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CHEMTRIC REPORT 3110

VAPOR COMPRESSION DISTILLATION MODULE

(Contracts NAS9-13714 & NAS9-14234)

Prepared by:

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June 1975

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FOREWORD

Summarized in this report is the work performed to develop and evaluate the Vapor Compression Distillation (VCD) module and spares for the Space Station Prototype (SSP) Life Support System. This work was performed under or thru NASA contracts, and an independent research and development (IR&D) project at CHEMTRIC. Initially, the VCD module was designed, fabricated and checked-out by CHEMTRIC under a subcontract on NAS9-10273 with United Aircraft Corporation's Hamilton Standard Division - the prime contractor for the SSP Life Support System. Then CHEMTRIC was awarded no-cost contract NAS9-13714 to retain the spare VCD unit and other residual property for the purpose of performing parametric tests with concentrated urine under CHEMTRIC IR&D Project 3105. Finally, contract NAS9-14234 was received to document the work performed as a subcontractor on NAS9-10273. This report is submitted to fulfill the report requirements for both NAS9-13714 and NAS9-14234.

All of the work summarized in this report was monitored by Messrs. M. Owen and W. Reveley, respectively, of the Crew Systems Division at the NASA Lyndon B. Johnson Space Center. Messrs. T. Moore, L. Ziegler, H. Kolnsberg and H. Brose, respectively, of the Hamilton Standard Division served as technical coordinators of the work performed as a subcontractor under NAS9-10273.

Phillip P. Nuccio served as Program Manager for the design, fabrication and testing of the VCD Module; Thomas L. Hurley directed the earlier system-definition phase. Other CHEMTRIC personnel who made substantial contributions to this program include Robert A. Bambenek, who performed the administration as well as being a council to resolve technical problems, and Walter J. Jasionowski, who provided the chemical technology for both the post-treat and pretreat portions of the integrated process. We are indebted to Mr. C. Verostko, of the Crew Systems Division for his support in obtaining detailed analysis of the generated water, Messrs H. Kline and J. Estep of the Materials Technology Branch for their extended test work to evaluate peristaltic pumps and tubing, and especially to Mr. W. F. Reveley of the Crew Systems Division who is dedicated to the eventual development of a flight-qualified water recycling system.

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INTRODUCTION AND SUMMARY

A Space Station Prototype (SSP) Environmental Control and Life Support System was designed, built and tested to generate operational data pertinent to the advanced systems necessary for very long duration flights. The prime contract (NAS9-10273) for the entire SSP-ECLSS was let by NASA to the Hamilton Standard Division, United Aircraft Corporation. The water renovation portion of that system was CHEMTRIC's responsibility, and was performed under a sub-contract to Hamilton Standard (HSD P.O. No. SS-863762). Design emphasis was placed upon evaluating and minimizing the time-and-effort penalty imposed upon the crew members for maintenance of the machinery. It is the intent of future spacecraft and certainly of a space station to maximize the crew time available for scientific investigation in that unique environment, and to minimize the time allocated to vehicle maintenance.

The three most significant criteria by which life support systems for the SSP were selected and designed are:

1. Regenerative. Closed-loop life support systems are imperative for a permanent space station, especially for the water and oxygen supplies. Should these and other materials be used by the crew only one time the cost of shuttling these essential materials would be prohibitive. For the SSP the re-supply period was set at 90 to 180 days. At those intervals the water system planned requirements are that the recycle tanks be returned to earth for solids disposition and replaced with fresh tanks containing silver-dosed water.

2. Longevity. Space stations must be operational for up to ten years; throughout that time span the systems on board must characteristically remain operational without a permanent performance degradation. Should any system require rejuvenation or replacement during the useful life period of the station the total cost penalty, including replacement, must be lower than that for an alternative system not requiring periodic restoration.

3. Maintainability. Separate from planned useful life expectancy any chance failure corrections and planned maintenance must be performed quickly, easily and with little technical cognizance of the machine details. While the above two criteria are characteristics, intrinsic to the selected systems, maintainability is a design objective to be applied to those systems and to the results of the design effort evaluated to establish the system adaptability to simplified maintenance.

As mission durations become longer the water loop is the first regenerative system to become advantageous, because the mass rate of water required for life support is greater than that of any other substance. The Vapor Compression - Vacuum Distillation technique of potable water regeneration was selected for the SSP because (1) longevity has been demonstrated*, (2) the maintainability goals could be realized, (3) the technique imposes the lowest power and heat rejection penalty upon the vehicle, and (4) vapor compression integrated with reverse osmosis is the most advantageous loop for regenerating waste water.

Summarized in this report is the design and initial testing of the SSP Vapor Compression Distillation System. The system includes the waste tankage, pumps, post-treatment cells, automatic controls and fault detection instrumentation necessary to evaluate the complete system and its application to space station requirements. Emphasis is placed upon the components comprising the complete system; the distillation unit is essentially that unit developed and successfully operated for more than 2,000 hours under contract NAS9-9191.

Development problems were encountered with two components - one with the liquid pumps, the other with the waste tank and quantity gage. Peristaltic pump characteristics are ideally suited to the operating requirements of the vacuum distillation process, but they have demonstrated a useful life span too short to be applied in their present state of development. In an effort to obtain longer useful pump life gear pumps were originally designed into the system. Gear pumps, however, produce unstable flow and vapor locking when the inlet pressure is near the saturation pressure of the medium. Corrective action was to again apply peristaltic pumps and concentrate upon improving their longevity. To that end a sub-program of materials and design optimization was undertaken resulting in an actually-measured peristaltic tubing life of more than 2100 hours and a projected life greater than 10,000 hours of continuous operation, or about 2 years of nominal operation.

A bladder tank was designed and built to contain the waste liquids and deliver it to the processor. The inclusion of a force-operated quantity gage into the tank design imposed a detrimental pressure pattern upon the bladder. Corrective action was effectively taken by rearranging the force application, and design goals were achieved.

System testing has demonstrated that all performance goals have been fulfilled. Potable water was generated from urine and urinal flush water containing more than 59% solids - which corresponds to more than 98% water removal. Automatic operation of the loop was achieved so that the process will start when waste is available. The quality of water produced will be constantly

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* CHEMTRIC Report No. 3014 (Contract NAS9-9191)

monitored. Should the quality be sub-standard, the system will automatically reject the output stream to be reprocessed until acceptable water is produced. Automatic control of the process is applied in the event of off-design operation such as might result from a leak, a power limitation or a complete power failure, off-design cabin temperature or pressure, or excessive water inventory present in the distillation unit. An automatic shutdown sequence is built into the system to assure (1) that there is no possiblity of contamination of the distilled water condenser by waste liquid when the unit is stopped in null gravity, and (2) that upon restart, the distillation process will begin immediately.

An additional empirical investigation was conducted to determine whether any abnormally high power consumption points exist within the distillation unit, and whether the vapor discharged by the compressor was detrimentally superheated. There are no higher than anticipated power sinks within the unit; superheat was detected, but a baffle was added to direct this vapor against the outer shell before it contacts the condensation surface.

One very compromising component, the purge pump, was built into the system for expediency and cost consideration. A standard 2-stage, dry-piston vacuum pump, which is operational on an Air Force bomber, was purchased and used to purge noncondensable gases from the distillation unit. Operation of that pump in the VCD application is acceptable except that power consumption and noise generation are excessively high. Subsequent to delivery of the module, a peristaltic pump replacement for the piston pump was investigated analytically and empirically. Results show that a peristaltic purge pump operating at a slow speed can perform both the initial evacuation and steady-state purging requirement. Power requirement is one-tenth that of the piston pump and noise generation will be negligible. Tubing life in the peristaltic purge pump application is unknown at this writing, but that determination is the objective of an on-going investigation at the NASA Crew Systems Division with the help of the Materials Technology Branch, Structures and Mechanics Division, and at CHEMTRIC under contract No. NAS9-14469. Simultaneously, the Plastics and Synthetics Division, Norton Company, Akron Ohio, is independently developing improved tubing materials for peristaltic pumps, and liaison is being maintained with that effort to benefit the VCD application.

DESIGN REQUIREMENTS

2.1 SSP Water Loop Requirements

The SSP Vapor Compression Distillation (VCD) Module is part of the renovation portion of a closed-loop six-man capacity water system. The system is designed to remain in operation for two years with resupply at 180-day intervals. A water renovation loop in that service must generate water for general housekeeping needs as well as for basic crew hygiene.

The schematic diagram showing how those housekeeping and crew hygiene loads are integrated into the SSP water system is shown in figure 1. Shown also in that diagram is the nominal daily water balance.

The closed-loop system includes subsystems for (1) the collection, distillation and post-treatment of urine and humidity condensate to generate potable water and electrolysis water, (2) the collection and processing of wash water for reuse, (3) the collection and processing of feces for storage, and (4) the collection and processing of anal wash water for re-use. Additionally, the system must manage excess water generated by food digestion and provide make-up water lost by normal cabin leakage and extra-vehicular activities, and supply the Portable Life Support Systems with nonreturnable water.

Vacuum distillation, via the vapor-compression technique, integrated with reverse osmosis (RO) comprises the processor of the closed water system. The water balance diagram (fig. 1) shows that integration quantitatively. Permeate from RO is applied as wash water for utensils, face and hands washing, clothes washing and showering, while all of the other more critical loads are supplied with distilled water. Provisions are included in all processors to dose recovered water with silver-ions and thereby maintain these waters in a sterile condition.

All three of the VCD modules are identical; therefore, all technical objectives could be met by building and testing only one module, designated VCD-1. The RO Processor module was not built; therefore the operating characteristics of VCD-3 which is integrated with the RO, could not be tested. Various other subsystems were built and tested (e.g., shower and the fecal collector) and are described by other contract reports.

2.2 Vapor-Compression Module Requirements

The Processor module shown, identified VCD-1 and shaded in figure 1, is the SSP assembly with which this report is concerned.

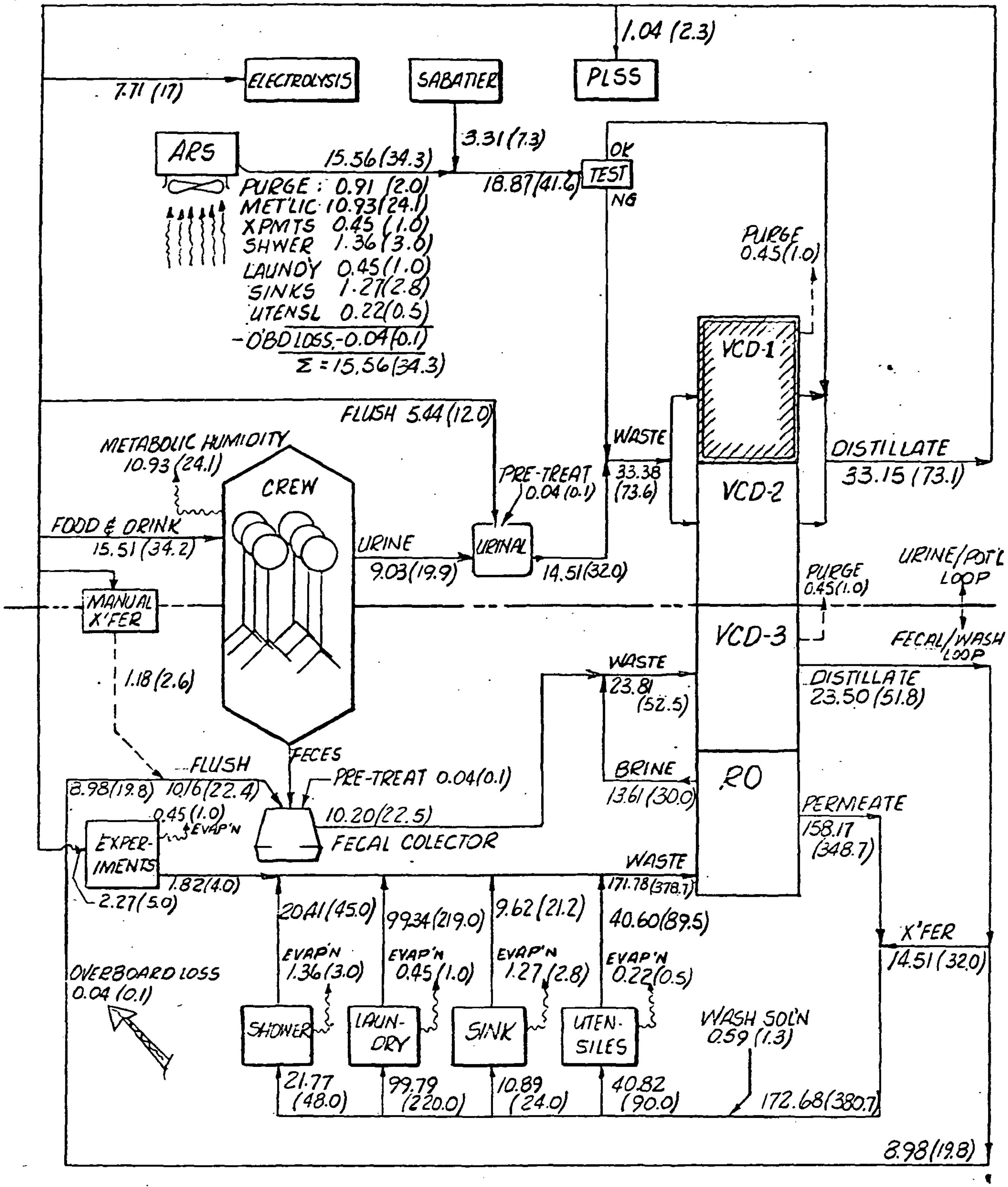


Figure 1 SSP NOMINAL DAILY WATER BALANCE

A detailed schematic diagram of that module is shown as figure 2.

Operational requirements of the VCD module are divided into five categories:

A. Waste Water Storage. The module must have the capacity to receive and contain pre-treated waste waters when (and as) delivered by various waste collection devices. Additionally, an analog signal must be generated in proportion to the quantity of fluid present in the waste tanks. Waste waters enter the subsystem at WM3-W1 and flows to the waste tank, C/N 561, which is pressurized by gas via interface port WM3-G1. The volumetric contents of the tank are measured by quantity gage C/N 576.

B. Water Distillation. A distillation unit and all of the related equipment necessary for its operation must be included. The water production rate must be controllable to meet the crew water use rate throughout the mission duration, and a method for convenient solids disposition is necessary.

C. Distillate Post-Treatment. A series of chemical and mechanical treatment cells must be placed in the distillate line to insure that the product water is potable by established standards, and that it is sterile.

D. Automatic Operation. Control of the processor module must be automatic irrespective of the water demand or waste production rates throughout the defined range of those rates and throughout the anticipated ranges of ambient temperature and solids concentration.

E. Packaging and the Modular Concept. System guidlines place a strong emphasis upon in-flight maintainability requiring that (1) instrumentation be included for fault detection and isolation (in addition to, or in consort with the minimum instrumentation necessary for automatic control), (2) failures must remain unattended over an eight-hour period without generating a hazard to the crew members or restricting mission objectives, and (3) maintenance operations must be performed quickly and easily.

Maintainability is a primary design requirement because the SSP is one of the first long-term life-support systems; the probability of chance failures over the mission duration is orders of magnitude greater than that for current systems, and for some expendables the design useful life is shorter than the mission duration. Further, less crewman time is allocated to maintaining the machinery. As is the evolutionary trend with all machinery the SSP life-support system is designed to be less demanding of the people it serves. To that end any failed part may be replaced

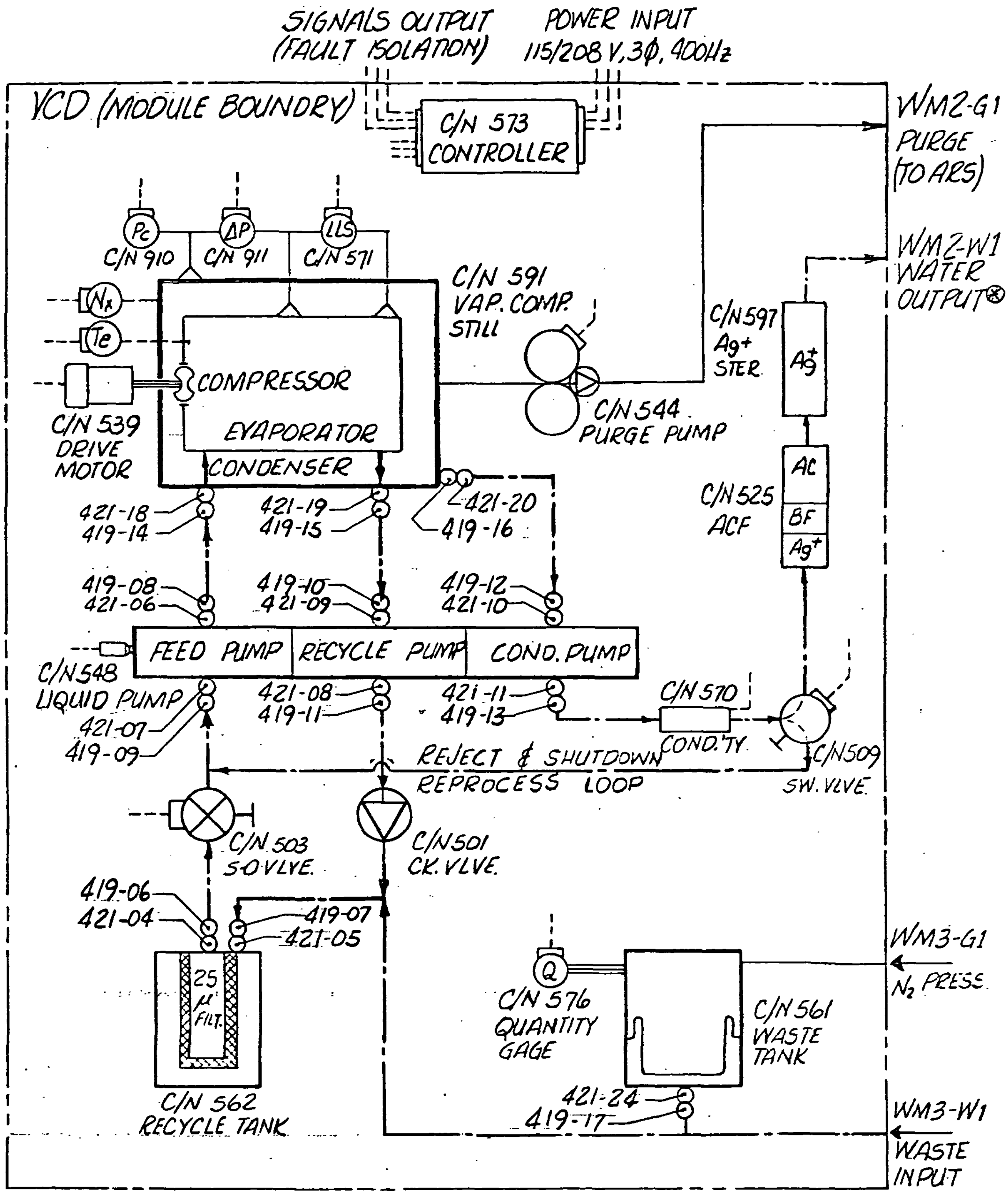


Figure 2 SCHEMATIC DIAGRAM OF SSP VCD MODULE

in flight by replacing the entire component containing the part. Every replacement operation requires only one or two standardized tools and may be performed rapidly without removing any other component. More importantly each of the systems, and in many cases sub-sections of those systems, are packaged into modules which can be replaced in flight using the same standard tools. This modular design permits renewing any portion of a system or an entire system for any reason from a performance deficiency to obsolescence.

2.3 Component Design Requirements

The design requirements of each component are described by the Mini-Spec for each component and included in Appendix A.

COMPONENT DESCRIPTION

Included in this section are narrative descriptions of the key components and component assemblies comprising the VCD Module. All of these items were designed and fabricated by CHEMTRIC - except the Controller (C/N 573), which Hamilton Standard developed for the VCD Module. Hamilton Standard also furnished the maintainable isolation valves and all of the transducers.

Greater-detail descriptions of the component design requirements, assembly procedures and test procedures and results are included in the appendixes of this report.

The assembly drawing identified for each of the components, and the associated parts list, is on microfilm file at NASA.

3.1 Activated Charcoal Filter (C/N 525)

The Activated Charcoal Filter is one of three post-treatment cells, all of which are passive cells requiring no external excitation or control. In VCD's 1, 2 & 3 raw distillate, as generated by the distillation units, is delivered to this component for the first water polishing operation, namely the removal of any bacteria which might have entered the water stream and the removal of trace organic contaminants which are co-distilled with water. Similarly this component is applied in the humidity condensate stream to remove organic contaminants as delivered by the ARS.

The component is an assembly of two separate canisters. In the first canister is located a biological filter (0.12 microns nominal, 0.35 microns absolute) and a bed of the biocide silver chloride. In the presence of silver chloride bacteria retained by the filter barrier are killed and the possibility of biological growth is eliminated in the first step of water treatment.

