OPERATOR'S MANUAL FOR THE US P-61-A1 POINT-INTEGRATING SUSPENDED-SEDIMENT SAMPLER

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Operator's Manual for the US P-61-A1 Point-Integrating Suspended-Sediment Sampler

Characteristics

Description: The US P-61-A1 is a sampler designed to collect suspended-sediment samples at any point in a stream or to collect depth-integrated suspended-sediment samples over a range of depths. The sampler is cast of bronze, weighs approximately 105 pounds, and has an overall length of 28 inches. The sampler body is streamlined and has tail fins to orient the sampler so the intake nozzle located in the head is directed into approaching flow (Figure 1). The intake nozzle has an internal diameter of 3/16 inch. There is only one size nozzle available for the sampler. The sampler utilizes either a pint "milk" bottle (Part No. 002110) or a quart bottle (Part No. 004010) as sample containers. The sample container is housed in the body. An early version of the sampler, the US P-61, only accepted pint sample containers. The sampler consists of two major parts: the head and body. The head contains an electrically operated, two-position rotary valve and several passageways that convey the sample and air. The body has a hollow interior, which serves as a compression chamber that forces air into both a cavity in the head and the sample container to equalize pressure in the sampler as it transits through the water. Pressure equalization prevents an in-rush of sample as the valve is opened. The sampler head is attached to the body by a hinge and held closed by a latch. The head pivots on the hinge to open and provide access to the sample container. When the head is closed the sample container is sealed against a gasket mounted in the rear of the head. A bottle spring exerts force against the base of the sample container in order to maintain a seal between the bottle gasket and the sample container.

Valve Mechanism: The valve serves two purposes: it starts and stops both sample flow into the sample container and airflow to and from the sample container. The porting diagram for the valve is shown in Figure 2. With no electrical power applied, the valve is in the pressure-equalizing position. As the sampler is lowered through the water, hydrostatic pressure forces water through the holes in the bottom of the sampler into the compression chamber compressing the air in the chamber. The increased pressure is transmitted through a tube or passageway that connects the pressure chamber in the body to the cavity in the head of the sampler. At the head-body junction, passageways in the head and body are sealed by an air-line gasket (Part No. 004122, Figure 1). The pressure in the head is transmitted through the valve plug (Figure 2, Section B-B, pressure-equalizing position) and to the sample container. The pressure in the sample container is balanced with the ambient pressure near the nozzle. When power is applied, the solenoid turns the valve to the sampling position (Figure 2). The connection to the head cavity/compression chamber closes and the passage leading from the nozzle to the sample container opens. The sample flows without surging into the sample container. Air displaced by the sample is expelled through a passage from the sample container to the exhaust vent on the side of the head. Sampling terminates when power is removed and the valve plug returns to the equalizing position.

Power Supply: The sampler must be suspended on a sheathed single-conductor cable. The cable should have a diameter of 1/8 inch or smaller to minimize drag. The resistance in the cable should not exceed 100 ohms per 1000 feet. The sheath, exterior load-bearing strands, is connected to a special clamp. The clamp is connected to the top end of the hangar bar. The insulated conductor, located in the center of the cable, is connected to the solenoid (electrical) lead, a coaxial insulated wire, on the left side of the head. The outer shielding of the coaxial cable on the left side of the sampler head is connected directly to the clamp. This provides proper grounding of the electrical circuit and completes connections at the sampler end of the cable. On the reel end, secure the cable to the reel then connect the center conductor to the slip ring of the reel. When power is applied at the reel, current will flow from the supply, through the center conductor of the cable and through the solenoid. Current will return through the grounding jumper wire, cable clamp, the cable sheath, and the reel frame.

The power supply must be direct current (DC) which, at remote sites, is most conveniently obtained from dry or wet cell batteries. The supply voltage is set by the required current and the total resistance in the cable and solenoid. For a 100-foot cable with a resistance of 100 ohms/1000 feet, the cable resistance will be 10 ohms. The rotary solenoid (Part No. 004170) has a resistance of 24 ohms and requires one ampere to rotate the valve. With this cable, the voltage must be no less than 36 volts. To provide a margin of reliability and compensate for battery discharge, a 48-volt DC supply is recommended. Eight to ten 6-volt lantern batteries can be used. Other batteries such as wet cells can be used, but any battery selected must have capacity sufficient to sustain the required voltage while delivering a current of one ampere. The power supply should be fully charged prior to going the field. A rechargeable power supply, the US RBP-95 (Part No. 004180) may be purchased from the Federal Interagency Sedimentation Project (FISP). Compared to individual batteries, the unit is lighter, smaller and more convenient, but is more expensive.

