Disclosure of Improvements for Waste Collection Systems for Space Flight

Problem: While there may never be a completely satisfactory method for collection of urine and fecal wastes in weightlessness, systems to date have had a series of recurring problems which render them unsatisfactory, including: backup of urine, retention of urine on subjects, retention of urine on collectors, questions of clean up and hygiene of the collectors, separation of fecal bolus, interference of waste with defecation, fecal contamination, difficulty with hygiene, difficulty with maintenance of hardware, turnaround time and expense, and others.
The number of proposed approaches, both theoretical and experimental, has been too great to describe here but such efforts will be described if pertinent in proposed solutions.

Overview: Urine and fecal collection might be treated separately, but there are also areas of commonality, as will be seen.

Urine Handling: There is no transport of liquid (as by gravity and water on earth) and air streams are substituted for such transport. An associated problem is removal of urine from surfaces.

Several situations are of concern in urine handling, including: Collection (body/machine interface), which should include removal of residual urine from the body, transport of urine both in the air and along conduits in a form of droplets to globules and removal of urine from collector and other surfaces.

From a theoretical viewpoint, these may be viewed as three cases:

1. Transport of fluid by an airstream - The practical considerations are that particles with appreciable velocity as in a splash from a stream, must be entrapped and that transport is rapid enough to prevent coalescence and cessation of air flow or "back up." (Fig. 1-A)

2. The second situation is movement of fluid attached to an extended surface such as the wall of a conduit. (Fig. 1-B)

3. Finally, there is need to strip fluid from a variety of surfaces and transport it by air, e.g., removal of residual urine from the body. (Fig. 1-C)

Theoretical treatments which cover these situations to varying degrees are available. In general, at the velocities here, the force on fluids is proportional to some power of velocity, typically the square, e.g., $F \propto V^2$ where V = velocity and F = force; hence, the effects can change drastically with relatively small changes in velocity. In addition, in the case of fluids attached to solid surfaces there are critical velocities below which no action occurs, e.g., below a "Weber number" of 3 no separation occurs.

The quantity of concern in air pumping is usually volume $\cdot$ time^{-1}, e.g., ft.^{3} min^{-1} and this is held constant in so far as possible. Velocity then becomes a function of the area of the orifice or conduit through which the volume passes; hence, effects of air at a given flow are proportional to the reciprocal of area squared and to (See Fig. 2) the square of flow rate. Although not rigorously demonstrated in weightlessness, simple demonstrations on SL-3 are in qualitative accord with this elemental