In the second canister is packed a bed of activated charcoal to adsorb organic constituents. The quantity of charcoal required is calculated from the required organic-contaminant removal rate and the loading capacity of the prepared charcoal. Applying Chemical Oxygen Demand (COD) as the measure of organic-contamination, it was determined, under contract NAS9-9191, that a COD reduction of 100 ppm is the maximum loading that will ever be applied to the charcoal by the distillate stream. McDonald Douglas reported that humidity condensate during their 60-day manned simulator test required up to 200 ppm COD reduction; that removal rate was taken as the SSP humidity condensate COD removal rate.

During the NAS9-9191 program the weight-loading ratio of prepared charcoal* was measured and improved until a ratio of 0.097 parts COD per part charcoal was achieved. Applying the nominal water flow rates of the distillate and humidity condensate streams , as shown on figure 1) the charcoal requirements are:

<u>For the Distillate</u>

$$\frac{100 \times 10^{-6}\ gCOD/gH_2O \times 14{,}510\ gH_2O/day}{0.097\ gCOD/gAC \times 0.448\ gAC/ccAC} = 33.4\ cc/day\ (2.04\ in^3/day)$$

<u>For the Humidity Condensate</u>

$$\frac{200 \times 10^{-6}\ gCOD/gH_2O \times 18{,}870\ gH_2O/day}{0.097\ gCOD/gAC \times 0.448\ gAC/ccAC} = 86.9\ cc/day\ (5.31\ in^3/day)$$

for a charcoal density of 0.448 g/cc (28 lb/ft^3).

During the design phase it was decided to make a common activated charcoal canister sized to meet the largest total COD loading. The component therefore was sized to meet the loading imposed by the humidity condensate stream (i.e., 86.9 cc/day).

The presence of a biological filter packed with AgCl upstream of a charcoal bed prevents microbial proliferation on the adsorbed organic materials. Tests performed under NAS9-9191 have shown that this configuration will remain effective over a period of 30 days or longer. The design useful life of this expendable component therefore is 30 days, and the required volume is:

$$86.9\ cc/day \times 30\ days = 2{,}607\ cc\ (159\ in^3)$$

In good contacting bed design the length/diameter ratio is between 4/1 and 6/1. Available standard tubing was used to establish the bed dimensions:

diameter: 8.56 cm (3.37 in.)

length: 45.72 cm (18.00 in.)

volume: 2630 cc (160 in^3)

L/D: 5.3/1

*Charcoal preparation procedure explained in assembly Spec. 3098-AS-2500, Appendix B this report.

Assembly drawing No. 3098-D-2500 shows this component configuration. The design requirements are shown by the component Mini Spec No. 3098-MS-2500, in Appendix A. The assembly procedure is described by Assembly Spec No. 3098-AS-2500, Appendix B, and the component test requirements and results are shown by 3098-TR-2500, Appendix C.

3.2 Deionizer (C/N 533)

The deionizer is the final cell in the sequence of potable water post-treatment; it is located in the galley, very near the water-use port (it is not packaged into the VCD module). Silver ions in concentrations between 1.0 and 1.4 ppm are present in the clean water tankage to maintain sterility. Additionally, trace quantities of various other ionic species are present. The water for crew ingestion and for experiments must be reduced in silver-ion concentration to 100 ppb. The loading imposed by the trace metals, determined by electrical conductivity measurements made during contract No. NAS9-9191, is equivalent to the loading imposed by removing 25 ppm NaCl.

A redundant AgCl-packed biological filter identical to that applied to protect the ACF (525), is placed upstream of the deionizer to assure sterility of the entering stream; so protected the demonstrated useful life of a deionizer column is greater than 30 days.

Selecting that period as the expendable life period for this component and by adding the nominal daily potable water use rate (15.51 Kg, or 34.2 lb) and experiment water requirement (2.27 Kg or 5.0 lb) the total ionic material to be removed is:

$$25 \times 10^{-6} \text{ NaCl/g}H_2O \times 17{,}780 \text{ g}H_2O\text{/day} \times 30 \text{ days} = 13.33 \text{ gNaCl}$$

(0.0294 lb NaCl)

That salt quantity may be converted to 228 milliequivalents of Na^+ and Cl^- ions. The loading capacity of each of the two required resin types (cationic = Amberlite IR-120, anionic = Amberlite IR-45) is 2.0 milliequivalents/ml of resin. The ionic load requires 114 ml of each resin type; de-rating the resin capacity for nonequilibrium conditions typical of columnar operation results in 228 ml of each type resin for a total volume of 456 ml (27.8 in^3). Each resin type is packed in a separate layer within a cylindrical housing. The cylinder dimensions are:

diameter = 5.08 cm (2.00 in.)

length = 25.40 cm (10.00 in.)

L/D = 5/1

Assembly drawing No. 3098-D-3300 shows the deionizer component configuration. The design requirements are detailed by Mini-Spec 3098-MS-3300, included in Appendix A of this report.

The assembly procedure is described by Assembly Spec. No. 3098-AS-3300 included in Appendix B. The component test requirements and results are shown by No. 3098-TR-3300, Appendix C.

3.3 Purge Pump (C/N 544)

The partial pressure of non-condensible gases in the distillation unit must be maintained at a level lower than 2 mm Hg (0.08 in. Hg) to avoid excessive power consumption by the vapor compressor within the distillation unit. Non-condensibles enter the distillation unit evaporator as dissolved gases in the waste waters. In-leakage of cabin gas and off gassing of distillation unit materials contribute insignificantly to the purging requirement. In order to avoid the potential spacecraft optical-surfaces contamination associated with purging those gases to space vacuum, and to retain the water vapor which unavoidably is extracted with the unwanted gases, the SSP was designed with a self-contained vacuum pump. Output from the pump is delivered to the ARS - and water therein condensed from that stream is returned to the water loop.

The composition and quantity of non-condensible gases stripped from waste water containing urine is strongly a function of diet. To date that gas analysis has not been considered complete, nor is the SSP diet controllable enough to be the criteria applied to size the purge pump. Instead a pump was selected which has a displacement rate near that of a laboratory vacuum pump which has adequately purged the still during previous testing. The selected pump is a two-stage, piston, dry-vacuum pump which is operational as a wave guide evacuation pump on the B-52 bomber. It is driven by a 3-phase 400 Hz motor. For the SSP application the pump is contained within an acoustically insulated chamber.

Assembly drawing No. 3098-D-4400 shows the purge pump component configuration, and the design requirements are detailed in Mini-Spec No. 3098-MS-4400 included in Appendix A. Acceptance test requirements and results are shown by the "Test Requirements" document No. 3098-TR-4400, Appendix C.

3.4 Liquid Pumps (C/N 548)

Three liquid streams cross the distillation unit boundary and interface with the remainder of the distillation module - namely, (1) waste liquid entering the evaporator, (2) waste liquid leaving the evaporator, and (3) distilled water leaving the condenser. Reference to those streams hereafter will be by the designations feed, recycle and condensate, respectively.

The feed and recycle streams are, in fact, portions of a recirculating waste-liquid loop which connects the recycle tank and the evaporator. Water is extracted from that loop as it passes through the evaporator - and the extracted water becomes the condensate stream. The volume of water separated from the loop is replaced by a like volume of waste liquid delivered by the waste tank which pressurizes the portion of the waste loop which lies outside the evaporator.

The feed pump must operate with a negative head rise - from the pressurized loop to the evacuated evaporator; it is more descriptively called a metering device than a pump. The recycle pump must operate across that same pressure profile, but with a positive head rise. Further, to prevent potential overfilling of the evaporator the recycle pump must have at least the same flow capacity as the feed pump. In practice the recycle flow rate is less than the feed rate, which places the requirement upon the recycle pump that it be able to pump a two-phase stream; it must accept all of the waste liquid remaining from the feed stream after evaporation, and some vapor without becoming vapor bound. Similarly, the condensate pump must be designed with enough capacity to remove all the condensate when the water production rate is high, and without cavitating when that rate is low.

Fail-safe operation is achieved by synchronizing all pumps to a single shaft driven by a single source (motor). So driven, should any pump stop operating the other two will also stop.

These requirements are met by a peristaltic pump assembly with three parallel stages - all driven by a single 400 Hz, 3-phase motor through a planetary gear box. The recycle and condensate streams are delivered by pumps contained within the same housing. In those stages three compression rollers are rotated along the peristaltic tubing circumference, along with three reforming rollers located between the compression rollers. The reforming rollers apply a lateral force to the tubing to aid its return to its original circular shape between compressions. That reforming force is applied to the recycle and condensate tubing because the inlet pressure to those pumps is approximately 14 psi lower than sea level ambient; that externally-applied load and the eventual loss of compression-set resistance through fatigue causes the tubing to collapse at the inlet with a resulting loss in pumping capacity.

The feed pump is a commercially-available, three-roller peristaltic pump. Reform rollers are unnecessary for the feed pump because the inlet pressure is greater than ambient pressure. The inlet pressure is sufficient to force the tubing to a circular cross section between every compression.

Stable operation of the distillation process can be achieved when the feed flow rate is greater than five times the evaporation rate - as determined during the distillation unit development program under NASA Contract No. NAS9-9191. At the maximum water production rate the minimum feed flow must be 150 ml/min (9.15 $in.^3$/min) for the SSP-sized distillation process; the maximum feed rate was set 20 percent higher at 180 ml/min (11 $in.^3$/min). Recycle pump capacity therefore, must be 180 ml/min minimum; it was set at 200 ml/min ± 20% (12.2 $in.^3$/min ± 10%). Condensate pump capacity need be no greater than approximately 30 ml/min (1.83 $in.^3$/min), but was set equal to recycle pump capacity. Justification for that simplifying decision lies in the experience with previous pump pairs where the excess condensate pump capacity was not detrimental to tubing life.

The entire assembly is replaceable as a single component. Maintenance disconnect valves are fitted at each of the six interfaces with the module piping, and captive fasteners attached to the base panel are applied to hold the component in place.

The liquid pump assembly is shown by drawing No. 3093-R-4800 and the design requirements presented by Mini Spec No. 3098-MS-4800, in Appendix A. Test requirements and results are shown by No. 3098-TR-4800 in Appendix C.

3.5 Waste Tank Assembly (C/N 561 & 576)

A variable volume waste tank is necessary to accommodate both intermittent high flow rate inputs and less intermittent lower flow rate processing of that waste by the distillation module. For positive liquid-surface definition in null-gravity a bladder-sealed piston tank design, with regulated gas pressure on the opposing side of the piston, was selected (fig. 3). The piston seal is formed by a rolling diaphragm which is a positive seal. Motion of a rolling diaphragm occurs without any difference between the standing and the dynamic coefficient of friction, thus it is free of sticking. That is particularly important when liquid is being expelled from the tank to the distillation processor. Additionally, the rolling diaphragm is insensitive to particulates which might be delivered with the waste liquid.

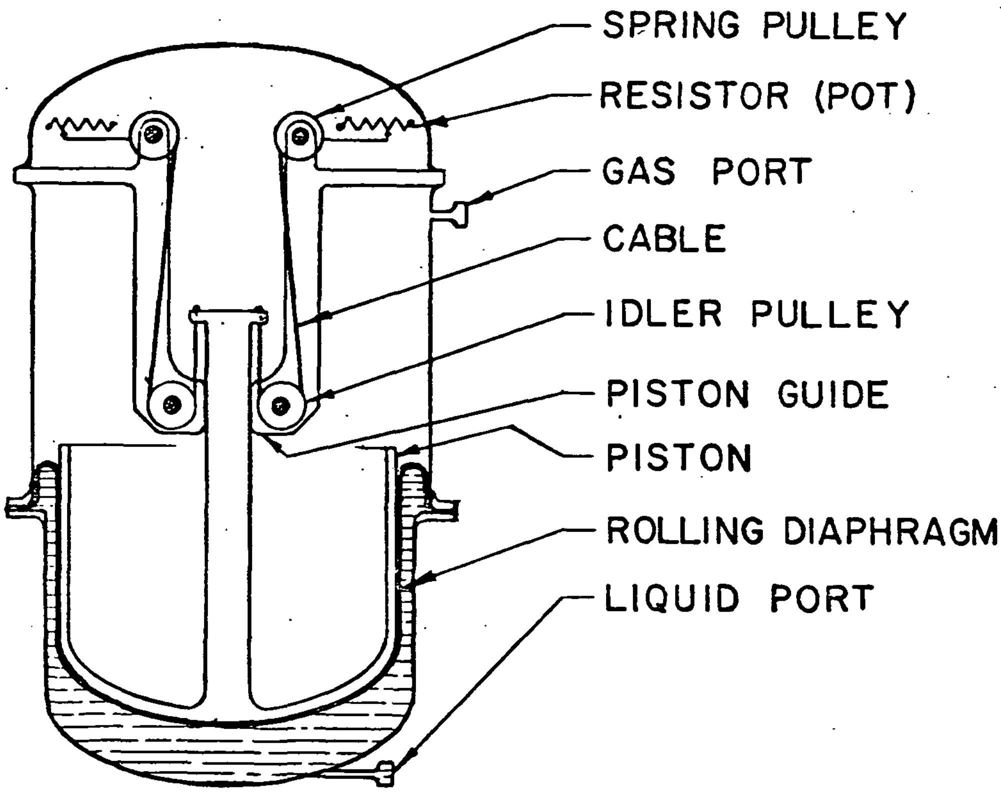


Figure 3 SCHEMATIC OF LIQUID-WASTE TANK

The piston is driven by changing liquid quantity; the piston location therefore is an accurate indication of the amount of waste present and to be processed. A quantity signal is determined from piston location by a system of cables, pulleys and electrical rotary resistors (pots). That signal is read by the controller to initiate distillation when sufficient waste quantity is present to sustain a run of at least 3 hour's duration - and to stop the process when the tank is nearly empty.

Maximum holding volume of the waste tank is that volume which it must retain in the event that the start quantity is present when a failure occurs, and waste is delivered to the tank over the following 8-hour period which might be necessary before maintenance time becomes available.

Further discussion of the tank configuration is included in Section 5 of this report where the explanation of a design problem and its solution is presented.

The waste tank is shown graphically by assembly drawings No. 3098-R-6140, and 3098-D-7600, and the requirements delineated by Mini-Specs No's 3098-MS-6100 and 3098-MS-7600 in Appendix A. The assembly procedure is outlined in assembly spec No. 3098-AS-6100. Test requirements and results are described in Section 5 and, in more practical terms by No. 3098-TR-6100.

3.6 Recycle Tank (C/N 562)

The recycle tank is a fixed-volume extension of the distillation unit evaporator. Waste liquid is circulated between the tank and the evaporator so that water can be boiled from that stream in the evaporator, and the residue carried back to the recycle tank rather than allowed to accumulate within the boiler. As water is removed from the stream a like volume of waste liquid is added to the stream from the pressurized waste-holding tank. Thus the solids contained in the waste accumulate in the loop. More than 99 percent of that loop is contained within the recycle tank, and solids disposition is effected by replacing the tank when the solids concentration is near the limit of economical or practical distillation. By previous testing the terminal concentration was set at 50 percent (specific gravity of the solution = 1.3). By the SSP design requirements the tank must have the capacity to contain the solids generated in 180 man-days of use, and by the SSP design specification the solids generation rate is 66.6g/man-day (0.147 lb/man-day) in the urine loop. Therefore, the required volume is:

$$\frac{(66.6\text{g solid/m-d} + 66.6\text{ g } H_2O\text{/m-d}) \times 180\text{ m-d}}{1{,}000\text{ g/liter} \times 1.3} = 18.5\text{ l } (1130\text{in}^3)$$

As the loop is operated the solids concentration increases and some precipitate out of solution. The tank is a convenient location to place a particulate filter in the recirculating loop. Located at the tank outlet port the filter will preclude large particles from entering the evaporator, and retain them in the tank for disposition with the concentrated solution. A 25-micron filter occupying 855 cm^3 (51 in^3) provided adequate protection of the NAS9-9191 evaporator. The pressure loss across the filter was not excessive after 120 man-days of solids accumulation and at a concentration approaching 56 percent. Two such filters, occupying 1,670 cm^3 (102 in^3), were designed into the SSP recycle tank.

A cylindrical tank with hemispherical ends was designed to contain the sum of the required liquid and filter volumes. Maintenance disconnect valves and convenient handles were fitted to the tank making periodic solids disposition a clean and easy task.

Assembly drawing No. 3098-R-6200 shows the recycle tank assembly, and the design requirements are established by the component Mini-Spec No. 3098-MS-6200, which is included in Appendix A. The test requirements and results are presented by document No. 3098-TR-6200, in Appendix C.

3.7 Controller (C/N 573)

This component provides the electrical control and interface function required for automatic operation of the module and data acquisition/fault detection by the onboard computer. The controller is an assembly of solid-state signal conditioners, control logic and power switching electronics integrally packaged within one case. All interface connections are made through electrical connectors and mechanical latches so that the component is readily replaceable.

Operational sequencing shown in a simplified form by the Block Logic Diagram (fig. 4 next page) is as follows:

Standby Mode: With power supplied to the module, and waste tank quantity less than 3.6 kg (8.0 lb), no electrical load is powered - but controller is ready to enter Start Mode.

Start Mode: When the waste tank quantity exceeds 3.6 kg the controller enters the Start Mode. The purge pump is turned on and the controller is ready to enter the Run Mode.

Run Mode: When the condenser pressure is lower than 40 mmHga the controller enters the Run Mode. The purge pump is powered, the liquid pump and the still motor are turned on, the

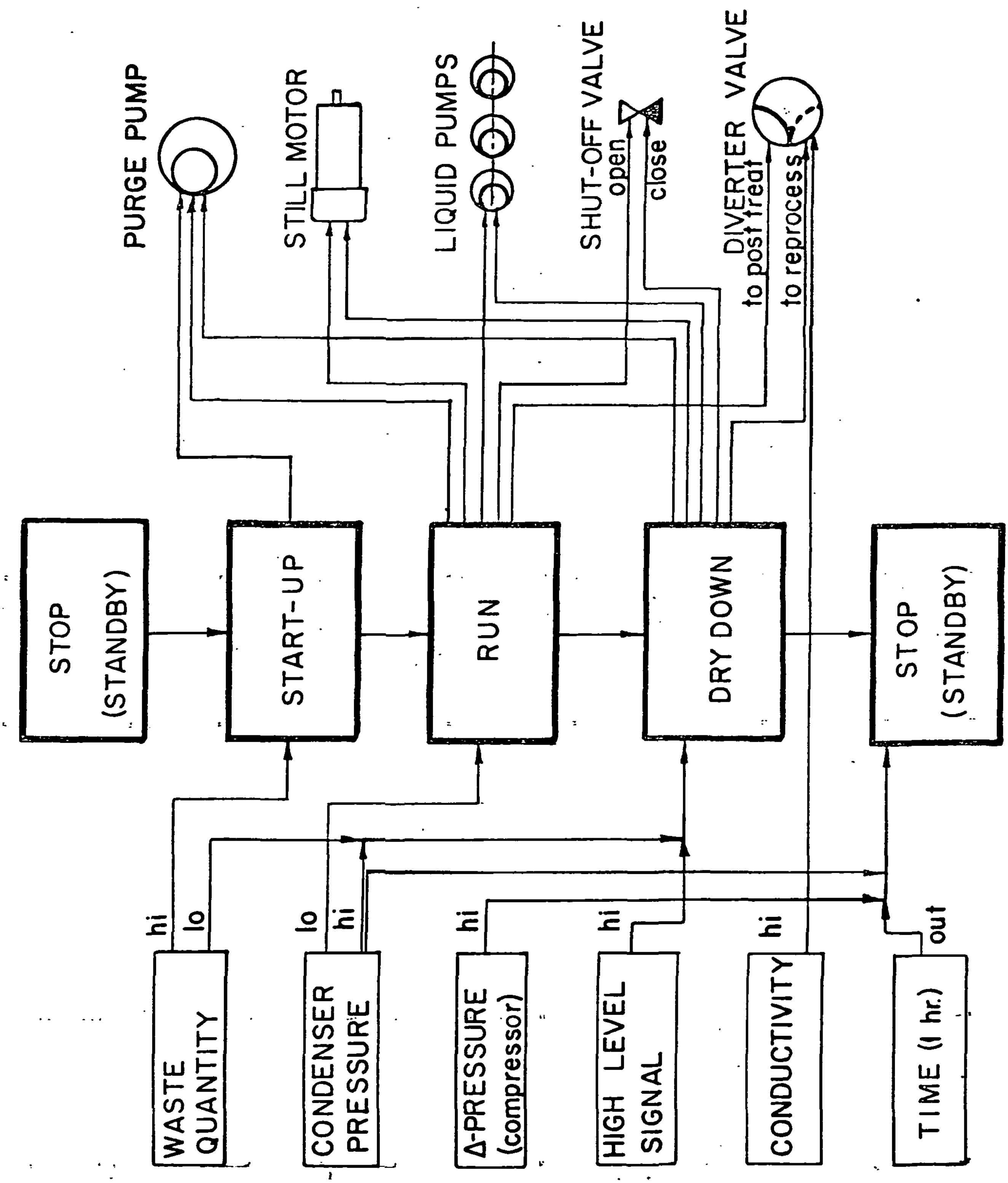


Figure 4 CONTROLLER LOGIC DIAGRAM

diverter valve is driven to the non-divert position to deliver water to the post-treatment cells and the shut off valve is driven to the open position. The controller is ready to enter the Shut-Down Mode. Also, the controller will drive the diverter valve back to the reprocess position should the electrical conductivity of the water produced be measured at greater than 50 micromhos per centimeter.