Operating Limitations

Velocity limitations: The US P-61-A1 sampler will collect acceptable flow weighted samples in streams with velocities from 1.5 to 13 ft/sec. An acceptable velocity range is one at which a representative flow weighted sample is collected at a sampler inflow efficiency between 0.9 and 1.1. Inflow efficiency is defined as the ratio of the sample velocity entering the nozzle to the ambient stream velocity. An inflow efficiency of 1.0 is referred to as isokinetic. The upper recommended operating velocity will normally be less the 13 ft/sec, due to the down stream displacement of the sampler from current induced drag. Depth of stream and velocity affect drag, therefore the operator should make a determination on the upper velocity limit based on the field conditions. The upper useful limit will likely not exceed 10 ft/sec. If the stream velocity exceeds 10 ft/sec a US P-63 (for point-integrated samples) or US D-96 (for depth-integrated samples) should be used

Depth limitation: The US P-61-A1 sampler can collect flow-weighted samples to a maximum depth of approximately 180 ft at sea level with a pint (milk bottle) sampler container and to 120 ft at sea level with a quart sample container. Note: See the section on Operation for an explanation of how to collect samples to these depths.

Unsampled zone: The US P-61-A1 can sample to within approximately 3.3 inches of the streambed. This unsampled zone is the distance between the nozzle and the bottom of the sampler. Care should be used if the sampler is allowed to touch the bottom. Fine sands and silts can be disturbed possibly affecting the sample.

Transit rate limitations: The transit rate is the speed of lowering and raising the sampler in the sampling vertical. Transit rate diagrams[1,2,3] for the US P-61-A1 are presented in Figures 3, 4, 5 and 6. See the section on Depth Integration Sampling for details on how to determine the proper transit rate.

Operation

Sampler Preparation: The sampler should be suspended by a hanger bar from a cable clamp with the electrical connection completed as described in the section on Power Supply. The US P-61-A1 solenoid is not sensitive to direction of current so the electrical connections can be made without regard to polarity. The valve plug should be checked for rotation by operating the power supply switch several times while looking through the nozzle. A light source positioned at the rear of the head near the nozzle exit will help observation of the valve movement. If the sampler has been in storage, water-formed deposits may cause the valve plug to seize in the valve body/head base. If the valve will not turn, connect the power supply directly to the sampler lead wire, apply power, and strike the side of the sampler head with a rubber or wood mallet. Never strike the nozzle. If a few sharp blows will not free the valve, refer to the Maintenance Section. The valve should open completely when power is supplied. No obstructions, such as the edges of the valve plug, should obstruct any part of the passageway.

When the valve is operating properly, insert a sample bottle and then close the head slowly. Guide the lip of the bottle so that it centers and seals against the face of the bottle gasket (Part No. 004050). A bottle adapter sleeve (Part No. 004140) must be inserted into the sample container cavity if pint bottles are to be used.

Once the valve mechanism is operating properly the nozzle (Part No. 004100) should be installed though the head cover and screwed into the head base. Prior to installation, the nozzle should be inspected for damage. The nozzle should be straight with no visible signs of damage. The bore should also be inspected for straightness and any signs of burrs or deformity. The threads on the nozzle should be checked for damage. If thread damage is found the threads can be chased with a 7/16-20 NF threading die. If damage or burrs are found in the bore or at either opening the nozzle should be discarded and replaced with a new nozzle. Do not use a wrench to tighten the nozzle; it should only be tightened by hand. The nozzle O-ring is positioned over the nozzle in the recess in the head cover. Use the nozzle nut to push the O-ring into the head cover recess and tighten the nozzle nut to compress the O-ring between the nozzle and head base. A wrench may be used to snuggly tighten the nozzle nut. However, caution should be used to avoid over tightening the nozzle nut, which can crush and destroy the O-ring and cause leakage into the head cavity.

Point-Integration Sampling: To collect a point-integrated sample, lower the sampler to the desired depth, apply power from a power supply (see the section on Power Supply) for the time interval to collect the required amount of sample. The sampler must remain at a fixed depth during the entire point-integrating sampling interval. Sampling time can be computed using the following formula:

$$\text{Time (sec)} = \frac{\text{Sample Volume (mL)} \times 0.1841}{\text{Stream Velocity (ft/sec)}}$$

The recommended maximum sample volume for a pint (milk bottle) sample container is 400 mL. The recommended maximum sample volume for a quart sample container is 730 mL.

Once the sample has been collected, close the valve, hoist the sampler to the surface, and remove the sample container. When handling a sampler filled with a sample, never allow the nozzle to tilt down more than ten degrees. A portion of the sample may escape through the tube leading to the head cavity and compression chamber. Optimum sampling intervals vary with stream velocity and container size, so some experimentation may be necessary. Samples that are over-filled must be discarded and the process repeated with a shorter interval. To be valid, a sample must enter the container only through the nozzle. With a pint container the US P-61-A1 sampler will function properly to a depth of 180 feet. With a quart container the depth is only 120 feet. At greater depths, water, instead of air, will flow from the compression chamber through the head cavity and enter the sample container.

