RECOVERY OF WATER FROM HUMAN URINE

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The rapid progress in recent years in the technology of rocket propulsion and space flight, necessitates a critical examination of the human supply requirements to be included in the original payload of a manned space vehicle. The initial amount of water to be carried for a specific flight is one of these requirements.

In space operations of long duration, a method of recovering water from all possible sources within the cabin, will be a prime requirement. This is so because of the necessity of keeping the payload of space vehicle at the minimum. Reduction of the initial supply of water taken aboard would contribute to a lighter payload. One way in which this can be done is to recover potable water from the human urine. Water recovered from this source must be usable to reconstitute dehydrated and powdered foods or drink, and as drinking water directly.

The method used in the final analysis must be as simple as possible, requiring the least amount of equipment from the standpoint of volume of space occupied, weight, and simplicity of operation.

Three possible methods of extracting pure water from urine were explored. These were:

1. Use of an ion exchange column
2. A combined chemical and distillation treatment
3. Essentially a distillation treatment

The ion exchange method was discarded as impractical because the size of the organic molecules in the urine quickly rendered the exchange column impermeable. It is possible that if distillation were done first, an ion column could be used in treatment of the distillate. This variation could be explored further.

The chemical method attempted was the addition of phospho-tungstic acid to the urine to precipitate the protein molecules, followed by distillation. This resulted in an extremely odoriferous and distasteful distillate, which was clear and colorless, and somewhat improved by aeration with air or 100 percent oxygen bubbling through the distillate. This method was also discarded.

The third method was found to be most practical and produced the best results. This was simply a distillation process carried on at 100°C. If 100°C temperature were not exceeded, the distillate was clear and colorless with little odor or taste, as compared to the previous method cited. When the temperature was elevated even 5-10°C the distillate acquired a yellow tint and was much more disagreeable.

In experiments where the temperature was held at 100°C, all odor and taste were removed by adding to the distillate, a small amount of activated charcoal, stirring and filtering with ordinary filter paper. Taste was flat as with any distilled water, and no odor was present. Taste was then improved by aerating with air or oxygen.

A variation of this procedure was tried by adding the activated charcoal to the urine before distillation, filtering and distillation of the filtrate. In this case, several times the amount of charcoal was required as was necessary in the previous experiment. It was decided that the charcoal was most advantageously used after distillation.

In both the latter procedures, bumping of the urine in the flask was prevented by the addition of a small amount of Dow-Corning AF Silicone Emulsion. This agent acts by decreasing surface tension of the bubbles, causing a very rapid combination of several bubbles into one, and the immediate bursting of the larger bubbles at the surface of the liquid to release the gases contained therein. Without the addition of the silicone emulsion, even with a slow elevation of temperature and the addition of beads or stones, bumping was severe enough to carry the urine or foam over into the condenser.

With the completion of these preliminary laboratory studies, it was decided to repeat the third method in the Sealed Cabin Simulator, both at ground level and at a simulated altitude of 18,000 feet.

Equipment consisting of ring stand, variac, heating mantle, distilling flask, tubing, charcoal, funnel and beakers was set up in the cabin. These are illustrated in Figure 1.

Insert Figure 1 here

Tubing from the flask was directed into a duct going directly into the air conditioner of the cabin. Under the cool coil is a drip pan (Figure 2)

Insert Figure 2 here

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with attached tubing returning through another duct into the main part of the cabin, there emptying into sterile containers.

The first experiment was done at ground level, using the same variac setting for the heating mantle, as was used in the preliminary laboratory test and temperature of 100°C was maintained.

The air conditioner coil worked satisfactorily as a condenser and a clear, colorless, odorless, and tasteless condensate was obtained in the receiving vessel. Samples of this condensate, before and after clearing with charcoal, were sent to the laboratory for examination for micro-organisms. The only organisms found on culturing the product were an actinomycete and Bacillus mycoides, both common soil organisms, not pathogenic and not normally found in the human host. This contamination was attributed to a small amount of residual dust in the drip pan, and on the cool coil of the air conditioner.

The experiment was then repeated at a simulated altitude of 18,000 feet and similar results were obtained. One word of caution at this point. The distillation flask should <u>not</u> be connected to the air conditioner and heating should <u>not</u> be started until the desired altitude is reached. Any gas evolution which occurs, is intensified by the sudden drop in cabin pressure (in this case from ground level barometric pressure to 18,000 feet equivalent in approximately twenty seconds).

Although the water resulting from this treatment of urine was chemically and microbially pure, only a very small number of the more dedicated personnel who were offered a drink of this "Space Cabin Cocktail" would accept the offering after it was discovered from whence it came.

Another facet of this problem which would be well worth investigating is the use of urine collected from subjects or patients suffering from acute and/or chronic urinary tract infections. It is not unlikely that a crew participating in prolonged space operations would develop this type of illness. This data would be particularly valuable in closed systems where a photosynthetic exchange system might be used.