Shut-Down Mode: When the waste tank quantity decreases to 0.36 kg (0.8 lb), or the High Liquid Level Switch becomes closed or the compressor head rise exceeds 15 mmHg after a 30-second period after start of the Run Mode, the controller will enter the Shut-Down Mode. The purge pump, still motor and liquid pumps are powered as during the Run Mode, but the shut-off valve is driven to "close" and the diverter valve is driven to the "reprocess" position (to flush the evaporator with clean water). The controller is ready to enter the Standby Mode.

Standby Mode: When the compressor head rise exceeds 15 mm Hg, or when the condenser pressure exceeds 40 mmHga, or when a one-hour time period has elapsed the controller will enter the Standby Mode. The purge pump, still motor and liquid pumps are turned off, and the controller is ready to enter the Start-Up Mode.

Additionally a Manual Shut-Down Override Switch will place the controller in the Shut-Down Mode, irrespective of waste tank quantity, and retain that mode until the switch is turned off.

Power supplied to the controller is 115-Volt, 400-Hz, 3-phase with 0.5 kw capacity.

The complete schematic diagram is identified as Hamilton Standard Drawing No. SVSK 86607. The wiring diagrams showing the connections made internal to CHEMTRIC-produced components are shown by Drawing No. 3098-B-7301.

3.8 Distillation Unit Assembly (C/N 591, 539 & 571)

The distillation unit, component No. 591, is the operating component around which the VCD Module is designed. Performance requirements and criteria of all other components are established to meet the characteristics of the distillation unit. The basic design is essentially that developed under contract NAS9-9191; following is a brief description of that unit with emphasis placed upon the design changes made for the SSP application. In configuration, shown schematically on the figure on the next page, the still can be described as a stationary evacuated chamber inside of which is mounted two dynamic parts. They are (1) a centrifuge to effect phase-separation between the liquid and the

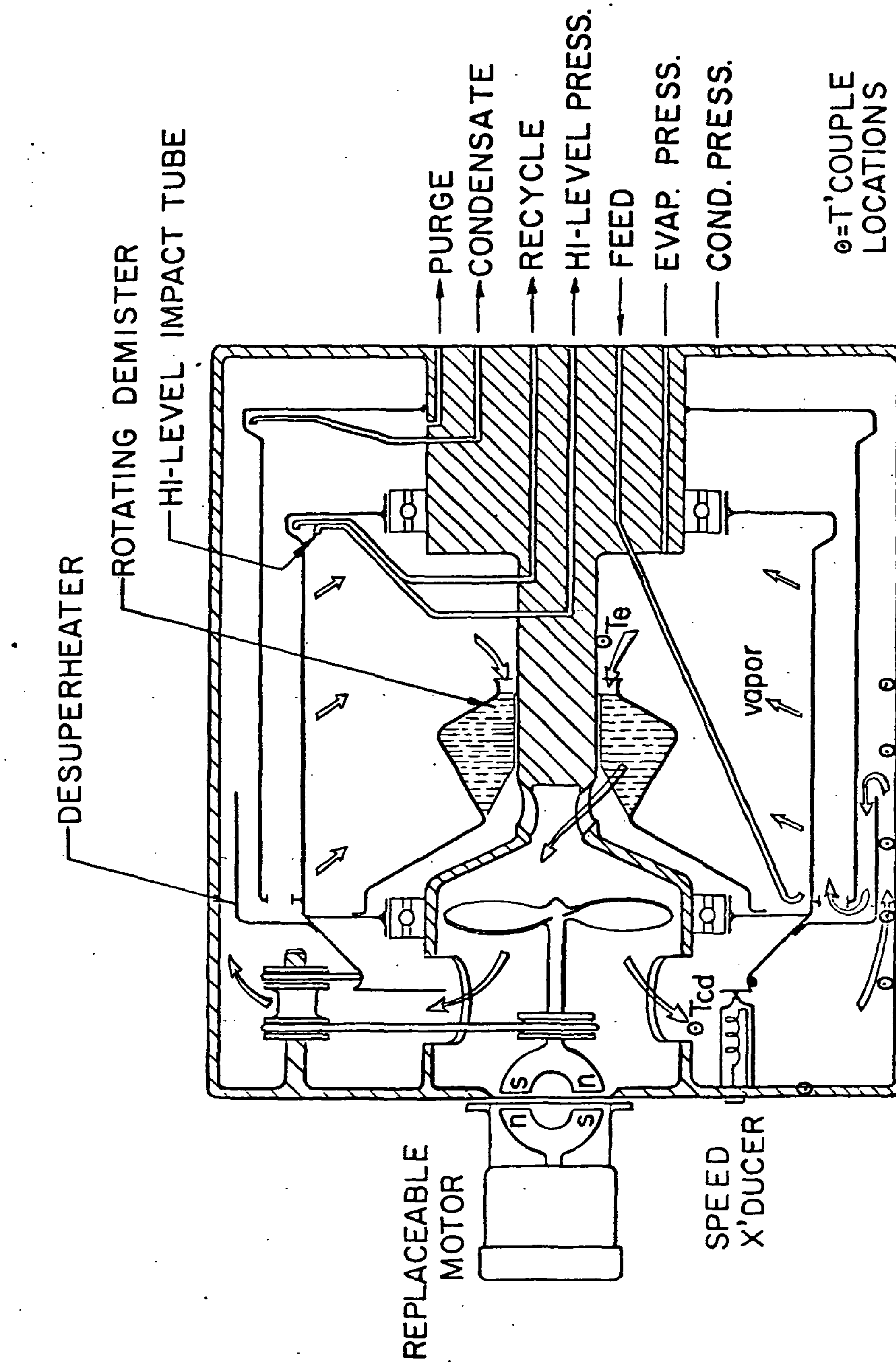


Figure 5 SCHEMATIC CROSS-SECTION OF DISTILLATION UNIT

gases, and (2) a compressor. The centrifuge is an assembly of two cylinders, an inner cylinder containing a film of evaporating waste liquid, and an outer cylinder which is located to collect droplets of water condensed on the outer surface of the inner cylinder. The compressor is located to draw vapor liberated by evaporation, elevate the temperature and pressure of the vapor, and deliver it to the condenser. Waste liquid is uniformly delivered to the rotating inner surface by a stationary circular manifold at one end of the cylinder. Only a fraction of the waste liquid is evaporated as it traverses the rotating cylinder; that which remains, together with the solids which were dissolved in the evaporated water, is centrifuged into an annular sump at the opposite end. An impact tube extending into the sump is located facing the rotating liquid. The kinetic energy of the liquid is converted to static pressure sufficiently high to drive the liquid to a pump inlet without flashing. Similarly the water condensed on the opposite side of the inner surface is collected in a rotating annular sump, driven against an impact tube and ducted to a pump inlet.

Liquid levels within the cylinders are automatically maintained at desired levels by (1) a dam at the exit end of the evaporator, (2) excess flow capacity in the recycle pump, so that all the feed liquid remaining after evaporation will be removed, and (3) excess capacity in the condensate pump to prevent water accumulation under conditions of maximum production rate. For safety considerations a high-level sensing impact tube is located in the evaporator. Should the quantity of waste contained within the still become high and the liquid reach the second impact tube, the static pressure so generated will close the contacts of a delta-pressure switch connected between that second tube and the evaporation chamber. The delta-pressure switch is designated component No. 571. Additional documentation including a description of the liquid switch is listed at the end of this assembly description.

The compressor is a two-rotor, rotary-lobe machine driven by an electric motor, component No. 539, at approximately 3600 rpm. For easy accessibility the motor is located external to the evacuated chamber. A syncronous magnetic coupling is applied to transfer the motor torque across the chamber boundry to the compressor input shaft without the need for dynamic sealing of a shaft. The centrifuge is driven by the compressor shaft through a system of belts and pulleys. At the compressor inlet a rotating demister is located to exclude any aerosol from the vapor stream. The demister is driven by the centrifuge at centrifuge speed and is shaped to throw any liquid separated from the gas stream outward to the film of waste liquid.

Non-condensible gases separated from the entering waste are carried with the water vapor through the compressor and through the condenser, then removed by a purge pump connected to a port at the end of the vapor path. That long path is advantageous because it precludes standing pockets of non-condensibles through the vapor/liquid path.

A speed-sensitive transducer is located to detect rotation of the centrifuge. At that location, the last element driven by the motor, should any drive element fail the failure will be detectable.

A thermocouple is located in the evaporator near the demister inlet. Evaporator temperature is useful information for determining solids concentration through boiling point elevation information and for math-modeling the distillation process, particularly during high-solids, high boiling-point-elevation operation, but it is not a part of either the automatic control or fault detection functions.

Assembly drawing No. 3098-R-9100 shows this distillation unit configuration in detail. The design requirements are delineated by the component Mini-Spec No. 3098-MS-9100, in Appendix A, and the assembly procedure described by assembly Spec No. 3098-DS-9100, Appendix B. Distillation unit test requirements and results are shown by document No. 3098-TR-9100, Appendix C.

Assembly drawing No. 3098-C-3900 shows the motor assembly, and the design requirements for that assembly are presented by Mini-Spec No. 3098-MS-3900, in Appendix A.

Assembly drawing No. 3098-C-7100 shows the Liquid Level Switch assembly, as configured to meet the design requirements shown by Mini-Spec No. 3098-MS-7100, in Appendix A.

Component testing of both the motor and switch was performed together with the distillation unit; the procedure and results are included in 3098-TR-9100, Appendix C.

3.9 Silver-Ion Sterilizer (C/N 597)

The silver-ion sterilizer is a passive contacting bed of AgCl granules dispersed with inert glass beads. A diameter ratio of 1.25 to 1 between the glass and halide particles (the glass is 0.05 cm diameter, the AgCl is 0.04 cm average diameter) is applied to maximize exposed surface area of the silver granules available for water contact. With a bed of that composition water passing through it at any superficial velocity lower than 240 mm/min (9.4 in/min) will become saturated with AgCl. The solubility of AgCl in pure water is dependent only upon temperature, and within the design temperature limits of 15.6^{o}C (60^{o}F) to 26.7^{o}C (80^{o}F), the silver concentration will range from 1.0 to 1.4 ppm. Extensive testing has shown that in that range of concentration sterility is maintained indefinitely.

Sizing of the SSP Silver-Ion Sterilizer was accomplished by making it equal to a sterilizer built under contract No. NAS9-5119, which was proven both effective and adequately sized throughout 180 days of use. The bed dimensions are:

diameter = 3.81 cm (1.50 in.)

length = 19.05 cm (7.50 in.)

L/D = 5/1

Assembly drawing No. 3098-D-9700 shows the sterilizer component configuration. Design requirements are presented by the component Mini-Spec No. 3098-MS-9700 in Appendix A. The chemical preparation and component assembly procedures are explained in Assembly Spec No. 3098-AS-9700 in Appendix B. The component test requirements and results are shown by 3098-TR-9700 in Appendix C.

MODULE DESCRIPTION

The arrangement of components as shown by the schematic diagram, figure 2, was devised to meet the VCD design requirements described in Section 2. Only minor modifications to that arrangement would be recommended for an operational flight system; they are explained in Section 8 of this report.

The assembly of components is shown by figures 6 & 7 which are photographs of the aisle and bulkhead sides of the module. Both sides and both ends are accessible in the planned vehicle layout. The upper half of the module, containing the distillation unit, is thermally insulated, but the photographs show the assembly with aisle-side and bulkhead-side panels removed.

Insulation is applied to the compartment not to reduce heat loss; that rate will always match the input energy. Rather, it is applied to increase the outer-surface temperature of the still from which the low heat flux can be rejected to the ambient - and thereby elevate the condenser temperature by 5 to 6°C (10°F). At that condition the evaporator temperature, which is 3 to 5°C cooler than the condenser, is always as warm or warmer than ambient. Feed liquid temperature, upon entering the evaporator, is at ambient temperature - established by the recycle tank temperature. The liquor does not violently flash and induce carry-over of a waste-liquid mist, as would occur if the liquid entered at a higher sensible temperature than that existing within the evaporator.

A hybrid philosophy was applied to the module packaging design. For those components contained within the frame envelope maintenance valves are located at the interface of each component with the system piping. The SSP maintenance concept is fully applied to that portion of the module - which would be a complete distillation processor module. The waste tank, post-treatment cells and electronic controller are located outside the frame envelope. Those components would likely be packaged into other modules in a 6-man or 12-man system. They were added to the exterior of the 3-man processor module without full weightless state maintainability for economic considerations, and because the concept will be fully evaluated by the processor components. The maintainable interfaces for the post-treatment cells and the gas side of the waste tank are formed by O-ring sealed unions, which will suffice for the gravity environment in which the SSP will be tested. A maintenance valve is located at the waste side of the tank to avoid spilling waste liquid during tank changes.

All of the interfaces, both mechanical and electrical are located on the surface facing the bulkhead. From that surface there is access to many small components; instruments and valves

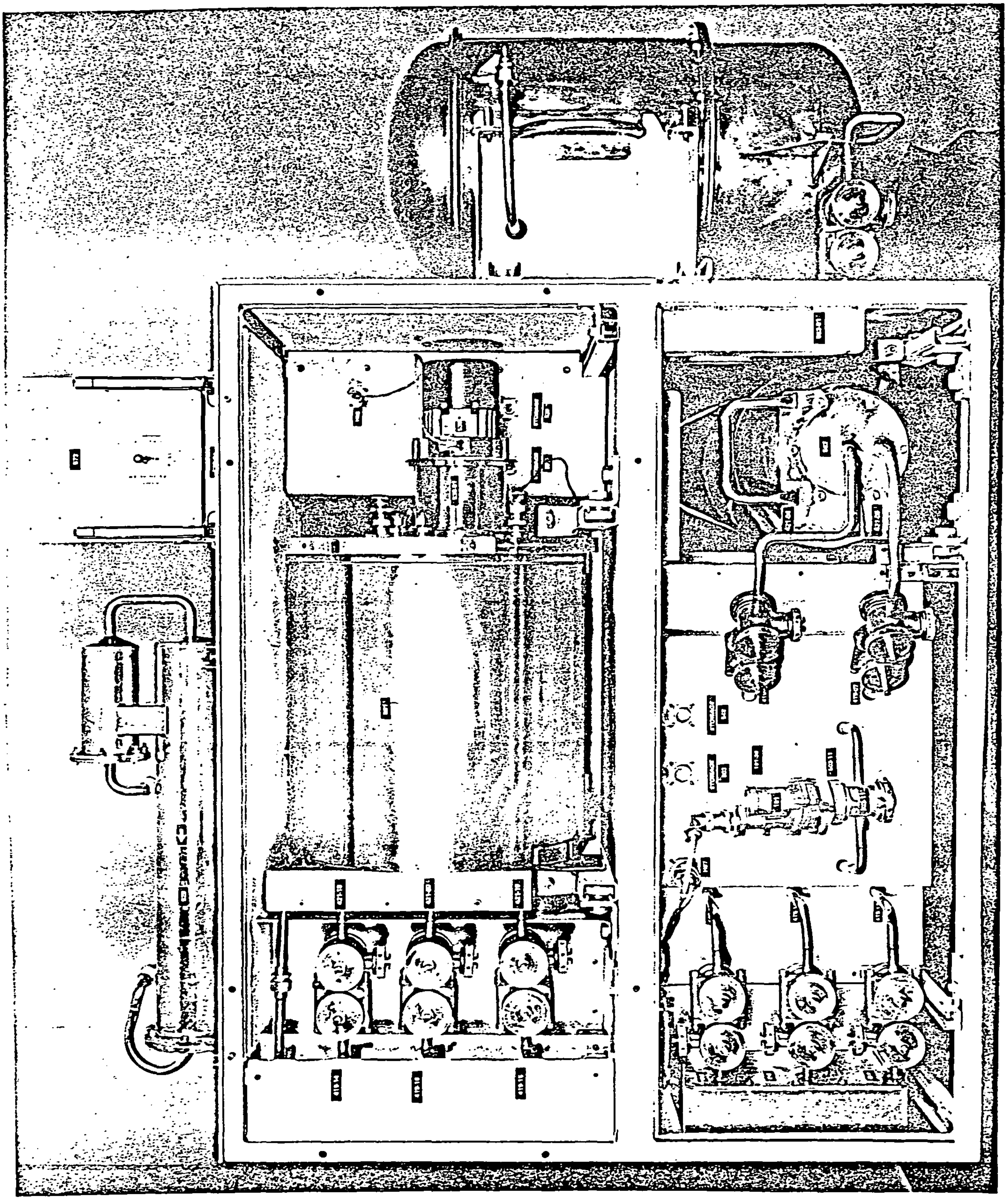


Figure 6 AISLE-SIDE VIEW OF SSP VCD MODULE

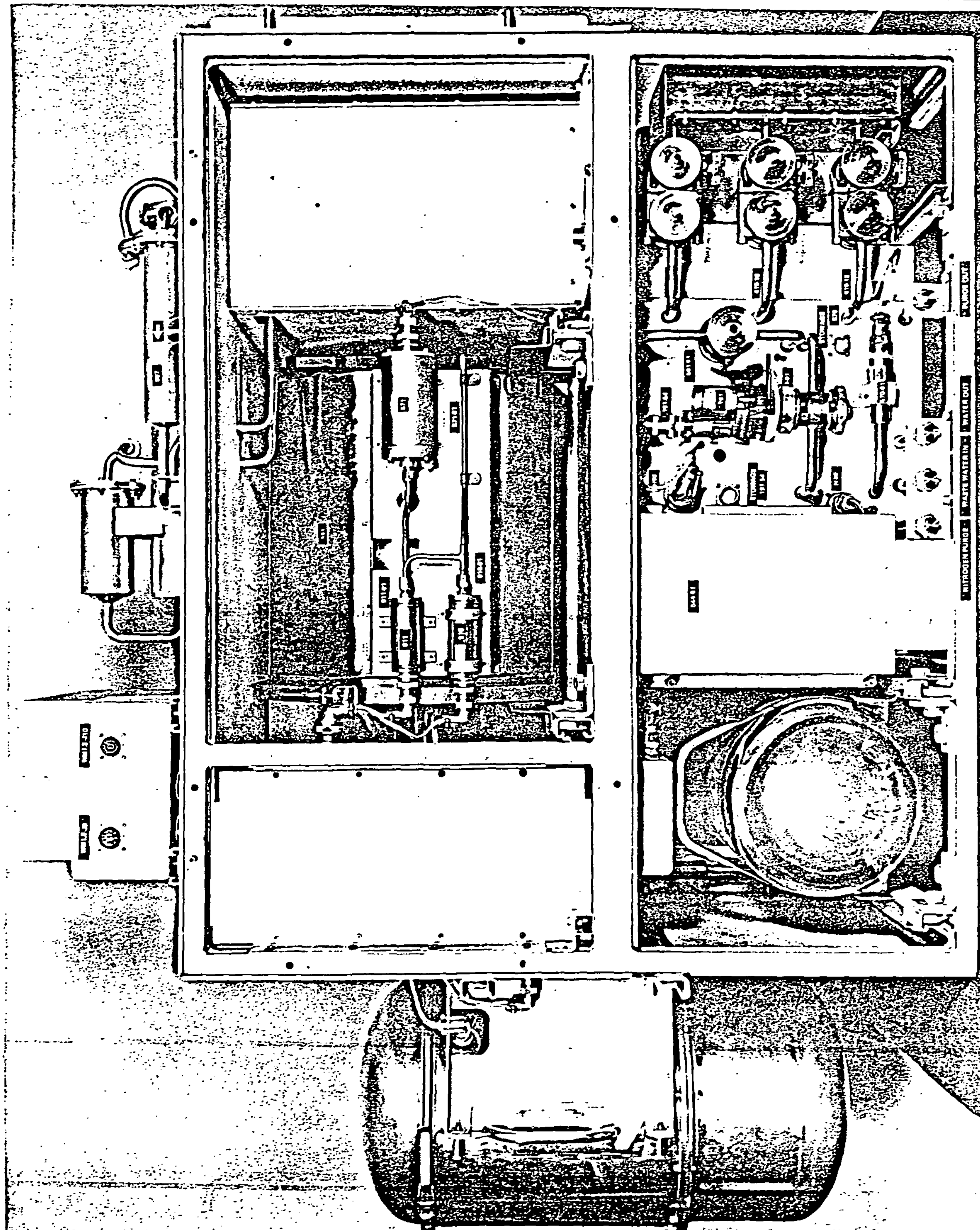


Figure 7 BULKHEAD SIDE VIEW OF SSP VCD MODULE

are accessible for maintenance or manipulation from the relatively small space between the module and the vehicle wall. Larger components (i.e., distillation unit and recycle tank) are accessible from the aisle side.