If samples are not being composited, cap and label each bottle. Each sample label should contain adequate information to identify the sample and to satisfy the purposes of the investigation. The following items are suggested:

- Name of stream
- Location of the cross section
- Location of the vertical
- Stream depth covered by the sample
- Stage of the stream
- Date
- Time of day
- Identification of personnel collecting the sample
- Sampling time
- Water temperature
- Coordination with sample groups
- Sampler type and serial number

Depth Integration Sampling: The US D-96 and US D-96-A1 samplers should be used to collect depth-integrated samples. The US P-61-A1 is not recommended for collection of depth-integrated samples. If the US P-61-A1 must be used, the following procedures should be followed. The sampler must be lowered and raised at a constant transit rate to collect a depth-integrated sample. Transit rates for transit depths of less than 14.5 feet may be computed from the diagrams illustrated in figures 3 and 4. The following factors should be considered when selecting a transit rate:

1. The transit rate must be fast enough so that the bottle is not overfilled.
2. The transit rate must be slow enough to obtain a sample of sufficient volume to provide enough sediment for analysis.
3. The transit rate must be slow enough to not exceed the approach angle limit. The approach angle limit for the US P-61-A1 (and all isokinetic FISP samplers) is 0.4 times the mean stream velocity.
4. The transit rate must be slow enough to not exceed the compression rate limit.

Transit rates derived from the diagrams in figures 3 and 4 meet these requirements.

For depth-integrated sampling in streams less than 14.5 feet deep the sampler should be lowered at a uniform transit rate from the water surface to the bottom of the stream and then raised to the surface at the same rate. The sampler valve must be opened before it enters the water. When the sampler touches the stream bottom, the transit direction should be instantly reversed and the sampler raised through the flow until it exits the water. Care should be to taken avoid disturbing the bed material as the sampler touches the bed to minimize the possibility of biasing the sample. The power to the solenoid should be turned off only after the sampler emerges from the stream. The power should not be left on, valve open, once the sampler has been removed from the water. This will avoid excessive power drain and possible damage to the solenoid or components of the US RBP-95 rechargeable battery pack or other power sources.

Streams with depths up to 180 feet (pint bottles) and 120 feet (quart bottle) may also be depth integrated in multiple segments by sampling on the descending and ascending legs of the sampling transit. At each sampling station, divide the vertical into segments that do not exceed 14.5 feet. Each segment is depth integrated individually. The sampler valve must be opened at the moment it passes the initial depth of the segment. The appropriate transit rate should be started prior to reaching the sampling segment and used through the entire segment. Appropriate transit rates may be derived from the diagrams in figures 3 and 4. When the sampler reaches the bottom of the segment, the transit direction is instantly reversed. The sampler is then raised at the same transit rate used on the descent. The power to the solenoid should be turned off (valve closed) at the moment the sampler passes the initial depth of the segment. This procedure should be repeated for each segment until the entire vertical has been sampled.

If samples are not being composited, cap and label each bottle. Each sample label should contain adequate information to identify the sample and to satisfy the purposes of the investigation. The following items are suggested:

- Name of stream
- Location of the cross section
- Location of the vertical
- Stream depth covered by the sample
- Stage of the stream
- Date
- Time of day
- Identification of personnel collecting the sample
- Sampling time
- Water temperature
- Coordination with sample groups
- Sampler type and serial number

Those unfamiliar with sampling theory or program objectives may refer to the U.S Geological Survey TWRI, Field Methods for Measurement of Fluvial Sediment[3].

Maintenance/Repairs

Routine Care: The US P-61-A1 requires routine maintenance to insure proper operation. A mall amount of water may leak into the head. The design of the valve and head allows a small amount of water to leak into the head. Slow leaks around the valve plug are unavoidable because the plug must be loose enough to rotate freely. Corrosive damage to the plug and solenoid assembly may be caused by water that collects in the head cavity. Even a small quantity will cause problems if the sampler is stored before removing the water. Prior to storage, remove the head cover (see Head Disassembly section below). The head should not be disassembled for storage. Drain and dry the interior of the head with a cloth and let the assembly air-dry. If the sampler is not used for a week or longer, the sampler should be stored without the head cover installed. This will prevent condensation from forming in the head and will allow the valve to be checked for proper operation prior to its next use. In addition to cleaning and drying the head, the entire sampler should be dried prior to storage. The sampler should be stored in its shipping case or in a secure dry fixture. A package of desiccant can be placed in the storage container to help prevent condensation that may cause corrosion. Prior to reinstallation of the head cover and the next use of the sampler the valve should be rotated by hand. If the valve rotates freely, a DC power source should be connected to the electrical leads and the valve checked for proper operation using a DC power source. Refer to the section on Power Supply.

Head Disassembly: The head should not be routinely disassembled. The head should only be disassembled to inspect the valve for damage that may be causing excessive leakage or to remove sediment particles that are hindering valve rotation. (Note: This section should be read completely prior to undertaking the disassemble of the head.)

Step 1. To disassemble the head the nozzle should be removed first. The nozzle is removed by first loosening and removing the nozzle nut. The nozzle can then be unscrewed and removed. The nozzle O-ring should be retained for use when reinstalling the nozzle and nozzle nut. The head should be removed from the body by removing the hinge pin. Care should be taken to support the head when removing the hinge pin. The head is heavy and if dropped it may cause injury. The catch does not have to be removed to disassemble the head. However, if the catch mechanism is disassembled, take precaution to restrain the catch spring, which is located under the catch pin and catch in the head base. When the head is free of the body, remove the six socket-head cap screws that hold the head cover to the head base. A 3/16-inch Allen wrench is required to remove the screws. Separate the two parts while taking precaution to avoid damaging to the head gasket.

