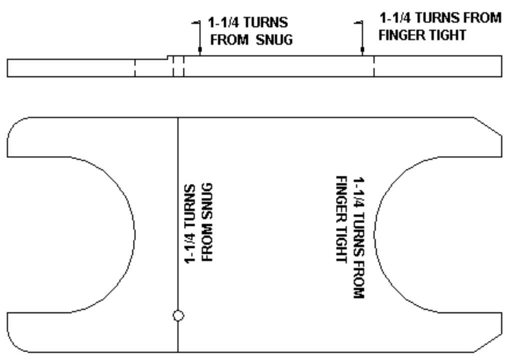


Figure 4.4-5 Typical Swagelok Gap Gage

CAUTION: Do not tighten fittings with gap gage in place.

NOTE:
- If gap inspection gage fits between nut and body hex, fitting is not sufficiently tightened.
- If any tubing/fitting makeup is found to be questionable, then remake, replace, or repair as necessary.

- If using Swagelok MS-IG 468 (multiple size) no-go gage, measure from finger tight.

D. If gap inspection gage fits between nut and body hex, tighten in 1/4 hex flat increments until gage does NOT fit into space. DO NOT tighten more than 2 hex flats (1/3 turn) past:

- For tubing OD $\geq$ 1/4 inch: 9 o'clock position (refer to Figure 4.4-3)
- For tubing OD $<$ 1/4 inch: 3 o'clock position (refer to Figure 4.4-4)

E. When gap inspection gage will NOT fit between nut and body hex, installation of fitting is correct.

4.4.10 If a gap inspection tool cannot be used and personnel safety depends on proper makeup, then check for proper fitting makeup as follows:

NOTE: Scribe mark is reference point used in subsequent fitting tightening.

A. Scribe fitting and nut in their final position.

CAUTION: If tubing end does not sufficiently extend past ferrule, improper fitting seal may result.

B. Remove nut , disassemble fitting, and visually inspect for:

- Ferrule(s) orientation is correct.
- Ferrule(s) swaged.
- Tubing extends past end of ferrule to ensure tubing bottoms out in fitting.
- If end tubing is visible, verify tube end is properly cut and free of burrs.

NOTE:
- It is recommended that Swagelok fittings not be tightened $>$ 1/6 to 1/4 turn past scribe mark.
- When reconnecting fitting, a slight increase in resistance (torque rise) will be felt indicating ferrule is being resprung to its original position.
- Fitting end plugs and port connections require only 1/4" turn from finger tight makeup in all sizes. Tightening fitting finger tight normally means manually, with no tools. Sizes 1/16 to 3/16 can be damaged (tube snapped or cut) by over tightening.

C. Reconnect nut as follows:

1. While ensuring tubing is aligned and bottomed against shoulder in fitting body, tighten nut finger tight.
2. Tighten nut to its original position as indicated by scribe marks, then snug slightly (with wrench), typically 1/6 to 1/4 turn maximum.

4.4.11 Verify fitting(s) makeup completed and document based on applicable Project Quality Management Plan.

Attachment 4.5

Tube Fitting Tightening Due to Leaking Fitting

WARNING:	• Before tightening fittings, system must be depressurized.

NOTES:

- It is recommended that fittings not be tightened more than 1/6 to 1/4 turn past the scribe mark.
- If fitting is not scribed, tightening may be done using good craft practice.

4.5.1 If fitting leaks, tighten fitting in increments of 1/4 hex flat until leak stops.

4.5.2 If fitting still leaks, isolate, depressurize, and disassemble the fitting, and proceed as follows:

1. Place the nut and ferrule on the tubing.
2. Apply a thin coat of approved Jet Lube V-2 to the O.D. of the tubing (over the last inch where the ferrules will eventually sit) and the O.D. of the ferrule. Be careful not to get any thread compound inside the tubing.
3. Insert the tubing into the Swagelok tube fitting body, making sure that the tubing rests firmly on the shoulder of the fitting body.
4. Tighten the nut until the tubing will no longer rotate freely by hand. If the tubing cannot be rotated (i.e. the tubing is on a spool), while supporting the fitting body with a backup wrench, use a wrench to tighten the nut up to ¼ turn past finger tight.
5. Scribe the nut and hex of the fitting body to indicate a starting point for tightening. While holding the fitting body steady with a backup wrench, tighten the nut 1 ¼ turns.
6. Wiggle and or bend the tubing above the fitting, secure the tubing in its final resting position, then retighten the nut.
7. Pressurize the tube with nitrogen and check for leaks.

Attachment 4.6
Tube Fitting Removal and Reconnection

4.6.1 Fitting Removal (system must be depressurized)

A. Inspect fitting for previously scribed marks.

B. If fitting is not scribed, before disconnecting, perform as follows:

1. Inspect fitting for leaks and indication of leaking.
2. Inspect fitting for looseness (by hand).
3. If leaks or looseness are noted:
    a. Evaluate the need to replace fitting.
    b. If necessary, replace fitting per applicable attachment of this specification.

NOTE:
- When scribing nut and fitting body on fittings where scribe reference on body may be used for more than one nut (e.g., union, elbow, etc.), scribe marks relating to each nut are to be distinguishable.
- For maximum number of remakes, mark the fitting and nut before disassembly to prevent over tightening caused by guesswork.