COMPONENT CHECK-OUT, CALIBRATION, AND MODIFICATIONS

Check-out testing was performed on the assembled components individually and in accordance with the Test Requirements document written for each of the components (Appendix C). Included in those documents is (1) a description of the tests to be performed, (2) the test procedure and set-up required, (3) the log sheet, upon which is entered the acceptable range of test parameters, and (4) the measured test results.

5.1 Test Results

The most significant performance parameters measured during check-out calibration of each component are listed below, together with the predicted level of those critical parameters.

Component	Parameter	Predicted	Measured
Activated Charcoal Filter (C/N 525)	pressure drop	0.16 psid max @ 5 lb/hr	0.15 psid @ 5 lb/hr
Deionizer (C/N 533)	pressure drop	0.2 psid max @ 5 lb/hr	0.12 psid @ 5 lb/hr
Purge Pump (C/N 544)	ultimate pressure	30 mmHga maximum	26 mmHga
Liquid Pump (C/N 548)	recycle pump flow rate with inlet @ saturation pressure	150 cc/min minimum	175 cc/min (peristaltic modification)
	condensate pump flow rate with inlet @ saturation pressure	35 cc/min minimum	175 cc/min (peristaltic modification)
	feed pump flow rate @ 20 psi negative headrise	150 cc/min maximum	135 cc/min (peristaltic modification)
Waste Tank & Quantity Gage (C/N 561 & 576)	gage calibration @ zero	8 ohms maximum	1.2 ohms

Component	Parameter	Predicted	Measured
	gage calibration @ 3.6 liters	- - - - -	320-325 ohms
	expelled quantity	18.2 liters minimum	18.4 liters (modified tank)
Recycle Tank (C/N 562)	pressure drop at 15 lb/hr	- - - - -	0.56 mmHg
Distillation Unit Assembly (C/N 591, 539 & 571)	water production rate	1.29 l/hr @ Pc=28 mmHga & zero solids	1.31 l/hr @ Pc=28 mmHga* & zero solids
	compressor delta P	4 mmHg @ zero solids	2.5 mmHg @ zero solids
	specific resistance of product water	2.0×10^4 Ω/cm minimum, w/feed 2×10^2 Ω/cm	16.5×10^4 Ω/cm (feed = 1.38×10^2 Ω/cm
	evaporator level switch	1) close feed valve when qty=2 liters 2) automatic restart	clsoed @ qty = 1.56 l restarted @ 10 min.
	speed pick-up (centrifuge)	280 rpm ± 5%	283 rpm
Silver-Ion Sterilizer (C/N 597)	Ag+ conc.	1.0 to 1.2 ppm	1.18 ppm

Most of the measured parameters were within the required ranges - as can be seen on the preceeding pages, and by analyzing the contents of Appendix C. The remainder of this section will explain the two failures encountered during component testing and described the corrective actions taken to qualify the components.

*Pc = 28 mmHga

5.2 Component Deficiencies

5.2.1 Liquid Pumps

It is necessary to pass three liquid lines across the distillation unit interface. The three lines are (1) waste liquid entering the evaporator (feed liquid), (2) waste liquor leaving the evaporator (recycle liquor), and (3) product water leaving the condenser (condensate).

The feed and recycle streams are parts of the same "recycle" loop passing through the recycle tank, which is pressurized to 5 psig, and the evaporator which is evacuated to saturation pressure at evaporator temperature (approximately 1/2 psia). The feed-liquid pump therefore must control flow passing to a lower pressure, and the recycle pump must draw liquid which is very near saturation pressure of flashing pressure. Similarly the condensate pump must draw distilled water which is only very slightly cooled.

The feed pump operated satisfactorily; a constant-flow regulator performed the feed-flow control function because the existing pressure difference, 19 psid maximum, was in the direction of flow. The gear pump was necessary, however, to overcome a psid back pressure relief valve placed downstream of the flow regulator. The relief valve closes to prevent evaporator flooding from the pressurized recycle loop whenever the distillation process is turned off.

Unacceptable performance of both the recycle and condensate pumps was encountered after less than one hour operating time. The test was run with the simulated distillation unit evacuated to saturation pressure and elevated 7 inches to reproduce the velocity pressure applied to the impact tubes via the centrifuge. There is an unavoidable back flow, or internal leakage within gear pumps from the higher pressure discharge side to the inlet side. The friction between the leaking liquid and the pump case is a source of heat, and the resultant temperature rise caused the already nearly saturated liquid to flash and vapor lock the pump. Test results show that at inlet pressures below 75 mmHga, liquid-phase flow through the pumps stopped.

An effort was made to decrease the back leakage by precision-fitting special oversize gears to the pump housing - which effectively lowered the pressure at which flashing occured to the range of 33 to 50 mmHga. Gear-to-housing clearance reductions in increments of 0.0001 inch were made until interference friction generated more heat than that eliminated by reducing fluid-leakage friction. It was accepted, finally, that efforts to improve the life to peristaltic pumps is a better solution than adopting any other known pumping principle to the vacuum distillation application.

An experimental peristaltic pump, which was built earlier in the program to evaluate tubing materials and roller geometry, was modified to become the SSP liquid pump. Modifications made include fitting a 400 Hz motor and a speed reducer, adding a commercially-available third peristaltic pump to the original two experimental pumps, and fitting the assembly with maintenance disconnect valves to make it interchangeable, in the VCD Module, with the gear pump assembly. The commercial pump was applied as the feed-control pump, while the other two streams which originate at near saturation pressure (recycle and condensate) were delivered by the two stages of the original experimental pump. Performance of the peristaltic pump assembly met all operational requirements; power consumption was measured at 14 watts. All of the subsequent parametric testing, approximately 100 hours running time, was performed with the peristaltic pump as assembled with the original tubing and without a failure or measureable degradation in performance.

Early in the program life of the experimental pump tubing was measured emperically at 520 hours of continuous operation, but the target life was 720 hours (30 days). For long-duration flights the tubing should operate for more than 2,000 hours, and ideally it should run indefinitely. The mode of tubing failures is by fatigue; longitudinal cracks originating at the ID are propagated radially outward. Various tubing shapes, other than cylindrical with concentric ID & OD, were analyzed - and simutaneously various formulations of cylindrical tubing material were run at NASA Johnson Space Center under conditions duplicating the recycle pump pressure profile flow rate and temperature with actual recycle liquor passing through the tubing. The best durability was measured for a Tygon formulation (Norton Plastics and Synthetics Number R-3603) at over 2100 hours with all performance parameters in the normal ranges. That test was run with a two-roller pump. The life can be extended by replacing the two rollers with a larger single roller; the number of tubing compressions for the same flow rate and within the same housing envelope will be reduced to less than half that applied during the 2100-hours life test. The single roller will generate a higher volumetric efficiency than two rollers, and be less abusive to the tubing, because it can be a larger diameter than either of two rollers operating in the same housing. The summation of all these data and results is a peristaltic pump design which will have a useful life well in excess of 90 days.

5.2.2 Waste Tank

Operation of the waste tank would have been normal had it not been for the particular quantity gage configuration incorporated into the tank assembly. Basically the tank is a familiar vessel design with a piston sealed by a rolling diaphragm. Liquid is applied to the inside of the diaphragm convolution, with gas pressure on the opposite surface. In this configuration the diaphragm is always pressure-balanced, and the liquid quantity may be increased or decreased causing the piston to move and exactly accommodate the liquid volume.

The malfunction detected during check-out testing was caused by the addition of two spring loads applied to the piston - pulling it away from the liquid side. The loads are applied by cables which are attached to the piston. The cables are wrapped around spring loaded pulleys to which are connected rotary variable resistors (pots). Liquid quantity thereby can be read as a value of resistance. In addition to facilitating quantity measurements the spring/cable mechanism was to be applied as a fault detection device. Should a rupture of the diaphragm occur, the springs, which were made larger than necessary for quantity measurement, would withdraw the piston from the liquid at a fast rate. Those spring loads distributed over the piston area result in gas pressure exceeding liquid pressure by 0.2 psid and, for a homogenous diaphragm, would not have caused buckling at the convolution. Filling the liquid side with water was accomplished with no apparent failure - even with intermittent liquid flow entering the tank. On expulsion however, when gas pressure becomes the driving force, the convolution was deformed and wedged between the piston and the vessel wall. Smooth motion of the piston was impeded causing progressively greater deformation and eventual rupture of the diaphragm.

The selected corrective action was to apply the spring loads in the opposite direction to (1) cause the liquid pressure to exceed the gas pressure, and (2) in the event of a chance diaphragm failure, to force the piston into the liquid space rather than into the gas space. With liquid pressure greater than gas pressure the convolution is stressed in membrane tension, thus precluding any buckling. Unfortunately that condition requires a slight complication to the configuration, which is shown in figure 3 in Section 3. The spring reel cables were lengthened and their direction reversed by stationary pulleys attached to the compression members which are rigid to the piston. The original piston stroke length was retained; thus, there was no sacrifice in usable tank volume. All check-out test parameters, including quantity gage calibration, were met by the modified waste tank.

VERIFICATION TESTING

After all of the components were assembled and individual performance verification tests run they were assembled into the Module. A series of performance-verification tests were run on the Module in accordance with the VCD Assembly Test Requirements (document No. 3098-TR-9800, in Appendix C).

All operating modes were successfully excercised over an operating period of seventeen cumulative hours. The tests included the following activities.

1. A complete-system leak check was made in four steps utilizing both the vacuum-decay/pressure-decay and visual techniques.

2. An operational checkout verification was made during which the system was automatically started by the addition of water to the waste tank, run to produce distillate, and then put through a normal automatic shut-down by draining the waste tank. The water process rate was within the design limits.

3. Off-design operations were synthetically generated to verify that the off-design control functions built into the module were both functional and effective in the application of corrective measures. Off-design operational checkout tests were made to verify the specific conditions.

   A. High evaporator-liquid caused by interrupting the recycle flow leaving the evaporator. The liquid level switch (C/N 571) responded properly and the controller (C/N 573) put the system into the shut-down mode.

   B. A gas leak to the evacuated distillation unit was simulated by opening a fitting. The condenser pressure transducer (C/N 911) responded properly and the controller put the system into the shut-down mode.

   C. Poor distillate quality was simulated by introducing a laboratory-prepared salt solution of 40 micromho/cm specific conductance to the distillate line. The conductivity sensor (C/N 570) responded properly and the controller drove the diverter valve to the reprocess position. Subsequently the line was flushed with deionized water, and the sensor and controller responded properly, permitting the valve to be manually reset.

D. A manual shut-down cycle was completed by activating the emergency switch on the controller. The controller maintained proper system configuration irrespective of waste tank quantity changes.

E. The maximum allowable dryout time was measured at 60 minutes by adding water to the evaporator (to prevent dryout) through a temporary tee in the feed line. The design maximum time limit is 60 minutes.

In order to verify that no leak existed within the distillation unit between the evaporator and the condenser (that part or all of the flow rate measured as distillate was not simply waste water leaking to the condenser) the tap water feed was replaced with a highly conductive salt (NaCl) solution (1.38×10^2 ohms-cm). The distillate produced from that liquor was measured at 1.65×10^5 ohms-cm, indicating that no waste liquid had reached the condenser.

Water loss rate with the purge gas was 12 ml/hr, which is slightly less than the nominal loss rate of 13.6 ml/hr established during the SSP analysis phase.

PARAMETRIC TESTING

Several series of detailed tests were conducted to establish the interaction of some known and some suspected phenomena upon performance parameters. All of the areas of investigation were directly related to the performance of the dynamic components. Consequently, the investigation could be conducted with only the SSP distillation unit and liquid pumps while all other components were laboratory-apparatus simulations of the SSP counterparts. Parametric investigations did not include the SSP purge pump because (1) the simple purging function could be duplicated by an equal-displacement laboratory pump, and (2) any flight application of VCD would require a significantly different purge pump (one that requires less power and generates less noise). The need to provide a more suitable purge pump was recognized long before parametric testing was initiated and efforts so directed were in progress during the testing phase. A summary of those efforts is presented in Section 8 of this report. Similarly, it was neither necessary nor advantageous to operate the entire loop to measure the performance parameters of interest, particularly during tests intentionally run outside nominal ranges. Each series of tests is described in following paragraphs, together with the results and conclusions reached.

7.1 Compressor - Discharge Superheat

In the vapor-compression cycle water vapor liberated by boiling is drawn into the compressor where both temperature and pressure of the gas is elevated. Ideally, that energy is transferred isentropically between the evaporator and the condenser pressure line. In the presence of friction, however, any departure from the ideal steam discharge condition would be in the direction toward higher superheated vapor.

The penalties of superheated vapor discharge are: (1) The coefficient by which superheated vapor transfers heat to the condenser wall is orders of magnitude lower than that by which condensing vapors transfer heat; should superheated vapor be present on the condensing side of the evaporator/condenser common wall, that portion of the common wall with the very low-coefficient heat transfer is masked from condensation and effectively from evaporation also. (2) If the superheated vapor is allowed to contact the portion of the evaporator/condenser common surface which is not normally wetted by evaporating waste liquid the temperature at that location will exceed saturation temperature within the evaporator. While that temperature gradient across the surface is not detrimental during steady-state operation in a null-gravity field, earth-bound operation or upset forces such as docking forces in space could cause a movement of the film onto those warmer areas. The evaporation from these warm spots might be more violent than from the film, and could induce carryover of contaminants to the condensor. The investigation of whether superheated vapor was leaving the condenser was lucrative for both performance improvement and expendables reduction.

Set-Up and Results

To set-up the test thermocouples were placed at the compressor-discharge port and along the compressed vapor path as shown in Figure 8. The distillation unit was operated with tap water entering the evaporator and, subsequently, with concentrated urine (up to 59% solids) as the feed liquor. At the compressor discharge vapor temperature rose steadily over a 4 to 6 hour period, then reached equilibrium at approximately 56°C (100°F) higher than saturation temperature. The maximum heat existing in that stream in excess of the saturation state point level is:

$$Q = \dot{M} \times Cp \times \Delta T, \text{ or}$$

$$Q = 33.4 \text{ Cal/hr } (132 \text{ Btu/hr}),$$

at the nominal water production rate of 1.36 Kg/hr (3 lb/hr). That is a small quantity of heat (less than 5%) relative to the quantity of latent heat circulating between the condenser and evaporator at that nominal condition.

Conclusions

It was calculated that rejection of that small quantity of heat could be readily accomplished passively - by passing the warm stream along the inner surface of the outer shell. The heat transfer coefficient achieved in that process could be set only approximately, because the effect of turbulance induced by the rotating centrifuge adjacent to the inner surface is not predictable. A sleeve was fitted to the centrifuge as shown in Figure 8, to force the steam along the inner surface and into contact with the condenser surface. Thermocouples placed in the steam path along the inner surface were read to determine the required path length necessary to reject all of the superheat before entering the condenser. Data show that the effective coefficient attained is sufficiently high to require only a very short extension of the steam path as shown by Figure 8.

Finally, and to verify those results, another run was made after thermal insulation was added to the condenser side of the non-wetted surface area; Viton rubber sheet stock, cut and formed to fit the contour, was applied with silicone adhesive to form the desired thermal barrier. Temperature

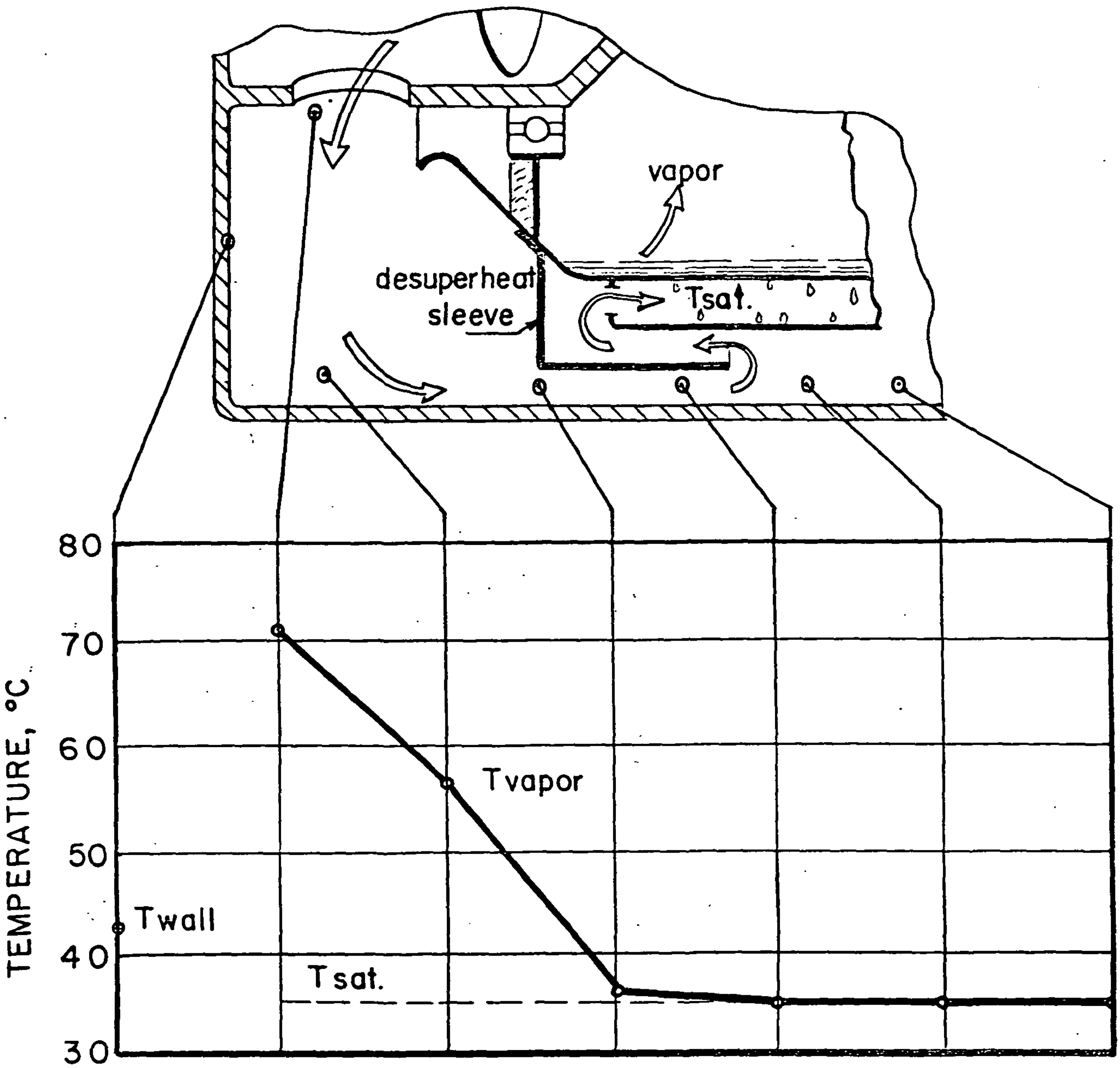


Figure 8 VAPOR TEMPERATURE PROFILE WITH DESUPERHEATER

measurements along the "desuperheater" surface verified that saturation temperature was reached at the same plane, indicating that any heat extracted from the un-wetted areas (by boiling of liquid existing at an un-wetted location) is either immeasurably small or non-existant. A more quantitative investigation of the necessity and/or effectiveness of the thermal barrier requires both a highly detailed analysis of the water generated with and without the barrier and/or photographs of that insulated surface during the distillation process.

7.2 Power-Loss Mapping

The most significant advantage of the vapor-compression distillation cycle is that both the input power required and the rate of heat energy rejected are very much lower than for any other distillation technique. Ideally, the total input energy is that necessary to elevate the enthalpy of the water vapor liberated in the evaporator by only two or three BTUs per pound of water recovered. The real compression process requires more power than the ideal, but the actual power is so low that a significant departure from conventional machine design practices is necessary.

The successful design of a vapor compression distillation unit is strongly related to the efficient transmission of very small power loads through the dynamic parts. Further, the coincident requirements for low power dissipation and long machinery life are mutually antagonistic, and large comfortable safety factors applied to such design decisions as bearing sizing and lubricant viscosity are intolerable. Aside from the obvious power absorbers which are the result of errors such as poor mechanical alignment or pre-loaded redundant bearings, there are some subtle sources of excessive power absorption within all dynamic machinery. In the distillation unit some of those potential power sinks are:

1. <u>A resonant vibration between the compressor timing gears</u>. The backlash (tooth-to-tooth clearance) is very small, less than 0.05 mm (0.002 in.); should a resonance occur, the relative velocity of both rotating masses will alternately be accelerated and decelerated at the resonant frequency through an excursion equal to the tooth clearance. The likelihood of vibrations occurring at the meshing of a highly-loaded pair of gears is less than when the transmitted load is light; for that reason, the centrifuge-driving load was designed to pass through the compressor timing gears, rather than being taken directly off the input shaft.