Many of the parts of the US P-61-A1 are manufactured to fit a single sampler and are not interchangeable. Care must be taken not to mix parts between samplers. Figure 5 is a diagram of the head and valve mechanism. Figure 6 is a photograph of a disassembled head and its associated parts.

Step 2. To function properly the valve mechanism must be assembled in proper order and orientation. The parts should be kept in order as they are removed to prevent errors during reassembly. The valve mechanism is disassembled by first removing the screw in the end of the valve plug and then removing the spring washer, valve spring and spring boss. Note the position of the spring in the spring holder. The valve arm and spacer washer are also removed at this time. Note the shape of the valve arm and its orientation. On many samplers punch marks on the valve plug and valve arm show their correct alignment. Note the orientation of the spacer washer: it must be reassembled with the same face against the head base. If the proper orientation of the valve washer is not maintained, the valve mechanism may not function properly.

Step 3. The solenoid must be removed to free the valve plug from the valve body (head base). Loosen the setscrew on the solenoid holder, and remove the exposed screw that anchors the solenoid holder to the head base. Note the orientation of the solenoid leads. The electrical leads should be positioned at the same point on the solenoid holder when reassembled. Once the solenoid holder has been loosened, the solenoid can be removed. The valve plug can then be removed from the head base. No additional disassembly of the valve plug should be attempted. Fine (4/0) steel wool or 400 grit sandpaper may be used to "clean and polish" the valve plug and the inside of the valve body. Care should be used to avoid scratching or changing the dimensions or shape of the valve plug or valve body. Household cleansers should not be used because the abrasive may become embedded in the brass valve body and cause the valve plug to bind.

Head Reassembly: To reassemble, reverse the above procedure. The valve spring should be wound approximately 1/2 revolution and mounted so that movement of the valve to the sampling position tightens the spring. After all parts are assembled, energize the solenoid. The valve arm should seat tightly against the stop and the valve plug sampling-intake hole should align with the corresponding hole through the valve body. If necessary, adjust the position of the solenoid so that it does not bind against the valve wheel. This is a trial and error process and may take several iterations. To check the solenoid and valve plug for proper operation, apply voltage directly to the solenoid lead wires. When power is applied, the solenoid and valve plug should rotate 45 degrees. When power is removed, the valve spring should return the valve plug to its rest position. If the solenoid fails to turn, corrosion may have damaged the winding or ball race and the solenoid should be replaced. A properly operating solenoid should open the valve when 30 volts DC is applied to the solenoid leads. A variable voltage power supply can be used to perform this test. If a variable power supply is not available five six-volt batteries connected in series can be substituted.

Once the valve mechanism is functioning properly, the gasket contact surfaces of the head cover and head base should be cleaned and the head gasket positioned on the head base. Do not use gasket cement or adhesives. The head cover should then be placed on the head base while being careful not to disturb the position of the gasket. Next, the six socket head cap screws should be installed. Seat the screws firmly, but do not tighten. Using a pencil or marker, label each screw, from 1 through 6, in a clockwise direction. The screws should be tightened in the sequence 1-4-6-3-5-2. Repeat the tightening sequence two or three times, each time increasing the torque. Final torque should be 100 to 125 pound-inches. The exact torque is not critical but all screws should be tightened as nearly equal as "feel" permits.

Reattach the head to the body. Parts that are missing or defective will cause serious leaks. A missing or defective nozzle O-ring will allow water to leak into the head. A worn or missing air-line gasket will allow water to enter the head and will interfere with the compression process. The air-line gasket must be pliable to seal properly. To check for proper seal, open the head and place a paper strip against the body where the air-line gasket makes contact and close the head. If the paper is loose or can be withdrawn easily, replace the air-line gasket. Contrary to expectation the head gasket (Part No. 004070) is seldom a source of leaks. If the head gasket must be replaced, order a replacement from FISP. In emergencies, gaskets may be cut locally, but be sure to use gasket stock of the same thickness as the original. Improper head gasket thickness will cause misalignment between the nozzle nut and valve body. Even with good seals, improper operation can cause leakage into the head. If the sampler is submerged to depths beyond its rating or if the sampler is submerged without a bottle gasket and a proper sample container, the compression chamber will fill and water will enter the head through the compression line.