4. If no leaks or looseness are noted, scribe fitting. Use this mark as original installation scribe mark.
5. Remove fitting. Ensure proper cleanliness level is maintained.

4.6.2 Fitting Reconnection

A. If both ends of tubing/fitting(s) are open, flush or blow down tubing/fitting(s), where practical.

B. Verify that visible internal and external surfaces of tubing and fitting(s) are clean of any foreign matter.

C. Check fittings visually for condition of threads, ferrule, and tubing. If fitting is damaged, initiate action to replace.

CAUTION: If Safety Installation Collar was installed on Swagelok fitting, remove it before connection.

NOTE: Safety Installation Collar may have been installed with Swagelok fittings on large OD tubing to verify proper swaging.

D. Insert assembly into fitting until ferrule seats into fitting.

NOTE: If resistance is felt when threading nut to finger tight, fitting should be cleaned or replaced, as applicable.

E. Thread nut onto body finger tight and tighten to original scribe mark.

NOTE: • A slight torque rise will be felt indicating ferrule is being resprung to its original position.   • It is recommended that fittings NOT be tightened more than 1/6 to 1/4 turn past scribe mark.

F. If connecting swaged ferrule/tubing/nut assembly with new fitting body (where fitting body will not have scribe mark):

1. Tighten nut until rise in torque is felt.
2. Scribe fitting body (align with nut scribe mark).
3. Snug fitting slightly with wrench.

G. If fitting body and nut are scribed:

1. Retighten nut by hand.
2. With two wrenches, tighten nut to its original position as indicated by scribe marks. A noticeable increase in mechanical resistance will be felt indicating the original position. Then tighten 1/6 to 1/4 turn with wrench.
3. If torque rise is NOT felt, tighten nut an additional 1/12 turn (1/2 hex flat).

H. If fitting still leaks, proceed as follows:

1. Clean the tubing thread on the fitting body as well as the nut.
2. Apply a thin coat of V-2 Jet Lube to the outside of the ferrule.
3. Insert the tubing with the ferrule into the fitting body.
4. Tighten the nut with a wrench until a sharp increase in resistance is felt. Tighten the nut an additional 1/16 to 1/8 of a turn.
5. Wiggle and/or bend the tubing above the fitting, secure the tubing in its final position, and retighten the nut.
6. Pressurize the tube with Nitrogen and check for leaks.

I. Verify and document based on applicable Project Quality Management Plan.

ATTACHMENT 7

Packer and APV Pressure Requirements

Minimum Packer Pressure Required

The formula used to determine the minimum packer inflation pressure required for proper system operation is as follows:

$$R_{\min} = 50 + M(50, 0.2h) + \frac{d_p - d_{hswl}}{2.31} \tag{1}$$

where,

R_{min} = minimum packer inflation pressure required, in psi

$M(a,b)$ = the maximum of *a* or *b*

h = head difference above and below packer, in feet

d_p = depth to packer, in feet

d_{hswl} = depth to the higher static water level of the two zones above and below the packer (usually that of the upper zone), in feet

Maximum Packer Pressure Allowable

The formula used to estimate the maximum safe packer pressure is as follows:

$$R_{\max} = 300 + \frac{M(-27, d_p - d_{lpwl})}{2.31} \tag{2}$$

where,

R_{max} = maximum allowable packer inflation pressure, in psi

$M(a,b)$ = the maximum of *a* or *b*

d_p = depth to packer, in feet

d_{lpwl} = depth to the lower pumping water level of the two zones, in feet

ATTACHMENT 7 (cont.)

Packer and APV Pressure Requirements

Minimum APV Pressure Required

The access port valves are opened by overcoming frictional forces and the packer pressure that is keeping the valves closed. The following formula can be used to estimate the pressure required:

$$R_{APV} = f + \frac{1}{2.2}\left[3.2P - \frac{M\left(0, d_{APV} - d_{cv} - 27\right)}{2.31}\right] \qquad (3)$$

where,

R_{APV} = minimum required APV pressure, in psi

f = estimated APV sliding friction pressure requirement, in psi

P = packer pressure, in psi

$M(a,b)$ = the maximum of *a* or *b*

d_{APV} = depth to APV in feet

d_{cv} = depth to check valve, in feet

All of the terms in Equation 3 are known exactly except the friction factor, *f*. This parameter varies from one APV to another, but 60 psi is considered a reasonable, conservative estimate.

ATTACHMENT 8

Cross Flow Calculation

Cross Flow Calculation

When a two-screen well stands open with no packer separating the screen zones, groundwater from the higher-head zone flows into the well and out of the lower-head zone. The cross flow rate, Q, can be computed using the following formula:

$$Q = h\frac{c_1 c_2}{c_1 + c_2}$$

where,

Q = cross flow rate, in gpm

c1 = specific capacity of screen 1, in gpm/ft

c2 = specific capacity of screen 2, in gpm/ft

h = head difference between screens 1 and 2, in ft

The total cross flow volume over a time, t, can then be computed as the product Qt. Expressing t in minutes yields the cross flow volume in gallons.