2. <u>Flexural friction of the centrifuge-drive belts.</u> Any torsional vibration between the centrifuge and the train of driving members will be damped by the elastic belts forming the last member of that train. Therefore, the acceleration/deceleration of relatively large masses, as is the possibility with the compressor, is not likely. Instead, vibration of the belts during normal operation might absorb power by internal heating of the belts and/or by the application of larger-than-calculated average radial loads on the pulley bearings.

3. <u>Impact tube drag</u>. Within the centrifuge, stationary impact tubes (pitot tubes) are held partially submerged in the rotating film of liquid to convert velocity pressure into stagnation pressure. The tube openings were designed to exhibit a low drag coefficient to the centrifuge, but the depth of their penetration into the liquid could not be predicted; total drag force therefore, could not be established analytically. The sensitivity of impact tube drag upon power absorption lies in the fact that drag force is applied at the centrifuge maximum diameter - where the influence upon torque is greatest.

Parametric testing afforded an opportunity to make emperical measurements of the power absorption of all dynamic members, including those locations where no high dissipation rates were considered possible.

<u>Test Set-Up and Results</u>

Power measurements were made by measuring the electrical input to the drive motor. Initially, the motor was run with no load to establish that point on the motor efficiency curve, and to draw a baseline from which delta powers could be measured. Power measurement runs were made as each part was added to the dynamic train so that each power increment was identifiable as the product of the load imposed by the incremental assembly of parts and the inefficiency of previous transmissions.

The test results are presented graphically as a power-loss map on the next page. It is significant to note that the no load power is much higher than anticipated, which was caused by the motor being of an unusual unbalanced 3-phase (scott-tee) stator configuration, and being driven by a conventional (balanced) 3-phase power supply.

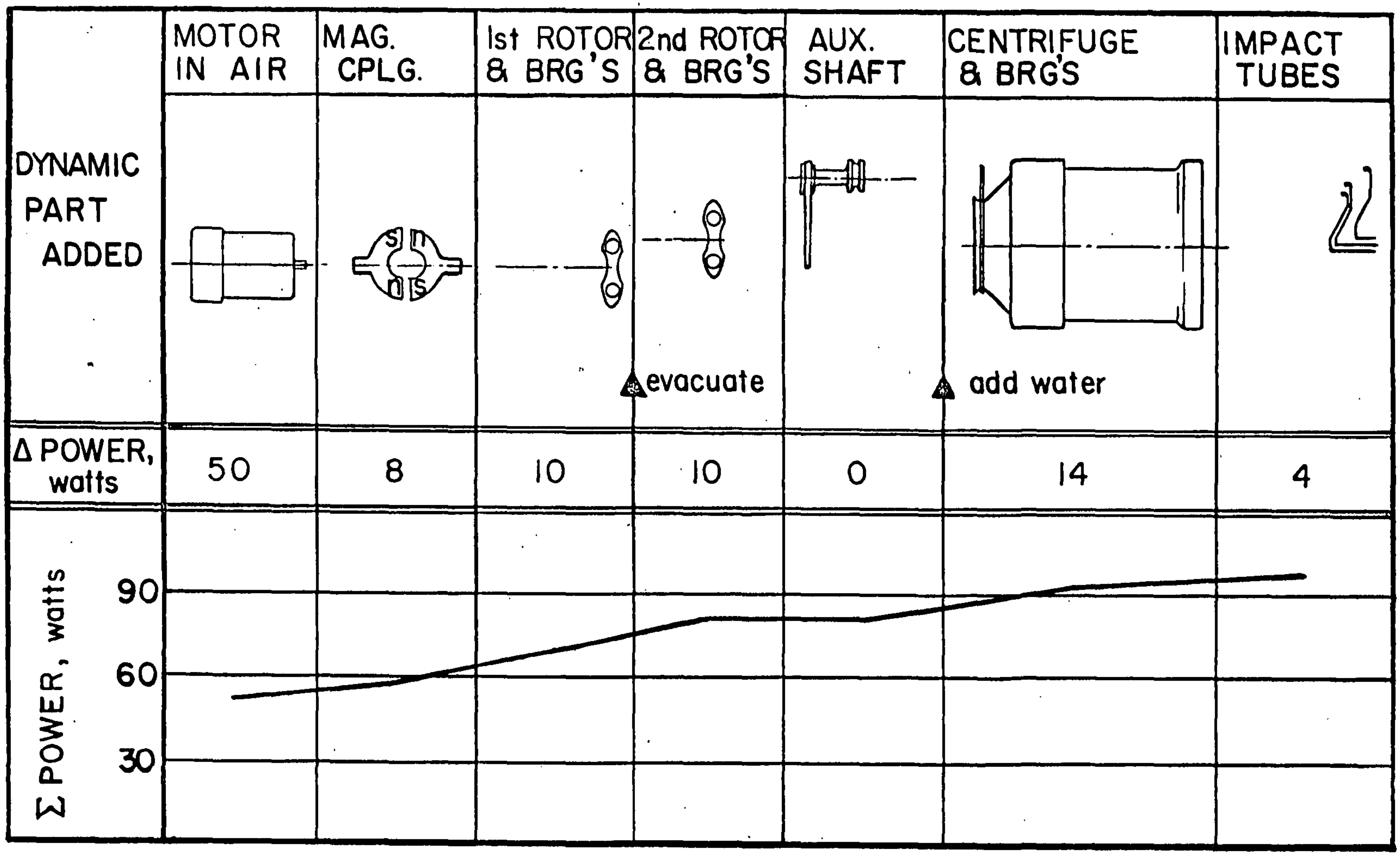


Figure 9 POWER-LOSS MAP FOR THE SSP DISTILLATION UNIT

Conclusions

With the exception of the centrifuge auxiliary shaft, the level of power absorption at each dynamic interface was within anticipated limits. As expected, the compressor bearings were the highest power sink, and the zero-increment of power absorption measured for the centrifuge auxiliary shaft bearings indicates that the power dissipation at that point is smaller than the range of experimental accuracy. That zero absorption, it is noted, should not apply when the auxiliary shaft is connected to the centrifuge.

The high compressor bearing load was anticipated because (1) those bearings carry rotors driven at high speed (3600 RPM), and (2) more importantly, because the bearings were intentionally made oversize to assure long mechanical life. The bearings selections were made to be identical to those carrying the rotors when operating under conditions requiring a 2 HP drive motor. The significance of the compressor-bearing power-absorption measurement lies in its usefulness when it becomes necessary to design a minimum-power compressor. That load, minus the lubricant viscous drag load, can be applied as a secondary (or checking) method for calculating the actual radial load applied through the bearings. The new bearings will be smaller and selected to carry only that load throughout the desired compressor life span. Power absorption will be lower with the smaller bearings because the same radial load operating through the same friction coefficient will be acting at a shorter lever length. Thus, a lower resisting torque will be applied through the shaft to the motor.

In a minimum-power redesign the entire power-absorption penalty imposed by the magnetic coupling could be eliminated. The driven magnet, located at an extension of one compressor shaft (see figure 1) could be replaced by the motor rotor. The outer magnet, which is presently motor-driven, could be replaced by the motor stator. Thus, the present condition of passing a rotating magnetic field though the thin non-magnetic sleeve would remain, but with the elimination of two magnet-carrier bearings and two motor shaft bearings. No sacrifice in maintainability is made by this change because the wound stator is accessible for replacement without "opening" the still.

7.3 Urine Distillation and Water Calibration Tests

A series of tests were run to reproduce the spacecraft-use operating profile over a ten-day period. The objective of the test was to verify that performance parameters lie within design limits - including that the entire profile could be repeated without a performance degradation and without maintenance, except to periodically dispose of accumulated solids by replacing the recycle tank. The series duration was extended to twelve days to establish that repeatability by including calibration runs, made with tap water feed, before and after ten-days exposure to urine input.

Test Set-Up and Results

The spare SSP distillation unit and liquid pump were assembled into the loop shown in figure 10. The loop was operated at a 3-man rate of input and recovery, and the recycle tank sized such that after thirty man-days of operation the solids concentration would be in the range of 55 to 60%.

Instrumentation and measuring techniques were as tabulated below:

PARAMETER	INSTRUMENTATION	DATA ACQUISITION
Motor Input Power	Polyphase Wattmeter	Direct Reading
Motor (and Compressor) Speed	Mechanical Tachometer	Direct Reading
Centrifuge Speed	Electronic-Pulse Tachometer	Oscilloscope
Condenser Pressure	Absolute Manometer	Direct Reading
Compressor Head Rise	Differential Manometer	Direct Reading
Ambient Temperature	Thermometer	Direct Reading
Demister Pressure Loss	Differential Manometer	Direct Reading
Liquor Feed Rate	Rotameter	Direct Reading
Evaporator Temperature	Thermocouple With Analog Pyrometer	Direct Reading
Compressor Discharge Temperature	Thermocouple With Analog Pyrometer	Direct Reading
Test Duration	Electric Clock	Direct Reading
Waste Quantity	See Below	
Waste Specific Gravity	See Below	
Water Production Rate	Graduated Cylinder	Direct Reading

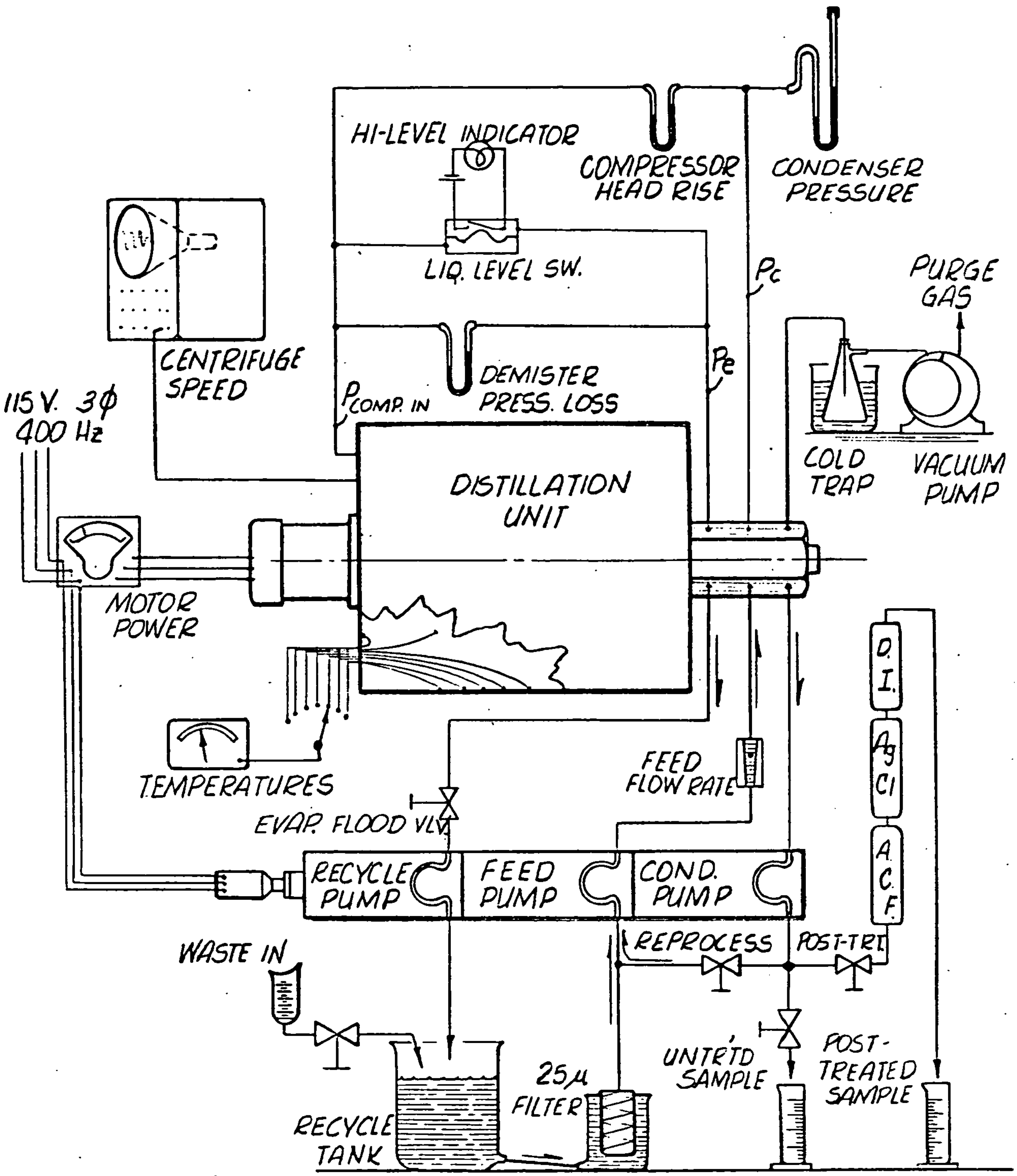


Figure 10 TEST SET-UP FOR PARAMETRIC DISTILLATION TESTS

PARAMETER	INSTRUMENTATION	DATA ACQUISITION
Liquor Solids Concentration	1. Hydrometer 2. Sample Drying	Read and Correlate Oven Dry and Weigh
Water Analysis (as distilled and as treated)	pH Meter	Direct Reading
	Sp. Res. Bridge	Direct Reading
	NH_3 Nesslerization	Colormetric
	COD Dichromate Oxidation	Titrametric
	Sterility Incubation	Observation

Urine Collection, Storage & Quantification

Human urine was donated as one-micturation lots by adolescent children and adults, both male and female. No control or intentional averaging was imposed upon the quantity collected; instead, each micturation was placed into a 1-liter bottle which had been predosed with 150 ml of the condensate collected during the previous day, and 2.25 g of pretreat solution (27% iodophor, 15% H_2SO4, and 6% antifoam by weight, blended with 52% water) to simulate actual urine collection, urinal flushing and pretreating. The contents of each bottle was weighed and the liquid volume measured to obtain specific gravity. The contents of 18 bottles were mixed together to made a day's feed batch. The specific gravity of the mixture was measured with a hydrometer. The mixture was stored at room temperature and added to the recycle loop in 1/2 liter batches, which is small enough to make dilution of the solids concentration in the recycle loop insignificant.

Water production rate during the tap-water calibration run was measured to be 1.68 kg/hr (3.70 lb/hr). That rate is 6 percent higher than the zero-solids-calibration production rate measured on the same size VCD unit built under contract No. NAS9-9191. The slightly higher performance is the effect of the slightly faster motor selected for the SSP distillation unit.

With pretreated urine and urinal flush water entering the evaporator the production rate followed the previously determined curve, showing a decreasing water production rate with increasing solids concentration (figure 11 next page). The decreasing rate is the predictable effect of varying fluid properties. The solid line plotted on figure 11 represents the minimum acceptable production rate as guaranteed by Mini-Spec No. 3098-MS-9100, in Appendix A. The dotted curve is drawn through the maximum rates measured during a 48-day test of the NAS9-9191 distillation unit.

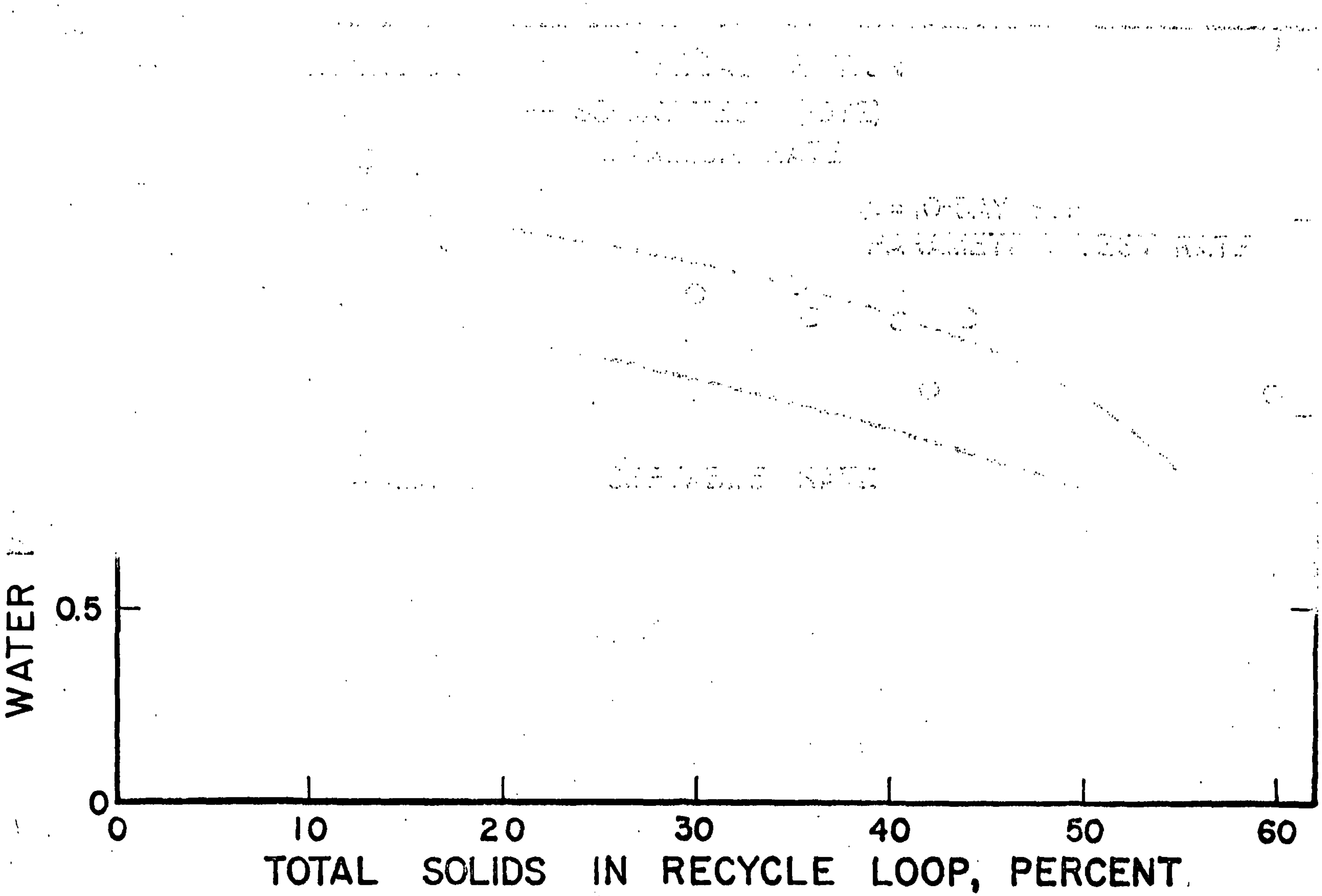


Figure 11 EFFECT OF SOLIDS CONCENTRATION ON WATER PRODUCTION RATE

That maximum trace, rather than an "average" performance curve, is taken as a comparison for the SSP because the original data was taken with feed rates which were shown to be too low. An excessively steep solids concentration gradient was present across that evaporator surface which caused an unnecessarily high boiling point elevation to depress the vapor generation rate at the exit end of the evaporator. It was learned late in that test that a volumetric feed rate-to-recovery rate ratio of 5 to 1 during zero-solids distillation would preclude a steep concentration gradient during high-solids distillation. The feed rate was increased incrementally during the NAS9-9191 test, and a performance improvement was experienced whenever the water production rate was lower than that maximum curve shown on figure 11. It was concluded that the maximum curve of production rate versus solids more accurately represents the performance capacity, and that comparisons should be made to that curve.

For the SSP the feed and recycle pumps were sized to preclude the formation of steep concentration gradients across the evaporator surface. The test results show that the previous maximum performance curve could be called the average performance curve for the SSP distillation unit, and that another higher maximum curve could be drawn to show the effect of high SSP compressor speed. Considering the range of experimental error the dotted line on figure 11 could be called the nominal water production rate.

Of exceptional significance is the data point at 59.7 percent total solids concentration, which corresponds to more than 98 percent water extractions from the waste liquid. Successful operations at that concentration is verification that the process can be safely programmed to operate at up to 50 percent concentration and include a margin for contingent operation.

After the 10-day urine test the recycle loop (including the evaporator) was flushed with tap water and the calibration test re-run. The initial water production rate was duplicated within experimental accuracy. Thus no degradation in performance was experienced and the urine exposure cycle could have been repeated - and the results duplicated.