Questions and comments regarding sampler operation should be addressed to:

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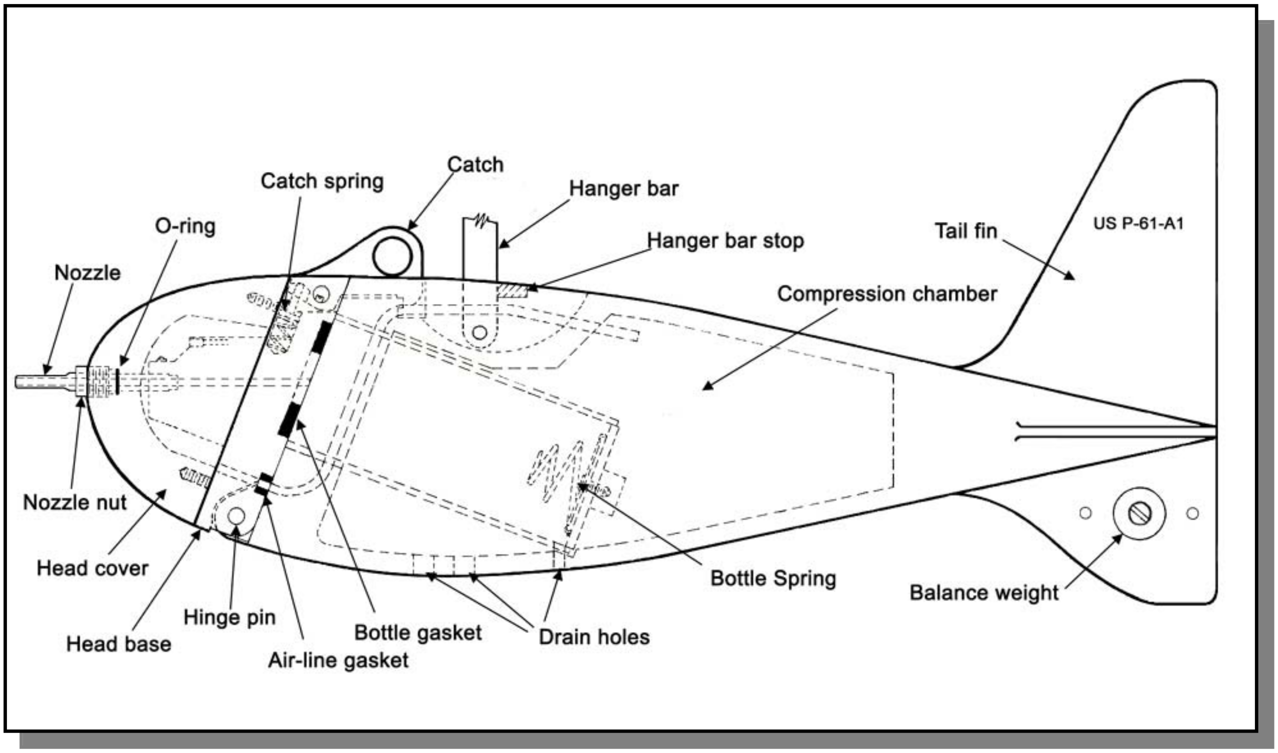

