A Solar Powered Water Purification System at Goldstone (DSS 13)

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The present energy intensive electrically powered still at the Venus Deep Space Station (DSS 13) has reached its end-of-life. The electric still has been producing the pure water required for cooling the 400-kW klystron tube of the Venus 26-m antenna at Goldstone, California. A new passive solar still, unique to the Goldstone complex, has been designed to replace the electric still. This new system will deliver 100% of the pure water requirement for cooling the klystron tube and will consume an insignificant amount of electrical energy. Construction will be completed by the end of 1981, followed by a one-year test and evaluation period to gather data on performance characteristics.

I. Introduction

At the Venus station (DSS 13) of the Deep Space Network (DSN) Tracking Complex at Goldstone, California, distilled water of a high electrical resistivity quality is required as a cooling medium in the microwave tube generator (klystron tube). An electrically powered distillation system to provide this pure water has been in service for over 15 years and as a result has reached its end-of-life. Although the electric still is currently in operation, the dramatic increases in energy and maintenance costs have led to the investigation of alternative configurations and sources of supply. Examples of alternate systems studied for technical feasibility and cost effectiveness include delivery from an independent commercial supplier of pure water to the geographically remote tracking facility; trucking in pure water from Los Angeles using a truck available from nearby Yermo; installation of a new electric still; a reverse osmosis system; and construction of a solar still.

After careful examination of the realiability and life cycle costs of the alternate approaches, a passive solar powered still was found to be the most viable solution due to the high quality of water produced, low installation, maintenance and operating costs, and minimal energy consumption.

Solar water purification units have been utilized for many years in arid areas as an efficient and inexpensive method for the production of drinking water from salty or brackish sources. The basic principles by which a solar still operates are straightforward: The sun's rays enter through a sloping cover glass, warming the water and producing a vapor which condenses on the inner surface of the sloping cover. The water droplets coalesce and flow down the slope into a discharge trough as distilled product water (Fig. 1).

II. Design Requirements

To satisfy the requirements of quantity and quality of the pure water produced, the new solar still system has been designed to deliver distilled pure water with a resistivity of at least 50 kΩ per cm at the underground storage tank. This system will be composed of eight 1.85-m^2 (20-ft^2) solar still panels producing a total annual yield in excess of 22.7 m^3 (6000 gal) of pure water. The system will also incorporate a time clock and a solenoid valve for totally automatic operation of the flush and fill functions. The system is gravity feed, utilizing a temporary holding tank to store pure water for release to the underground storage tank.

III. System Configuration and Operation

Each solar still panel is a molded fiberglass tray with glass glazing sealed with silicone rubber (RTV) as illustrated in Fig. 1. The bottom of the panel is insulated with rigid foam and reinforced with marine plywood. The base of the wetted tray is colored black to help accelerate the evaporation, and the balance is colored white. The eight solar still panels, oriented to present a south facing slope as shown in Fig. 2, are attached to unistrut and held down with steel clamps that are mounted to a welded steel frame. All piping interconnections are polyvinyl chloride (PVC) and stainless steel. The complete system is elevated 3.35 m (11 ft) above ground level to facilitate the gravity feed, eliminate shadowing, and place panels above excessive traffic flow.

Local well water (with a high mineral content) is supplied to the solar still system by gravity as shown in Fig. 3 from the existing elevated raw water storage tank. The storage tank outlet is 91 m (300 ft) above the inlet to the solar stills. Solar radiation produces distilled pure water in the solar panels which is then gravity fed to a 322-liter (85-gal) temporary holding tank for a period of two to four days. This water is then released to the existing 5.7-$in.^3$ (1500-gal) underground pure water storage tank. An automatic once-a-day cycle puts the still in a flush mode to remove accumulated mineral concentrations and provides fresh fill water for the next day's pure water production. Previous studies and operation indicate that the efficiency of operation does not decrease if the pan is contaminated or the top glass becomes dirty. This eliminates any type of routine maintenance or cleaning.

IV. System Environment

The Goldstone NASA tracking station in the Mojave desert with an elevation of 914 m (3000 ft) has abundant solar radiation, clear sky and clean air, which provides for an ideal solar application. There are 2591 heating degree days per year and an average annual horizontal insolation of 5.81 kWh/m^2 day (1843 Bth/ft^3 day).

V. Costs

The solar still is a totally passive system that does not use any significant electrical power. The occasional use of electrical control power for a supply line solenoid, timer, and indicator light is the only power required.

The 1981 annual maintenance and operation (M&O) costs for the existing electric still, including the electrical energy consumption, are $5.1K. Based on a 1981 M&O cost of $20/1000 gallons for a solar still, the annual savings over operation of the electric still would amount to $4.9K. With a 10% per year escalation factor in labor and electrical costs, the payback period for the $24K construction and installation costs of the solar still will be 3.5 years. The rapid payback period with improved reliability and reduced M&O costs were driving points to size the system for 100% solar.