Specific energy is a measure of the operating cost to produce distillate in terms of watt-hours per kilogram of water produced. Electrical power consumption of the SSP distillation unit, Figure 12, was higher than for the previous machine for three reasons; rotational speed was increased, the torque was increased, and the motor selected for SSP was less efficient. Several power absorbing mechanical loads were added in efforts to make performance improvements. They include a rotating demister located within the centrifuge, an increased centrifuge speed, and two bearings to locate the magnetic coupling. Additionally, the speed of the

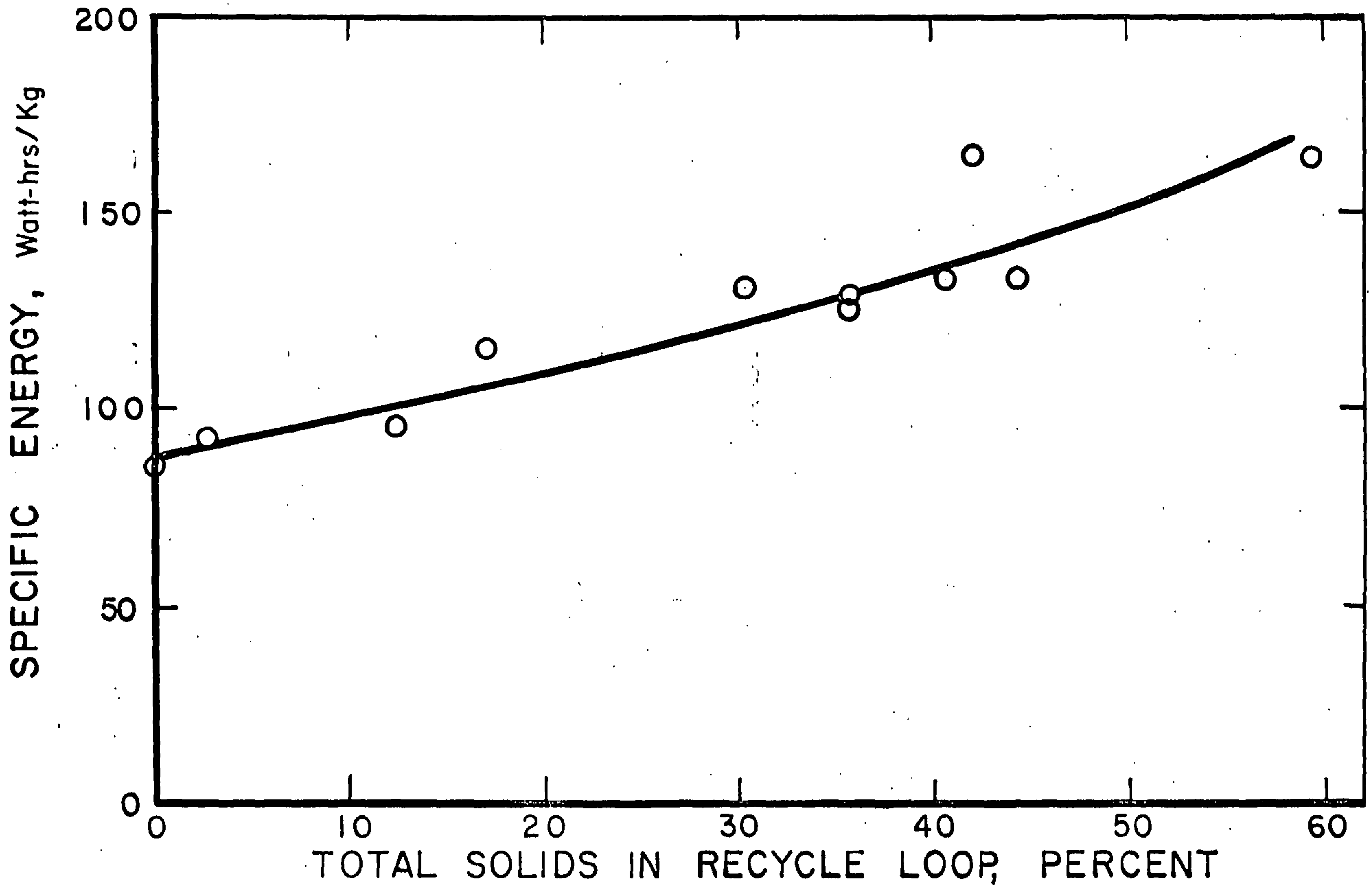


Figure 12 EFFECT OF SOLIDS CONCENTRATION ON SPECIFIC ENERGY

selected 400 Hz motor at rated load is slightly higher than rated speed of the previous 60 Hz motor; thus, with a constant torque load, mechanical power input increased linearly with speed. The resulting increased compressor speed is advantageous because any speed increase exceeding the slip speed (that speed necessary to overcome compressor internal leakage) is productive. None of the other added loads were measurably advantageous because either no significant performance improvement was realized or, in the case of the coupling bearings, a configuration change could produce the same kinematic results without the power loss. A more efficient motor with an externally mounted stator magnetically coupled to the internal rotor, driving a compressor at SSP-compressor speed and driving the centrifuge at NAS9-9191-centrifuge speed and with a rotating demister operating without a bearing, would display a specific energy requirement lower than that shown by figure 12.

Water Quality

Chemical analysis of the water produced both before and after post-treatment was made in the CHEMTRIC laboratories and repeated on samples forwarded to NASA. In most instances where CHEMTRIC and NASA ran duplicate tests the results are within experimental accuracy (see Table 1). A significant discrepancy exists, however, in measurements of pH; CHEMTRIC's measurements are universally higher than those made at NASA. A plausable explanation for the lower (more acidic) pH measured for the untreated distillate, which was known to be unsuitable, is that microbial growth occurred during the transit period between Illinois and Texas, and CO_2 so generated caused the measured pH shift. That possibility is supported by the fact that the differences between CHEMTRIC's and NASA's readings for the post-treated water (all samples of which were sterile) is smaller than the discrepancies among the unsterile samples (see Appendix D for detail analyses).

In addition to the cursory analysis made of the daily samples NASA ran a complete analysis of the untreated water produced on days No. 2, 5 and 10; those results are presented in Table 2 in the format generated by NASA. Three elements (iron, lead and nickel) show concentrations higher than the "Specification Limits". While those metals were introduced by the specific alloy applied to Nicrobraze some of the centrifuge parts during manufacturing, it is noted that the deionizer column (located downstream from the point where these samples were drawn) would have reduced these concentrations substantially. A different brazing alloy was found to alleviate that trace-metals-introduction problem.

The high mercury concentration (42 ppb) shown for the day No. 2 sample is undoubtedly the result of accidentally blowing the contents of a mercury monometer into the still before testing began. It is shown that by day No. 5 the mercury had been flushed from the machine and the anomaly had disappeared.

day No.	Sample	spec. res. ohm-cm	pH	N ppm	COD ppm	sterile ?	spec. res. ohm-cm	pH	$N-NH_3$ ppm	Ag ppb	Cl- ppb	COD, ppm Approx.
1	untreated	82,000	8.1	0.3	60	ster.	150,000	5.2	- -	50	- -	37.5
	post-trtd	44,000	8.0	0.25	20	ster.	45,000	7.1	0.036	300	- -	13.5
2	untreated	68,000	8.1	0.3	80	not str	67,000	4.8	0.120	50	170	48
	post-trtd	68,000	8.1	0.3	20	ster.	70,000	7.0	0.150	500	- -	10.5
3	untreated	48,000	7.8	0.3	70	not str	30,000	4.2	0.192	50	- -	60
	post-trtd	60,000	7.9	0.3	20	ster.	57,000	6.7	0.258	800	- -	12
4	untreated	46,000	7.9	0.3	80	not str	30,000	4.1	0.450	50	210	63
	post-trtd	58,000	8.0	0.3	25	ster.	38,000	4.8	1.428	1,200	500	16.5
5	untreated	44,000	7.8	0.3	70	not str	50,000	4.8	1.290	50	160	72
	post-trtd	58,000	8.0	0.3	20	ster.	55,000	6.9	0.960	1,200	830	18
6	untreated	43,000	7.4	2.0	80	not str	50,000	4.8	1.250	50	270	69
	post-trtd	64,000	8.0	1.0	20	ster.	70,000	6.8	1.150	1,400	620	21
7	untreated	36,000	7.7	2.0	90	not str	40,000	4.6	1.535	50	30	129
	post-trtd	62,000	8.1	1.0	20	ster.	67,000	6.8	1.160	1,300	600	21
8	untreated	35,000	7.4	2.0	120	not str	43,000	4.5	1.625	100	200	96
	post-trtd	58,000	8.1	1.5	20	ster.	67,000	6.8	1.350	1,000	550	81
9	untreated	33,000	7.9	2.0	110	not str	35,000	4.4	1.485	50	240	72
	post-trtd	47,000	8.1	2.0	25	ster.	45,000	6.9	1.510	900	900	42
10	untreated	30,000	7.5	2.0	110	not str	30,000	4.5	- - -	- - -	255	72
	post-trtd	59,000	8.0	1.5	25	ster.	54,000	6.6	1.450	50	610	24

Table 1 SUMMARY OF CHEMTRIC AND NASA WATER ANALYSES

WATER ANALYSIS REPORT				
Source: Chemtric	Date: 7-18-74	Untreated Sample		
Determination	Specification Limits	Day #2 Ref.No. 474-67	Day #5 Ref.No. 474-81	Day #10 Ref.No. 474-107
pH	6–8	4.8	4.8	4.5
Resistivity (Megohm–cm at 25 deg C)	Reference only	0.067	0.05	0.03
Total Solids, ppm	TBD but < 500	11.6	1.5	2.5
Organic Carbon, ppm	TBD but < 500	16	24	24
Inorganic Carbon, ppm	Reference only	< 1	< 1	< 1
Cadmium as Cd, ppb	10	<10	<10	< 10
Chromium as Cr^{+6}, ppb	50	1.2	2.7	8.5
Copper as Cu, ppb	1000	<50	<50	< 50
Iron as Fe, ppb	300	2000	500	600
Lead as Pb, ppb	50	<500	<500	<500
Magnesium as Mg, ppb	Reference only	20	< 10	< 10
Manganese as Mn, ppb	50	< 50	< 50	< 50
Mercury as Hg, ppb	5	42	< 5	IS
Nickel as Ni, ppb	50	<100	1000	1000
Potassium as K, ppb	Reference only	70	150	IS
Silver as Ag, ppb	50	< 50	< 50	IS
Sodium as Na, ppb	Reference only	100	250	80
Zinc as Zn, ppb	5000	70	40	IS
Ammonia as N, ppb	3000	120	1290	IS
Fluoride as F^-, ppb	20,000	675	800	550
Nitrate as N, ppb	TBD	3300	< 50	< 10
Sulfate as SO_4^{-2}, ppb	250,000	400	500	500
Chloride as Cl^-, ppb	450,000	170	160	255

Table 2 ANALYSIS OF DAYS 2, 5 & 10 UNTREATED DISTILLATE

CONCLUSIONS AND RECOMMENDATIONS

It has been demonstrated that all the additional equipment necessary to build a vapor compression system rather than only a VC unit is available with existing technology. The SSP Vapor Compression Distillation system has true null-gravity capability and demonstrated automatic operation.

Specific energy consumption of the SSP VCD is excessively high but significant reductions are readily available to future-system designers. The power reductions which can be made are: (1) Develop a peristaltic purge pump to replace the piston pump selected for SSP. The peristaltic pump should perform the purging function with 20-watts input; the piston pump requires 200 watts. (2) Reduce the distillation unit centrifuge speed to the range at which the original centrifuge (NAS9-9191) was driven. The 20 percent speed increase built into the SSP unit was not lucrative. (3) While the rotating demister in the VC unit evaporator should be retained it should be cantilevered from the evaporator bulkhead rather than mounted on a bearing to the central shaft. The friction load imposed by the bearing mounting could have been eliminated for the SSP design but that required a design change too extensive to be justified within the SSP program objectives. (4) Four bearings and their associated power loss and reliability penalty can be eliminated by integrating the distillation unit motor and the magnetic coupling. The inner (driven) magnet should be the motor rotor and the outer magnet with its carrier bearings should be replaced by the motor stator. The same advantages of ready replacement of the most unreliable part (the stator) and complete absence of dynamic seals are retained. This design improvement also could not be justified for the SSP program.

Operating life of the peristaltic liquid pump assembly is only 22 days of continuous operation. Subsequent investigation into peristaltic pump geometry and tubing materials has shown that the life can be extended to at least 88 days, and probably much longer. By designing the pump with a single large roller, holding the tubing in a tight omega-shape, carefully controlling the tubing occlusion, selecting a tubing material completely inert to the medium, and by selecting a lubricant which is compatible to all the requirements, the pump life is projected to be in excess of 525 days of continuous operation.

The most lucrative area of penalty reduction lies in post-treatment improvement. For short-term missions, less than 30-days, the post-treatment penalty is not excessive because the useful life of all the present post-treatment cells are at least that long. The variable penalty which is linear with mission duration is not paid until after that period has elapsed. When VCD is considered for longer missions the replacement cell imposes maintenance crew-time penalties which must be reduced through either significant improvements in the present technique or the development of a technique which operates without expendables.

On shorter-duration space flights, those applications for which VCD development as an experiment is more urgent, emphasis must be placed upon understanding the differances in operating characteristics caused by a null-gravity environment. The major unanswered questions which prevent the immediate application of VCD as an on-line water renovation system are concerned with boiler film stability, waste liquid droplet behavior "above" the rotating evaporator surface and the potentially rapid plugging of even a very large recycle loop filter by precipitated solids, which have always "settled" in the gravity environment existing with all VCD tests to date. No such potential questions remain relative to the system performance, operating economy, reliability or longevity; those important parameters have been conclusively established as being achievable, or as good or better than any potable water renovation technique applicable to the requirements of space flights in the foreseeable future.

COMPONENT DESIGN AND PERFORMANCE REQUIREMENTS

This section is composed of Mini-Specs describing the eleven CHEMTRIC-built components which are listed below. Similar documents generated by the prime contractor, Hamilton Standard Division, United Aircraft Corporation, describe the other seven components required to build a VCD module and are included in the other SSP reports.

Component Name & Number	Mini-Spec No.
Activated Charcoal Filter, 525	3098-MS-2500
Deionizer, 533	3098-MS-3300
Drive Motor, 539	3098-MS-3900
Purge Pump, 544	3098-MS-4400
Liquid Pump, 548	3098-MS-4800
Waste Tank, 561	3098-MS-6100
Recycle/Filter Tank, 562	3098-MS-6200
Liquid Level Switch, 571	3098-MS-7100
Quantity Sensor, 576	3098-MS-7600
Distillation Unit, 591	3098-MS-9100
Silver Ion Sterilizer	3098-MS-9700

1.0 Scope: This specification describes the design requirements for the SSP-WWMS Activated Charcoal/Biological Filter (Component No. 525).

2.0 Function: To remove trace organic contaminants from raw condensate water by adsorption on activated charcoal, and to remove bacteria greater than 0.12 microns, nominal, and 0.35 microns, absolute from the processed water stream.

3.0 Description: This component is an assembly of two separate canisters; the first is a bacteria filter and the second is an activated charcoal bed. The assembly is replaceable via maintenance disconnects and brackets. Both canisters contain springs to load their filter elements against vibration, and will be marked with a warning to caution personnel against disassembly. The description of the bacteria filter is per Mini-Spec No. 3098-MS-2400. Carbon in the ACF is retained between perforated CRES sheets and pyrex wool to permit axial flow of the process water stream.

4.0 Materials: Internal: corrosion resistant steel housing, retainers, spring and maintenance disconnects, pyrex wool pads for particle containment, Viton-A O-ring seals and activated charcoal.

5.0 Performance:

5.1 Fluid:	Clean renovated water (distillate from Still and ECS)
5.2 Flow Rate:	5.0 lb/hr maximum (distillation loop) (ARG condensate ≈ 60 lb/hr)
5.3 Pressures:	Operating, 30 psig nominal, 28 to 32 psig range Proof: 48 psig Burst: 64 psig Drop Across Assembly: See Graph 9.0
5.4 Temperatures:	Normal operating: + 60 to + 160°F Autoclave Cycle: 228 to 233°F
5.5 Leakage:	External: < 1cc/year Internal: N/A
5.6 Weight:	Installed: 20.38 lb Expendable: 17.49 lb Spare: 17.49 lb
5.7 Interfaces:	Fluid: 1/2" diameter tubing ports with maintenance disconnects Mechanical: Brackets Electrical: N/A

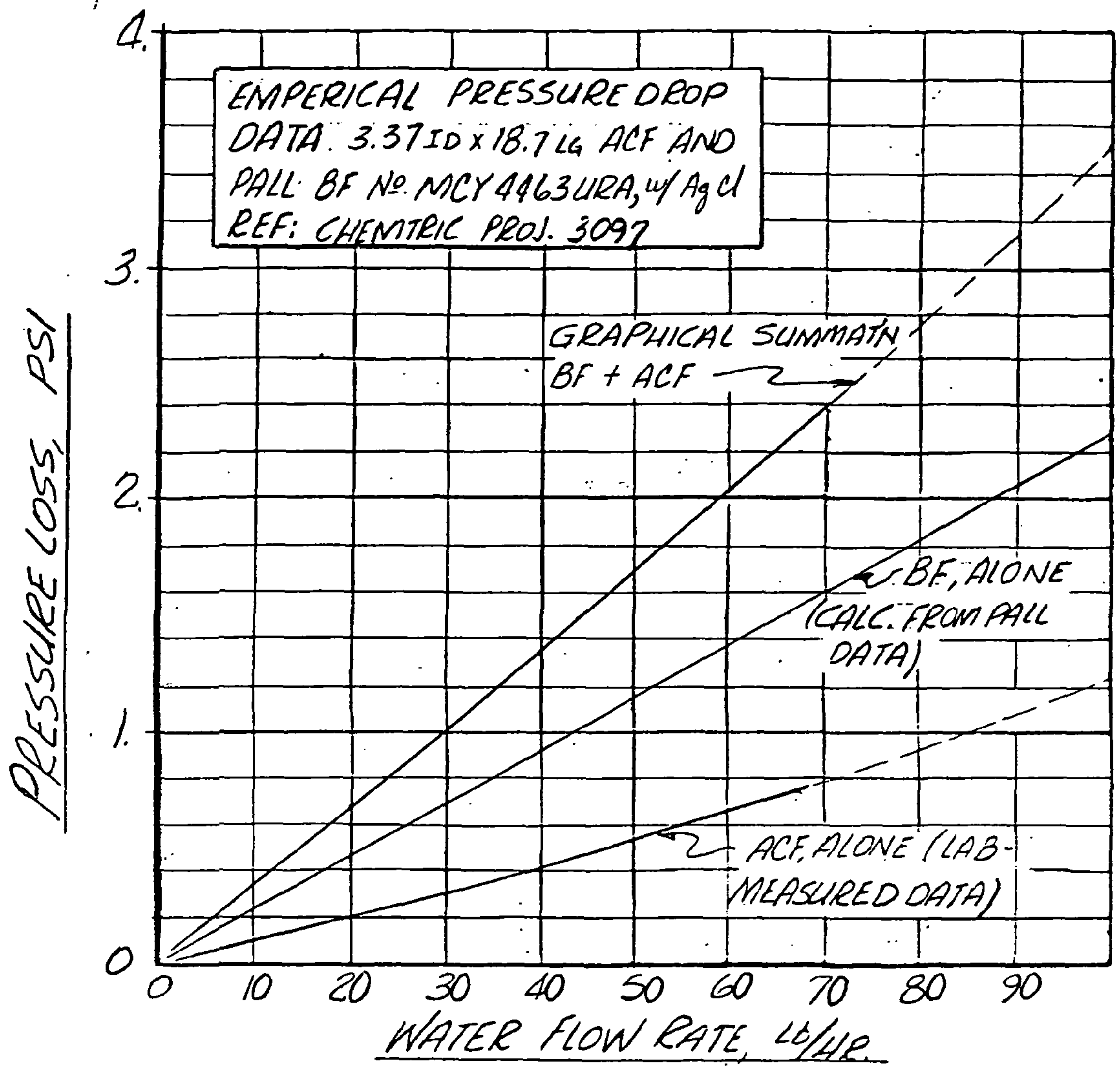
ORIGINAL DATE OF DRAWING Dec 2/71	CHEMTRIC, Inc. 9330 WILLIAM STREET • ROSEMONT, IL. 60018			
DRAFTSMAN P. P. Nuccio	DATE	TITLE: COMPONENT MINI-SPEC ACTIVATED CHARCOAL/BIOLOGICAL FILTER (Component No. 525)		
CHECKER P P Nuccio	DATE 1/8/72			
ENGINEER P P Nuccio	DATE			
APPROVED P P Nuccio	DATE			
DESIGN ACTIVITY APPROVAL		CODE IDENT. NO. 14958	SIZE X	DWG. NO. 3098-MS-2500 · REV D 10/20/72
OTHER APPROVAL		SCALE ~	WEIGHT ~	SHEET 1 Of 2

6.0 Environment: Cabin Ambient

7.0 MTBF: TBD (Goal = 3.3×10^6 hrs)

8.0 Expendable Life: 30 Mission-days

9.0 Measured Pressure Loss:



ORIGINAL DATE OF DRAWING Dec 2/71	CHEMTRIC, Inc. 9330 WILLIAM STREET • ROSEMONT, IL. 60018	
DRAFTSMAN P. P. Nuccio DATE	TITLE COMPONENT MINI-SPEC ACTIVATED CHARCOAL/BIOLOGICAL FILTER (Component No. 525)	
CHECKER P.P. Nuccio DATE		
ENGINEER P.P. Nuccio DATE		
APPROVED P.P. Nuccio DATE		
DESIGN ACTIVITY APPROVAL	CODE IDENT. NO. 14958 / SIZE X / DWG. NO. 3098-MS-2500	REV D 10/20/72
OTHER APPROVAL	SCALE ~ / WEIGHT ~	SHEET 2 of 2

1.0 Scope: This specification describes the design requirements for the SSP-WWMS Ion Exchange Column. (Component No. 533)

2.0 Function: To remove trace metallic ions from recovered water generated by the distillation process, and to remove bacteria greater than 0.12 microns nominal and 0.35 microns absolute from the processed water stream. The bacteria filter is primarily a redundant barrier to prevent back-migration of bacteria which might enter the loop during maintenance operations.