Figure 1. US P-61-A1 Diagram

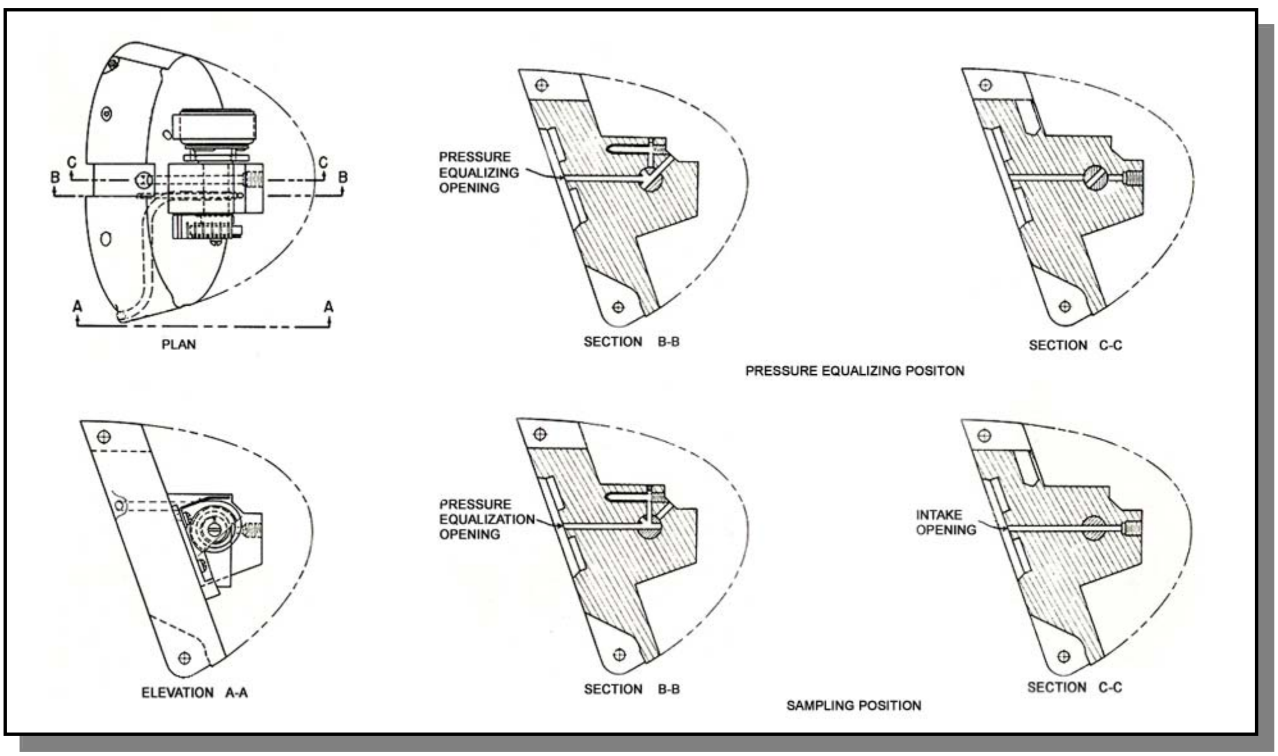

Figure 2. US P-61-A1 Head Diagram

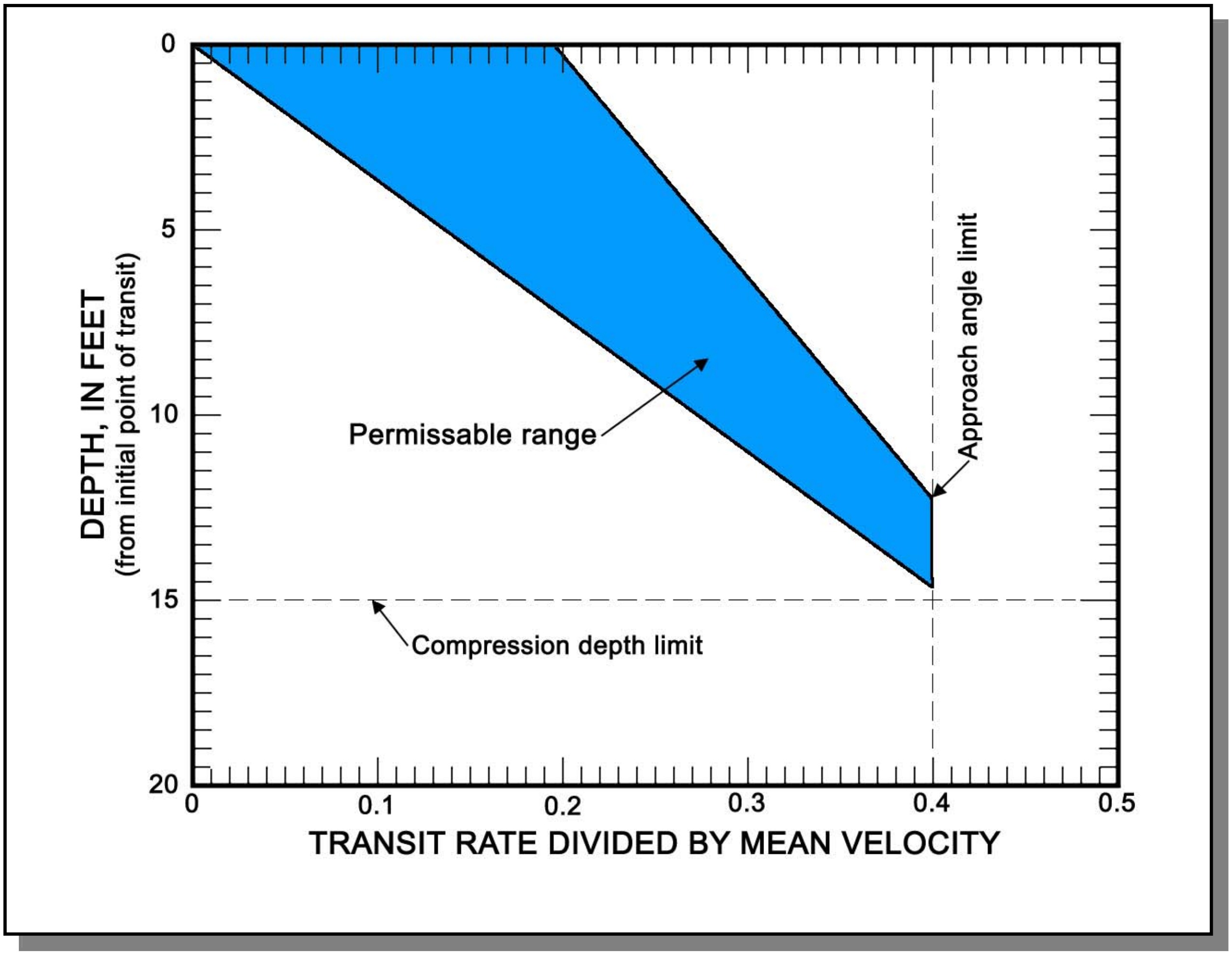

Figure 3. US P-61-A1 Transit Rate Diagram for a Pint (milk bottle) Sample Container