The project will be operational in October 1981. Twelve months of testing will follow to develop data pertaining to weather conditions relative to pure water production quantity, temperature, purity, etc.

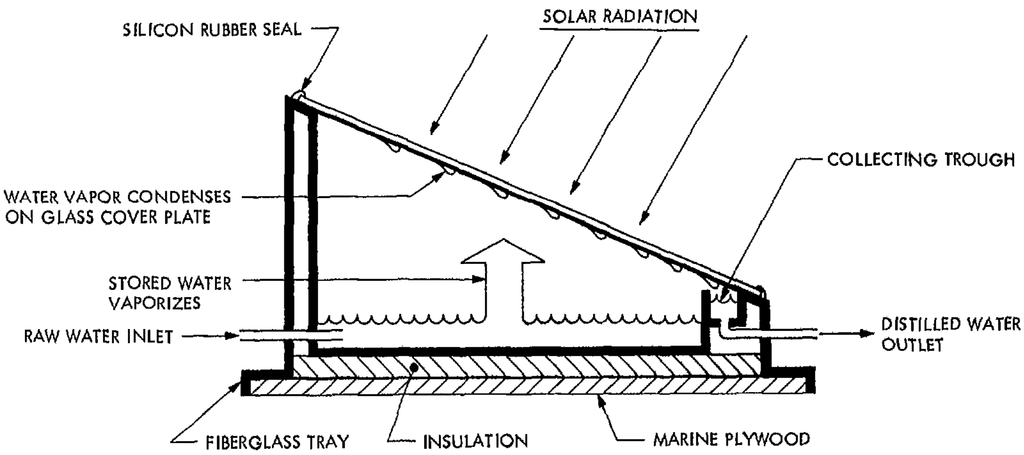

Fig. 1. Solar still panel function and construction

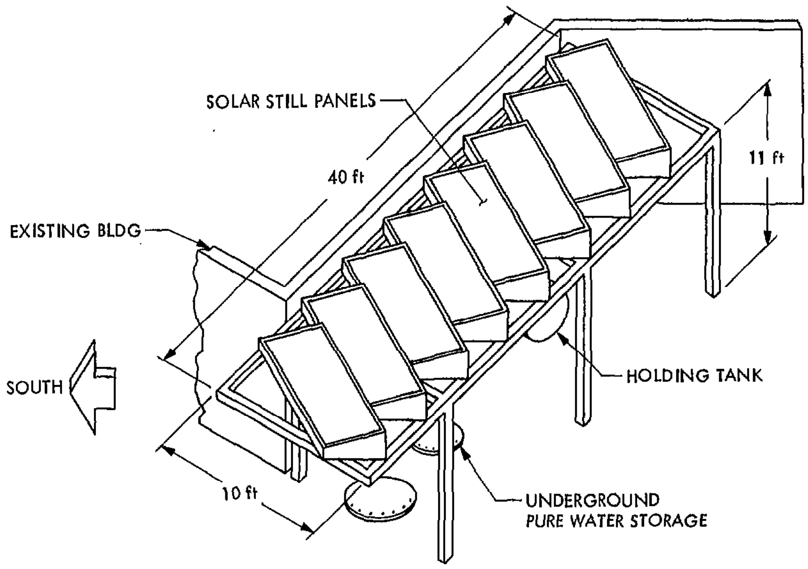

Fig. 2. Solar still system installation

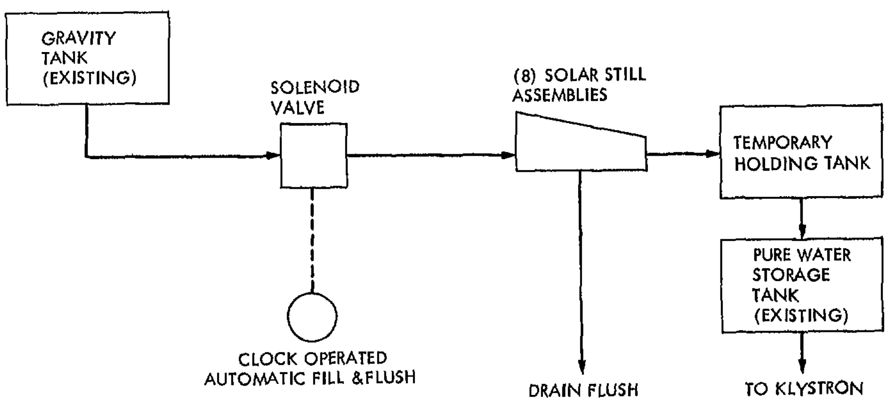

Fig. 3. Solar still system flow diagram