3.0 Description: This component is an assembly of two separate canisters; the first is a bacteria filter, and the second is a deionizer bed. The assembly is replaceable via maintenance disconnects and brackets. Both canisters contain springs to load their filter elements against vibration, The description of the bacteria filter is per Mini-Spec No. 3098-MS-2400. Ion exchange resin in the second column is retained between perforated CRES sheets and pyrex wool to permit axial flow of the process water stream.

4.0 Materials: Internal: Corrosion resistant steel housing, retainers, spring and maintenance disconnects, pyrex wool pads for particle containment, Viton-A O-ring seals and silica based amberlite IR-120 and IR-45 resin, which is wetted with deionized water before packing and maintained wet throughout storage life by the sealed canister. External: 316&316L SS.

5.0 Performance:

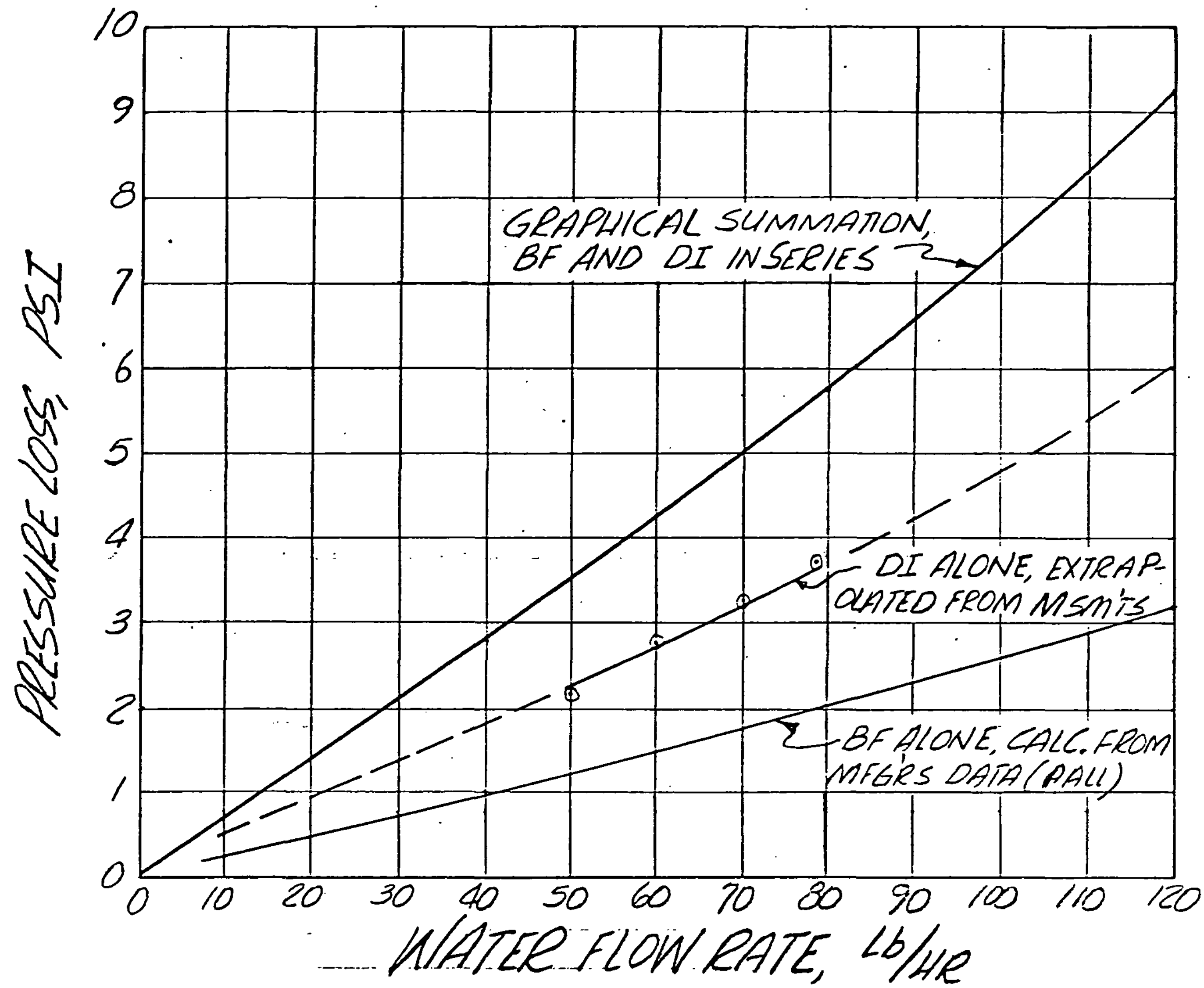
5.1 Fluid:	Clean renovated water (Distilled and sterilized)
5.2 Flow Rate:	120 lb/hr, Nominal
5.3 Pressures:	Inlet Pressure: 30 psig nominal, 28 to 32 psig, range.
	Proof Pressure: 48 psig
	Burst Pressure: 64 psig
	Operating Pressure Drop: See Graph, Section 9.0
5.4 Inlet Temperature:	70 - 90°F (228 to 232°F During autoclave cycle
5.5 Leakage:	External <1 cc/year
	Internal N/A
5.6 Weight:	Installed 10.94 lbs (est.)
	Expendable 8.04 lbs (est.)
	Spare 8.04 lbs (est.)
5.7 Interfaces:	Fluid: 1/2 inch tubing ports with maintenance disconnects
	Mechanical - Brackets
	Electrical - N/A

6.0 Environment:	Cabin ambient
7.0 MTBF:	TBD (Goal = 2×10^6 hrs)

ORIGINAL DATE OF DRAWING: Dec 6/71	CHEMTRIC, Inc. 9330 WILLIAM STREET • ROSEMONT, IL. 60018
DRAFTSMAN: A. Dembski / DATE	TITLE: COMPONENT MINI-SPEC — DEIONIZER (Component No. 533)
CHECKER: [signature] / DATE	
ENGINEER: [signature] / DATE	
APPROVED: [signature] / DATE: 1/8/72	
DESIGN ACTIVITY APPROVAL	CODE IDENT. NO.: 14958 — SIZE: X — DWG. NO.: 3098-MS-3300 — REV: F 12/14/72
OTHER APPROVAL	SCALE: ~ — WEIGHT: ~ — SHEET 1 of 2

8.0 Expendable Life: 30 days

9.0 Pressure Loss Data



ORIGINAL DATE OF DRAWING Dec 6/71	CHEMTRIC, Inc. 9330 WILLIAM STREET • ROSEMONT, IL. 60018		
DRAFTSMAN P.P. Nuccio DATE	TITLE		
CHECKER DATE	COMPONENT MINI-SPEC		
ENGINEER DATE	DEIONIZER		
APPROVED DATE	(Component No. 533)		
DESIGN ACTIVITY APPROVAL	CODE IDENT. NO. 14958	SIZE X	DWG. NO. 3098-MS-3300 — REV F 12/11/72
OTHER APPROVAL	SCALE ~	WEIGHT ~	SHEET 2 of 2

1.0 Scope: The Specification describes the design requirements of the distillation unit drive motor (Component No. 539).

2.0 Function: To start and maintain rotation of the distillation unit compressor and centrifuge; the centrifuge is driven through belts by one of the compressor shafts.

3.0 Description: This device is an induction motor. Identified by Manufacturer's P/N (IMC Magnetic Corp.) FBJ 2918 Modified per CHEMTRIC Drwg. 3098-C-3902.

4.0 Materials: Metallics (Aluminum Motor Hsg. and Coupling, Stainless Steel Shaft).

5.0 Performance:

5.1 Ambient Pressure:	14.5 to 16.2 PSIA
5.2 Ambient Temperature:	+60 to +100°F
5.3 Power Required:	150 Watts
5.4 Weight:	TBD
5.5 Interfaces:	Fluid: N/A Mechanical: Bolted Flange Electrical: 115/208 V, 3 Phase 400 Hz 5-wire Connector per MS 3112E10-6P *
5.6 Output Torque:	30 oz-in at 3400 RPM

6.0 Environment: Cabin Ambient

7.0 MTBE: TBD

*NOTE: Motor stator is an unbalanced 3-Ø WYE (Scot Tee) and must be run without neutral connected between controller and motor.

ORIGINAL DATE OF DRAWING May 5, 72	CHEMTRIC, Inc. 9330 WILLIAM STREET • ROSEMONT, IL 60018			
DRAFTSMAN P P Nuccio DATE	TITLE			
CHECKER DATE	COMPONENT MINI-SPEC			
ENGINEER P P Nuccio DATE	DRIVE MOTOR, DISTILLATION UNIT			
APPROVED P P Nuccio DATE	(Component No. 539)			
DESIGN ACTIVITY APPROVAL	CODE IDENT. NO. 14958	SIZE X	DWG. NO. 3098-MS-3900	REV. A 12/1/72
OTHER APPROVAL	SCALE —	WEIGHT —		SHEET 1 of 1

1.0 Scope: This specification describes the design requirements for the SSP WKMS Purge Pump (Component No. 544).

2.0 Function: To evacuate and maintain the vapor compression distillation unit (Component No. 591) at a low operating pressure by withdrawing non-condensible vapors from the condenser, pressurizing and discharging the mixture of water and gas into a urinal for reprocessing.

3.0 Description: A motor-driven reciprocating two-stage piston pump. The reciprocating mechanism consists of a two-stage cylinder (driving through stationary pistons), connecting rod, and eccentric drive. The eccentric drive is coupled through a shaft to a speed reducer driven by a 115 VAC 400 Hz motor.

4.0 Materials: Corrosion-resistant steel throughout with Teflon piston seals and Teflon insulated electrical wiring. Non-combustible, non-degrading epoxy adhesive and electrical potting.

5.0 Performance:

5.1 Fluid:	Distilled Water - 90% (by weight)	
	Non-condensible - 10%	
5.2 Flow Rate:	1.68 cu ft/min	
5.3 Pressures:	Operating:	
	Inlet Pressure - 0.2722 psia	
	Outlet Pressure - 17 psia	
	Proof:	26 psia
	Burst:	34 psia
5.4 Temperatures:	Inlet:	+80°F to + 100°F
5.5 Leakage:	External:	1 cc/yr
	Internal:	N/A
5.6 Weight:	Pump Only:	28.5 lbs
	Installed:	34.3 lbs
	Expendable:	31.4 lbs
	Spare:	31.4 lbs
5.7 Power Input:	300 watts, Peak	
	200 watts, Average	
5.8 Interfaces:	Fluid: 3/8 (outlet) and 1/2 (inlet) CPV	
	Mechanical: Mounting flanges	
	Electrical: 115 VAC, 400 Hz, 3 Phase	

6.0 Environment: Cabin Ambient

7.0 MTBF: TBD

8.0 Envelope: 5.65 in (dia) x 10.33 in x 15.75 in
(143.5 mm x 262.4 mm x 400.0 mm)

ORIGINAL DATE OF DRAWING: Jan 13/72	CHEMTRIC, Inc. 9330 WILLIAM STREET • ROSEMONT, IL. 60018
DRAFTSMAN: T. G. Studt DATE:	TITLE: COMPONENT MINI-SPEC PURGE PUMP (Component No. 544)
CHECKER: [signature] DATE: 1/17/72	
ENGINEER: TGS DATE:	
APPROVED: [signature] DATE: 1/17/72	
DESIGN ACTIVITY APPROVAL	CODE IDENT. NO. 14958 · SIZE · DWG. NO. 3098-MS-4400 · REV
OTHER APPROVAL	SCALE ~ · WEIGHT ~ · SHEET 1 of 1

1.0 Scope: This specification describes the design requirements for the SSP-WWMS Liquid Pump (Component No. 548).

2.0 Function: To meter pretreated urine and flush water into the vacuum distillation unit (Item 591). To pump concentrated waste from the vacuum distillation unit to the recycle tank (Item no. 562). To pump condensate from the distillation unit through the post treatment process to the fresh water storage tank. ([illegible]).

3.0 Description: Two magnetically coupled gear pumps are driven off of a doubled ended electric motor. A third magnetically coupled gear pump is driven from its own electric motor at approximately the same speed as the other two. The two pumps on the doubled ended electric motor are arranged to pump recycle and feed fluids while the remaining one pumps condensate. The three pump heads are identical units. They are sealed and driven through a ceramic magnetic coupling. The units have an internally adjustable by-pass for recirculation of excess pump flow. The output of the feed pump is plumbed to a constant flow valve and an in-line relief valve arranged in series.

4.0 Materials: Corrosion resistant steel throughout with glass filled Teflon pump gears and ceramic couplings.

5.0 Performance:

5.1 Fluid: Pretreat urine, flush water and distillation condensate

5.2 Flow Rate: Feed - 15 lb/hr
Recycle - 12.65 lb/hr nominal, (0 to 15 #/hr Range)
Condensate - 2.45 lb/hr nominal, (0 to 15 #/hr Range)

5.3 Pressure: Operating:

Inlet Pressure (psia)	Minimum	Nominal	Maximum
Feed	10.00	15.00	20.00
Recycle	0.44	0.60	0.70
Condensate	0.50	0.74	0.94
Outlet Pressure (psia)			
Feed	0.44	0.60	0.70
Recycle	10.00	15.00	20.00
Condensate	33.00	35.00	37.00

Proof (pump casing): 40 psig,
Burst (pump casing): 60 psig,
Collapsing: 15 psi applied externally

5.4 Temperatures: Inlet + 60°F to 100°F

ORIGINAL DATE OF DRAWING	Dec 10/71
DRAFTSMAN / DATE	T. G. Studt
CHECKER / DATE	P. P. Nuccio
ENGINEER / DATE	
APPROVED / DATE	P. P. Nuccio
DESIGN ACTIVITY APPROVAL	
OTHER APPROVAL	

CHEMTRIC, Inc.
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TITLE
COMPONENT MINI-SPEC
LIQUID PUMP (Component No. 548)

CODE IDENT. NO.	SIZE	DWG. NO.	REV
14958	X	3098-MS-4800	C 6/14/73
SCALE ~	WEIGHT ~	SHEET 1 Of 2	

5.5 Leakage: External: <1 cc/yr
Internal: NA

5.6 Weight:
Installed: < 48 lb
Expendable: < 48 lb
Spare: < 48 lb

5.7 Power Input: 120 watts, avg.
460 watts, peak

5.8 Interfaces: Component side MDV
Mechanical - Brackets
Electrical - 115 VAC - 400 cps 3 phase

6.0 Environment: Cabin Ambient

7.0 MTBF: TBD

8.0 Envelope: 19.99 in x 12.50 in x 6.00 in
(507.7 mm x 317.5 mm x 152.4 mm)

9.0 Duty Cycle: 100%, Design value; 0 to 100% range

ORIGINAL DATE OF DRAWING: Dec 10/71	CHEMTRIC, Inc. 9330 WILLIAM STREET • ROSEMONT, IL. 60018				
DRAFTSMAN: T. G. Studt / DATE	TITLE: COMPONENT MINI-SPEC / LIQUID PUMP (Component No. 548)				
CHECKER: P. P. Nuccio / DATE					
ENGINEER / DATE					
APPROVED: P. P. Nuccio / DATE					
DESIGN ACTIVITY APPROVAL	CODE IDENT. NO. 14958	SIZE X	DWG. NO. 3098-MS-4800		REV C 6/14/73
OTHER APPROVAL	SCALE ~	WEIGHT ~		SHEET 2 of 2	

.0 Scope: This specification describes the design requirements for the SSP WWMS Waste Storage Tank (Component No. 561). The quantity sensor (Component No. 576), which is integrated into the tank design, is described by Mini-Spec No. 3098-MS-7600.

) Function: To receive, contain and expell waste liquids. An electrical signal proportional to the quantity of liquid present in the tanks is provided by Comp. 576.

.0 Description: The tank is cylindrical with elliptical ends in which a piston moves axially to accommodate the quantity of waste solution present. The piston is contoured to match the elliptical end and is sealed to the tank by a rolling diaphragm. The back-side of the piston is pressurized by N2 to 5 psig. The position of the piston is translated to the position of a potentiometer driven by a cable/reel mechanism attached to the piston; quantity measurement therefore is made by measuring the electrical resistance through the potentiometer. Replacement via Maintenance Disconnects and electrical connector.

.0 Materials: Corrosion resistant steel, polypropylene, Teflon and viton-A elastomers.

.0 Performance:

5.1 Fluid:	Waste waters containing body, clothes and utensil impurities; fecal flush water containing pretreatment solution and silver ions; urine and urinal flush water.
5.2 Capacity:	1100 cubic inches (18.02 liters) or 40 # Liquid Nominal.
5.3 Expulsion Efficiency:	98% minimum (trapped volume 22 in^3 (0.36 liters) maximum)
5.4 Pressures:	Operating, 5 psig nominal; 13.5 psig maximum; proof, 21 psig Burst, 27 psig. (Diaphram ΔP = 0.2 psid
5.5 Temperatures:	+60 to +160°F, normal operating +228°F autoclave nominal +232°F autoclave maximum
5.6 Leakage:	External, <1 cc/year(see Permeation, Sect. 9.0) Internal, <1 cc/year
5.7 Weight:	Installed: 26.5 lb empty, 65.7 full (25.7 dry) Expendable: 26.5 lb Spare: 25.7 lb

ORIGINAL DATE OF DRAWING Nov/18 71	CHEMTRIC, Inc. 9330 WILLIAM STREET • ROSEMONT, IL 60018		
DRAFTSMAN P.P. Nuccio DATE	TITLE		
CHECKER PPNuccio DATE	COMPONENT MINI-SPEC		
ENGINEER PPNuccio DATE	WASTE TANK		
APPROVED PPNuccio DATE	(Component 561)		
DESIGN ACTIVITY APPROVAL	CODE IDENT. NO. 14958	SIZE X	DWG. NO. 3098-MS-6100 — REV E 11 22 72
OTHER APPROVAL	SCALE ~	WEIGHT ~	SHEET 1 of 2

5.8 Interfaces: Fluid, 1/2" tubing diameter inlet and outlet with MDVs; Gas Port 1/2" tubing Dia with CPV ftg
Mechanical, Brackets
Electrical connector per STSV 204 (to Comp 576)

6.0 Environment: Cabin Ambient

7.0 MTBF: TBD (Goal = 0.21×10^6 hrs).

8.0 Composition of Pretreatment Solution: (By Weight)

Iodophor	-	27%
H_2SO_4	-	15
Antifoam	-	6
H_2O	-	52
		100%

9.0 Permeation Through Diaphram:

Waste Tank: 30.8 cc/month

ORIGINAL DATE OF DRAWING Nov/18 71	CHEMTRIC, Inc. 9330 WILLIAM STREET • ROSEMONT, IL. 60018			
DRAFTSMAN P. P. Nuccio DATE	TITLE COMPONENT MINI-SPEC WASTE TANK (Component 561)			
CHECKER PPNuccio DATE				
ENGINEER PPNuccio DATE				
APPROVED PPNuccio DATE				
DESIGN ACTIVITY APPROVAL	CODE IDENT. NO. 14958	SIZE	DWG. NO. 3098-MS-6100	REV E 11/22/72
OTHER APPROVAL	SCALE —	WEIGHT —		SHEET 2 of 2

1.0 Scope: This Specification describes the design requirements for the SSP WWMS Recycle/Filter Tank (Component #562).

2.0 Function: To contain recycled liquor delivered by the distillation unit (591) and original waste liquid delivered by the waste tank (561); to mix those streams passively and send the filtered mixture to the distillation unit for processing. Filtration shall be down to 25 microns nominally.

3.0 Description: A welded cylindrical tank with spherical ends, and containing a built-in solids filter. Periodic replacement is facilitated by maintenance disconnects at the inlet and outlet ports. Quantity measurement not required because tank is maintained full at all times.