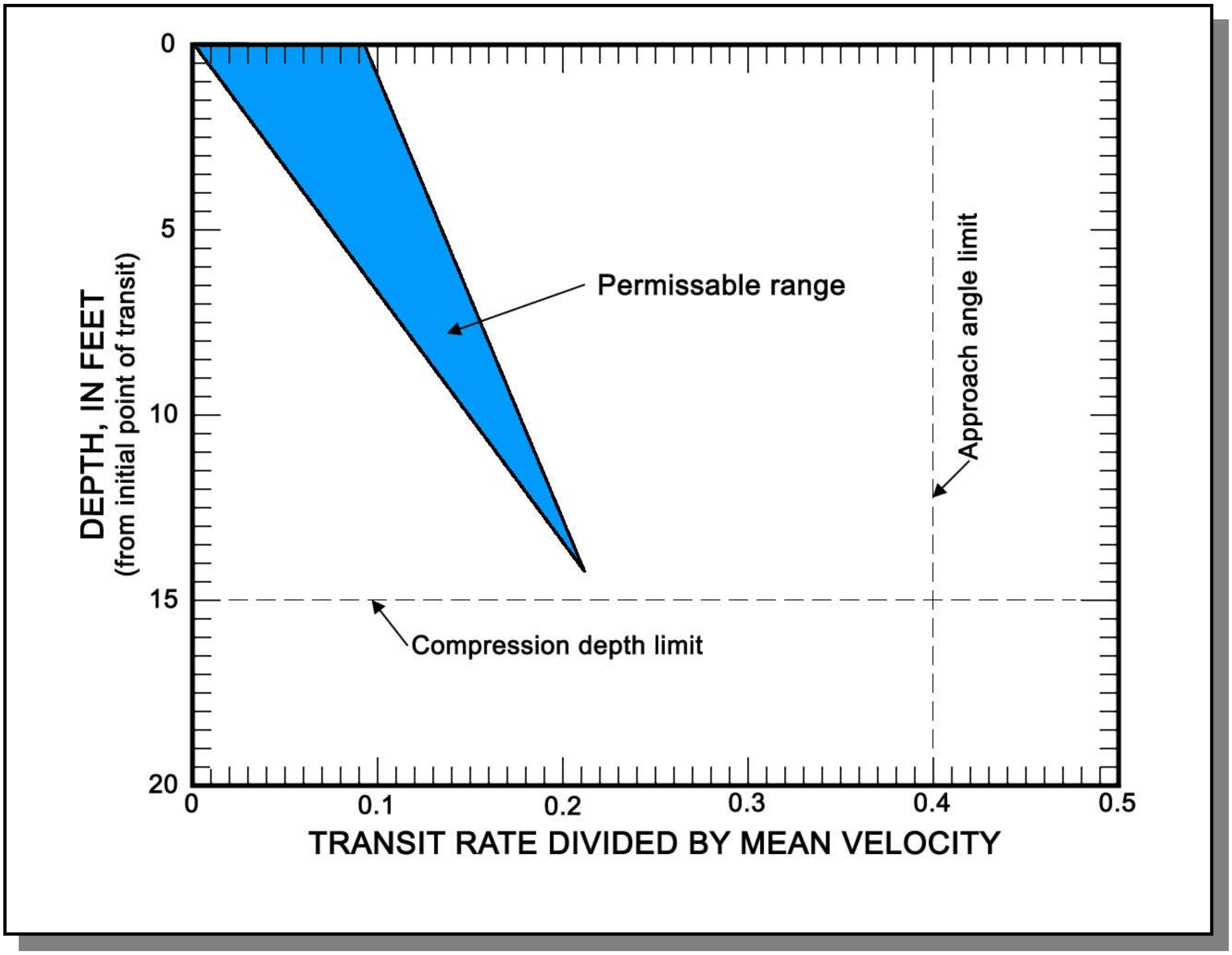

Figure 4. US P-61-A1 Transit Rate Diagram for a Quart Sample Container

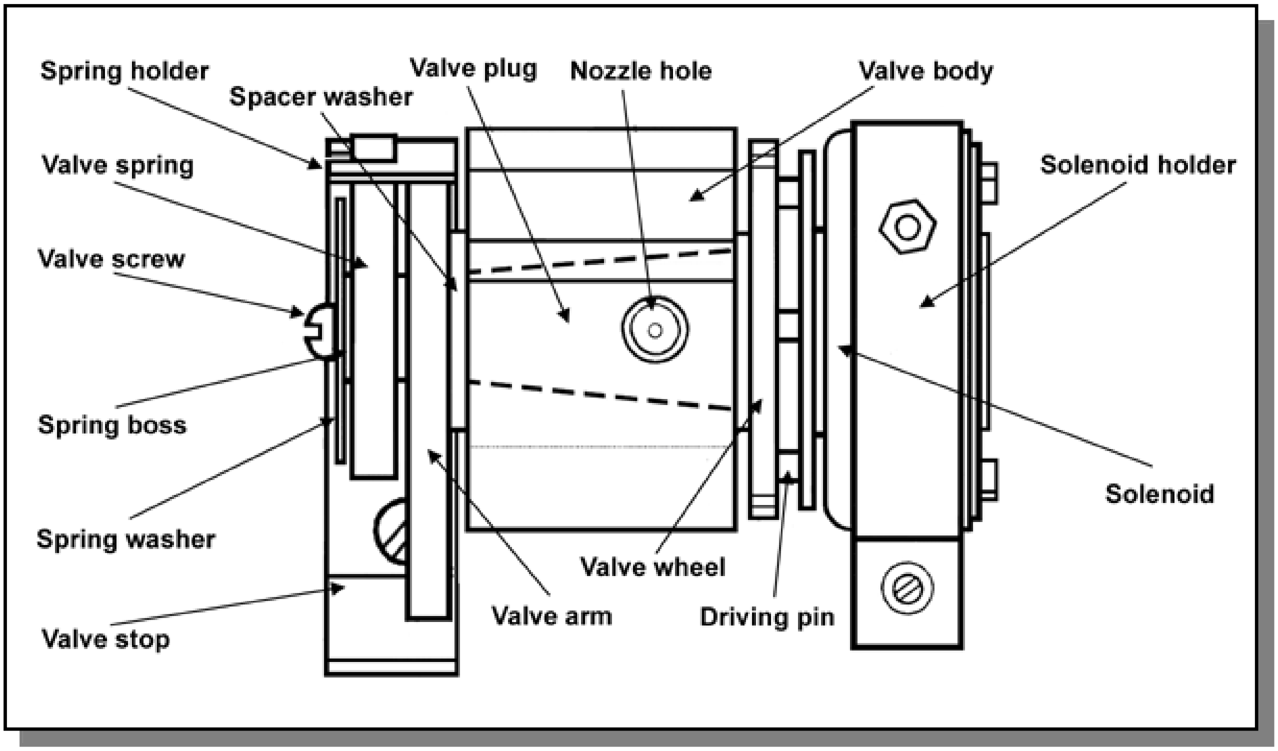

Figure 5. US P-61-A1 Head Base Diagram

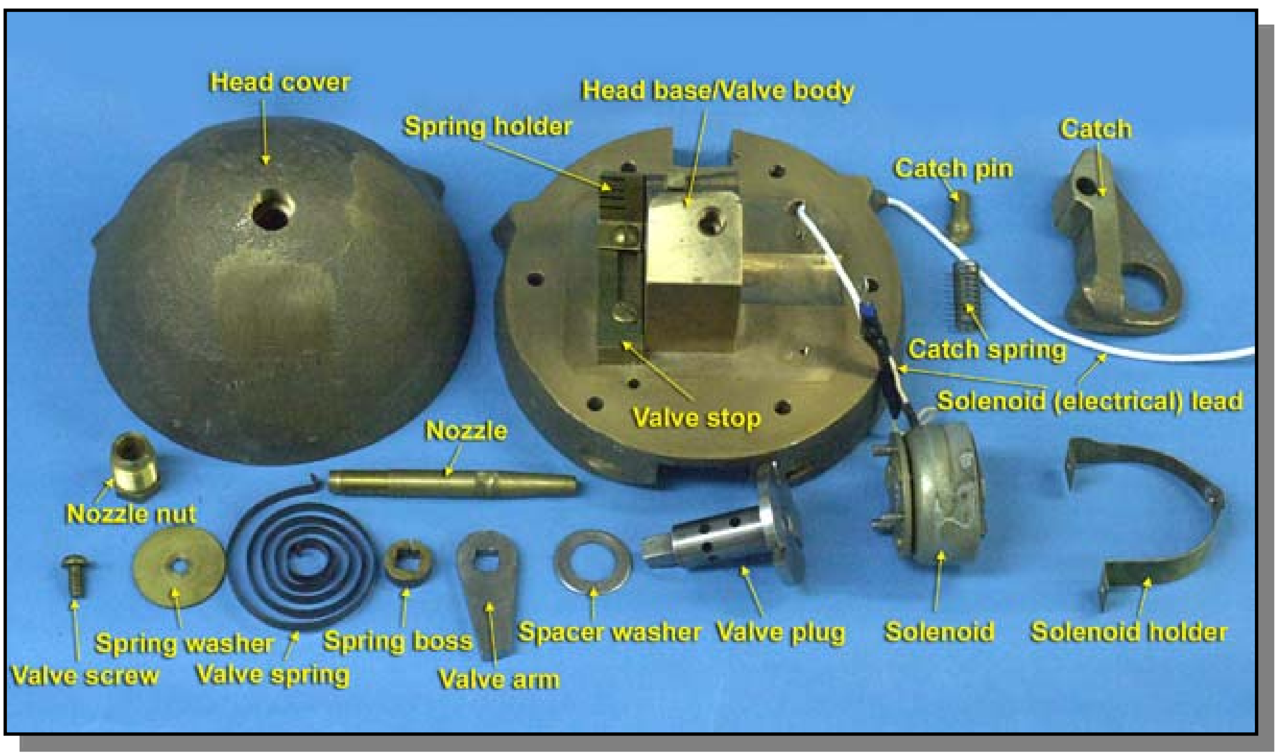

Figure 6. US P-61-A1 Head (disassembled)