4.0 Materials: Corrosion resistant steel. Filter material is polypropylene fiber.

5.0 Performance:

5.1 Fluid:	Liquid consisting of concentrated waste (urine, wash water and fecal flush water), pretreatment solution and silver-dosed water. Initially, before installation into the recycle loop, the tank assembly contains only silver-dosed water.
5.2 Flow Rate:	15 #/hr, Nominal; 0-20 #/hr, Range
5.3 Pressures:	Operating: 5 psig Nominal, 6 psig Max. Proof: 30 psig Burst: 40 psig Drop Across Tank: 0.1 to 0.5 psid (Measured Range)
5.4 Temperature:	60 to 80°F Operating Range
5.5 Leakage:	External: <1 cc/year Internal: N/A
5.6 Weight:	Installed: 54.9# (9.8 # dry) Expendable: 63.8# (at 50% solids) Spare: 54.9#
5.7 Interfaces:	Fluid: 1/2" Dia tubing with maintenance disconnects Mechanical: Brackets Electrical: N/A

6.0 Environment: Cabin Ambient

7.0 MTBF: TBD (Goal = 3.3×10^6 hrs)

8.0 Expendable Life: 30 Days (Urine Loop); TBD (Wash Loop)

ORIGINAL DATE OF DRAWING	Nov 11/71
DRAFTSMAN: P. P. Nuccio	DATE
CHECKER: P Nuccio	DATE
ENGINEER: P Nuccio	DATE 1/5/72
APPROVED: P Nuccio	DATE 1/5/72
DESIGN ACTIVITY APPROVAL	
OTHER APPROVAL	

CHEMTRIC, Inc.
9330 WILLIAM STREET • ROSEMONT, IL. 60018

TITLE
COMPONENT MINI-SPEC
RECYCLE/FILTER TANK (Comp. No. 562)

CODE IDENT. NO.	SIZE	DWG. NO.	REV
14958	X	3098-MS-6200	C 7-7-72
SCALE ~	WEIGHT ~	SHEET 1 of 1	

1.0 Scope: This specification describes the design requirements for the SSP-WWMS VCD high-level switch (Component No. 571).

2.0 Function: The switch senses high-liquid level in the evaporator of the VCD and closes a circuit in the VCD controller. The controller interupts the flow of waste water to the VCD until the high-level condition subsides.

3.0 Description: The differential pressure switch is pneumatically connected between the VCD evaporator and an impact tube located in the evaporator approximately one centimeter closer to the VCD centerline than the recycle impact tube. During normal operation the recycle circuit has sufficient capacity to maintain evaporator liquid contents at the level established by the evaporator geometry. During upset conditions, however, (caused by either an increased feed rate or a decreased recycle rate) the liquid level in the rotating evaporator might rise. When it rises one centimeter the rotating liquid will apply its velocity pressure to the second impact tube and be sensed by the switch. The switch closes at differential pressures of 0.3 to 0.5 inches of water; velocity pressure of the rotating liquid is 7 inches of water higher than evaporator static pressure. Burst pressure difference across the switch is 8 psi (222 inches of water). The component assembly consists of a vacuum chamber containing the switch and open to the VCD evaporator. One side of the switch is connected to a port open to the second impact tube, the other is left open within the chamber to sense evaporator pressure. The chamber assembly is mounted to a probe-type MDV for convenient maintenance.

4.0 Materials: Molded polycarbonate body, brass eyelets and terminals, 316 stainless steel chamber, Viton-A O'ring seals, surgical grade silicone rubber tubing.

5.0 Performance:

5.1 Fluid:	Water vapor on both sides of switch	
5.2 Differential Pressures:	(Across switch) -	
	Applied at Hi-Level:	7 in H_2O Max.
	Actuation:	0.4 ± 0.1 in. H_2O
	Deactuation:	0.3 in. H_2O (Measured)
	Burst:	8 psi (222 in. H_2O)
5.3 Absolute Pressures:	Evaporator:	0.25 to 15 psia range
	Proof:	(housing & adapter) 15 psig
	Burst:	(housing & adapter) 30 psig
	Buckling:	15 psi, applied externally

ORIGINAL DATE OF DRAWING	March 10/72
DRAFTSMAN	P. P. Nuccio /
CHECKER	P.P. Nuccio
ENGINEER	
APPROVED	P.P. Nuccio
DESIGN ACTIVITY APPROVAL	
OTHER APPROVAL	

CHEMTRIC, Inc.
9330 WILLIAM STREET • ROSEMONT, IL. 60018

TITLE

COMPONENT MINI-SPEC

Liquid Level Switch (Component No. 571)

CODE IDENT. NO.	SIZE	DWG. NO.	REV
14958	X	3098-MS-7100	B 5/15/72

SCALE ~ WEIGHT ~

5.4 Temperatures: Operating: +60 to +100°F

5.5 Leakage;
- Internal; <1 cc/year
- External: <1 cc/year (housing and adapter only)

5.6 Weight:
- Installed: 2 lb. (estimate)
- Spare: 2 lb. (estimate)

5.7 Interfaces:
- Fluid: MDV-Probe
- Mechanical: MDV-Probe
- Electrical: Connector STSV204-E-14 P4-(x)-2

6.0 Environment: Assembled component, Cabin ambient; differential pressure switch, VCD evaporator

7.0 MTBF: TBD

8.0 Expendable Life: Indefinite (Rated at 1×10^6 operations)

9.0 Electrical Characteristcis:
- Current Rating: 10 Ma Resistive, DC
- Operating Voltage: 30 V AC/DC Maximum or 120 AC Neon Lamp Load

ORIGINAL DATE OF DRAWING March 10/72	CHEMTRIC, Inc. 9330 WILLIAM STREET • ROSEMONT, IL. 60018
DRAFTSMAN P. P. Nuccio / DATE	TITLE
CHECKER P.P. Nuccio DATE	COMPONENT MINI-SPEC
ENGINEER DATE	Liquid Level Switch (Component No. 571)
APPROVED P.P. Nuccio DATE	
DESIGN ACTIVITY APPROVAL	CODE IDENT. NO. 14958 · SIZE X · DWG. NO. 3098-MS-7100 · REV B 5/15/72
OTHER APPROVAL	SCALE ~ · WEIGHT ~ · SHEET 2 of 2

1.0 Scope: This specification describes the design requirements for the SSP Waste Tank Quantity Sensor (Component No. 576).

2.0 Function: This instrument measures the location of a piston, which is effectively a bladder, in the Liquid tank, and generates a signal proportional to that position. The signal is in the form of electrical resistance. This component performs a secondary function; it applies a mechanical force to the piston which pulls the piston to a fail-safe position in the event of a bladder puncture or rupture.

3.0 Description: The sensor consists of two spring/cable reels, which are connected to potentiometers. The entire assembly is mounted by a bracket which is located within the liquid tank on the gas side. As the quantity of Liquid on the liquid side of the piston changes the piston moves and either pulls the cables or permits the reels to take-up the cables. As the reel position changes the resistance across the potentiometers changes. two spring/cable reels are applied, rather than only one to maintain a high "return" force on the piston in the event that one spring/cable reel fails. The reel assemblies are purchased from Hunter Spring, Lansdale, Pa; Their Model ML 1912, rated at 10 to 16 lbs force and 100,000 cycles of operation. The potentiometers are purchased from Spectrol, Inc.; their model No. 830-500. They are three-turn pots rated at 3-watts at 40°C with linearity ± 0.25% over the temperature range -55°C to 105°C. Full scale resistance is 500 ohms. The sensor assembly is mounted to the tank nest with Three STSV 209-23 captive fasteners.

4.0 Materials: 303/304 and 316 Stainless Steel and non-metallics within the pot which are Sealed from The environment by a Viton o-ring applied By Spectrol.

5.0 Performance:

5.1 Fluid:	N/A
5.2 Flow Rate:	N/A
5.3 Pressures:	Normal Operating, 31 psig MAX (LHTL)
5.4 Temperatures:	+60 to + 160°F
5.5 Leakage:	N/A
5.6 Weight:	2 lb est.
5.7 Power Req'd:	+ 15 VDC, 1.15 Ma Maximum
5.8 Interfaces:	Fluid: N/A Mechanical: Bracket, Captive Fasteners and Cable Clips (3) Electrical: Connector per STSV 204

6.0 Environment: Operational; nitrogen, gaseous, at 30 psig, nominal, 31 psig maximum. Spare Storage; Cabin Ambient. (LHTL Pressures, Applications, Lower Pre...

ORIGINAL DATE OF DRAWING May 27,72	CHEMTRIC, Inc. 9330 WILLIAM STREET • ROSEMONT, IL. 60018			
DRAFTSMAN P. P. Nuccio DATE	TITLE COMPONENT MINI-SPEC QUANTITY SENSOR-WASTE TANK (Component No. 576)			
CHECKER [signature] DATE				
ENGINEER [signature] DATE				
APPROVED [signature] DATE				
DESIGN ACTIVITY APPROVAL	CODE IDENT. NO. 14958	SIZE X	DWG. NO. 3098-MS-7600 >STO	REV B 11/22/72
OTHER APPROVAL	SCALE —	WEIGHT —		SHEET 1 of 2

7.0 MTBF: TBD

8.0 Expendable Life: Indefinite (100,000 cycles rated; at 42 micturations per SSP day, rated life is 2381 days or 6-1/2 years).

ORIGINAL DATE OF DRAWING May 27, 72	CHEMTRIC, Inc. 9330 WILLIAM STREET • ROSEMONT, IL. 60018
DRAFTSMAN DATE P. P. Nuccio	TITLE COMPONENT MINI-SPEC QUANTITY SENSOR-WASTE TANK (Component No. 576)
CHECKER DATE	
ENGINEER DATE	
APPROVED DATE	
ESIGN ACTIVITY APPROVAL	CODE IDENT. NO. 14958 / SIZE X / DWG. NO. 3098-MS-7600 / REV B 11/22/72
OTHER APPROVAL	
	SCALE — / WEIGHT — / SHEET 2 of 2

1.0 Scope: This specification describes the design requirements for the SSP WWMS Vapor Compression Vacuum Distillation Unit (Component No. 591).

2.0 Function: To distill water from concentrated urine, humidity condensate, fecal flush water, and wash water brine. The attached curves indicate the performance characteristics of the unit as a function of cabin temperature and concentration of dissolved solids in the feed liquid.

3.0 Description: The unit consists of a rotating condenser and evaporator shell enclosed in a stationary outer shell. The 3400 RPM drive motor (Comp 539) is magnetically coupled to the rotary-lobe compressor. The evaporator and condenser assembly is driven at 260 to 290 RPM by a speed reducer (belts and pulleys) coupled to the compressor drive motor. Waste water fed into the still is distributed over the rotating evaporator, and concentrated by distillation. The concentrated liquid and condensate are collected in annular sumps and transferred out of the unit by pick-up tubes mounted on the stationary central shaft.

4.0 Materials: Corrosion-resistant steel, Neoprene rubber and Viton-A.

5.0 Performance:

5.1 Fluid:	Input - Waste water; Output - Distilled water	
5.2 Pressures:	Nominal Operating:	0.7 psia (0.4 to 0.9 range)
	Proof:	22 psig
	Burst:	30 psig
	Collapsing:	15 psi applied externally
	Compressor Pressure Rise:	0.12 psi Nominally (0.31 psi Maximum)
5.3 Temperatures:	Operating:	+60 to +100°F
5.4 Leakage:	External:	<1 cc/year
	Internal:	N/A
5.5 Power Required:	N/A	(115 VAC, 400 HZ, Three Phase - to comp 539)
5.6 Weight:	Installed:	134 lb
	Spare:	142.7 lb
5.7 Interfaces:	Fluid:	See Dwg. No. 3098-R-9100
	Mechanical:	Brackets
	Electrical:	MS Connectors (2)

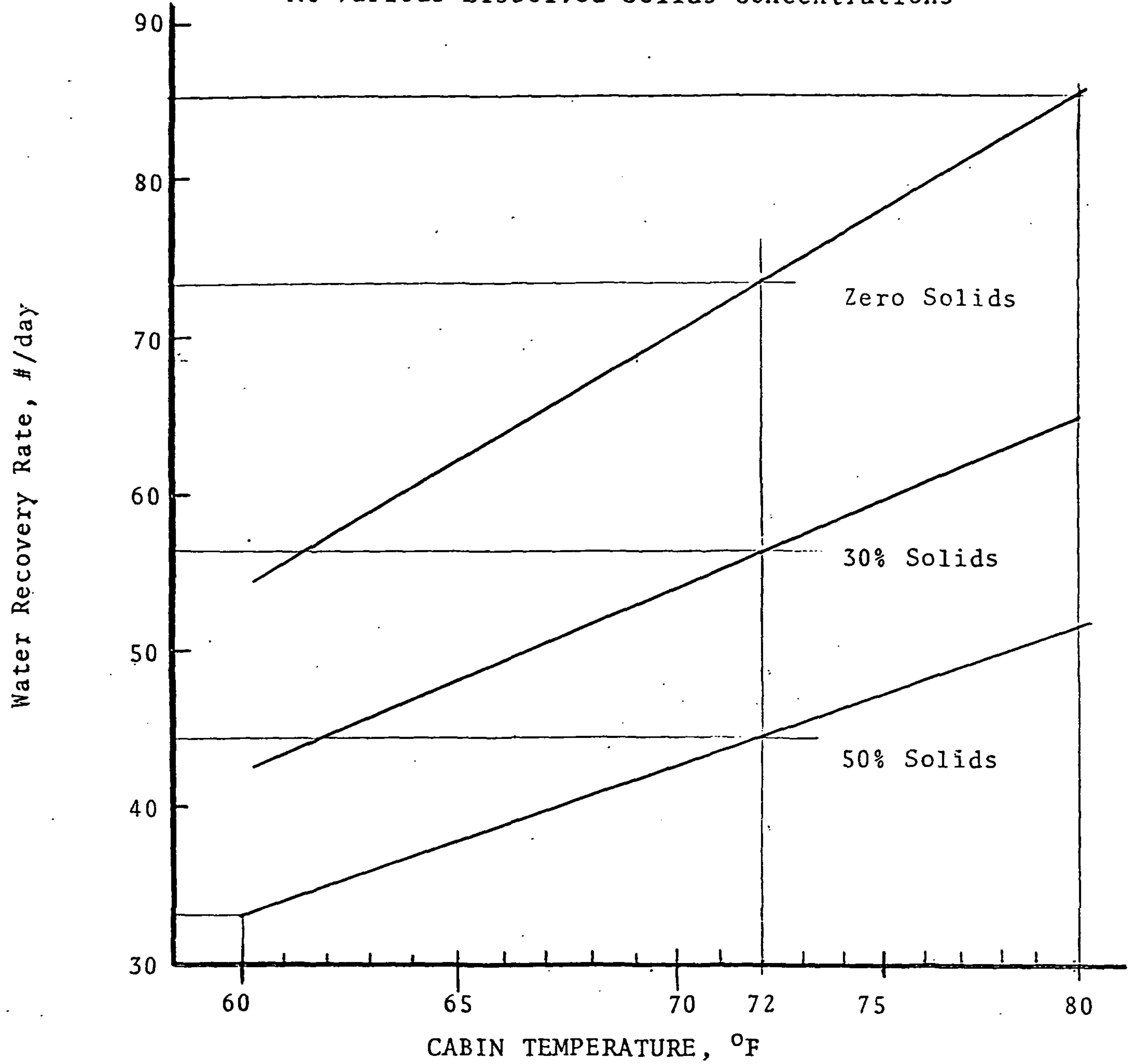
6.0 Environment: Cabin Ambient

7.0 MTBF: TBD (Goal = 0.05×10^6 hours)

8.0 Performance Curves: See Attached Graph

ORIGINAL DATE OF DRAWING: Nov 29/71	CHEMTRIC, Inc. 9330 WILLIAM STREET • ROSEMONT, IL. 60018				
DRAFTSMAN: P. P. Nuccio — DATE	TITLE: COMPONENT MINI-SPEC VAPOR-COMPRESSION VACUUM-DISTILLATION UNIT (Component No. 591)				
CHECKER: P P Nuccio — DATE					
ENGINEER: VP Nuccio — DATE					
APPROVED: P. Nuccio — DATE					
DESIGN ACTIVITY APPROVAL	CODE IDENT. NO. 14958	SIZE	DWG. NO. 3098-MS-9100		REV B 11/21/72
OTHER APPROVAL	SCALE ~	WEIGHT ~		SHEET 1 of 2	

Recovery Rate of Vapor-Compression Vacuum-Distillation Unit (Component No. 591) Vs. Cabin Temperature At Various Dissolved Solids Concentrations



ORIGINAL DATE OF DRAWING Nov 29, 71	**CHEMTRIC, Inc.** 9330 WILLIAM STREET • ROSEMONT, IL. 60018	
DRAFTSMAN P Nuccio DATE	TITLE	
CHECKER P Nuccio DATE	COMPONENT MINI-SPEC	
ENGINEER P Nuccio DATE	VAPOR-COMPRESSION VACUUM-DISTILLATION UNIT	
APPROVED P Nuccio DATE	(Component No. 591)	
DESIGN ACTIVITY APPROVAL	CODE IDENT. NO. 14958	SIZE X / DWG. NO. 3098-MS-9100 / REV B 11/21/72
OTHER APPROVAL	SCALE ~	WEIGHT ~ / SHEET 2 of 2

.0 Scope: This specification describes the design requirements for the SSP-WMS Silver Ion Sterilizer (Component No. 597).

.0 Function: To dose filtered condensate or permeate with 1.0-2.0 ppm silver ions to maintain sterility. Condensate originates in the VCD; R.H. heat exchanger, and Sabatier reactor; permeate in the RO cell.

.0 Description: Stainless steel housing containing a mixture of AgCl and glass beads retained by spring loaded inlet and outlet screens. Flow is single pass, axial. Replacement is via maintenance disconnects at the inlet and outlet ports.

.0 Materials: Corrosion resistant steel (type 316), silver chloride, glass beads, Viton-A seal and pyrex wool pads.

.0 Performance:

5.1 Fluid:	Condensate and/or Permeate
5.2 Flow Rate:	Permeate - 25.0 lb/hr, nominal; 27.5 lb/hr, maximum. Condensate - 60 lb/hr
5.3 Pressures:	Inlet, 30 psig, nominal, 28 - 32 psig, range Proof, 48 psig Burst, 64 psig Operating pressure drop, 1.7 psid at 60 lb/hr
5.4 Temperature:	60 to 100°F, operating 228 to 232°F during autoclave cycle.
5.5 Leakage:	External < 1cc/year Internal N/A
5.6 Weight:	Installed 8.72 lbs Spare 5.82 lbs
5.7 Interfaces:	Fluid - 1/2" diameter MDVs Mechanical - Brackets Electrical - N/A

6.0 Environment: Cabin ambient

7.0 MTBF: TBD (Goal = 5 x 10^6 hrs)

8.0 Expendable Life: 180 Days

9.0 Preparation Procedure, REF Only: Mixture comprised of 44.4% by wt. AgCl (Fischer Scientific Co. Catalog No. S-174) and 55.5% glass beads (Sargent Welch Catalog No. S-61760-30, 0.45 to 0.50 mm dia.). Size AgCl to pass between 6 mesh and 45 mesh sieves. Combine ingredients & moisten with deionized water to prevent density stratification. Pack mixture into previously-cleaned canister. Maintain dampness throughout storage and use periods.

ORIGINAL DATE OF DRAWING	Dec 13/71
DRAFTSMAN: P. P. Nuccio	DATE
CHECKER: P. Nuccio	DATE: 1/11/72
ENGINEER: P. Nuccio	DATE: 1/11/72
APPROVED: [illegible]	DATE: 1/11/72
DESIGN ACTIVITY APPROVAL	
OTHER APPROVAL	

CHEMTRIC, Inc.
9330 WILLIAM STREET • ROSEMONT, IL. 60018

TITLE: COMPONENT MINI-SPEC
SILVER-ION STERILIZER (Component No. 597)

CODE IDENT. NO.	SIZE	DWG. NO.	REV
14958	X	3098-MS-9700	D 12/1/72

SCALE	WEIGHT	SHEET
~	~	1 of 1

ASSEMBLY PROCEDURES

This section is comprised of the documents written to control the methods, tools and procedures to be followed and the measurements to be made during assembly of those SSP components for which that control is necessary. An assembly log is included with each procedure document in which is entered a completion confirmation or parametric measurement for each step in the prescribed procedure. Assembly procedures are included for the following components:

Component Name & Number	Document No.
Activated Charcoal Filter, 525	3098-AS-2500
Deionizer, 533	3098-AS-3300
Liquid Waste Tank, 561	3098-AS-6100
Distillation Unit, 591	3098-AS-9100
Silver-Ion Sterilizer, 597	3098-AS-9700

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ORIGINAL DATE April 23, 1973

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DESIGN ACTIVITY APPROVAL

OTHER APPROVAL

CHEMTRIC, Inc.

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TITLE

Assembly Procedure

ACTIVATED CHARCOAL FILTER
(SSP Component No. 525)

CODE IDENT. NO.	ASSY SPEC. NO.	REV
14958	3098-AS-2500	A

REF. ASSY. DWG: 3098-R -2500 | SHEET 1 of 9

1.0 Scope: This procedure document describes the assembly of an activated charcoal/bacteria filter assembly which is designated SSP Component No. 525. The assembly is shown by Drawing No. 3098-R-2500.

2.0 Parts List: This assembly is comprised of the subassemblies and parts shown on P/L No. 3098-PL-2500.

3.0 Tools & Instruments: Only normal and customary tools are required for the assembly. Preparation of the packing, activated charcoals, and the assembly and check out of the assembly requires a 6 mesh (Tyler) screen, a 45 mesh (Tyler)screen, chromic acid, hydrochloric acid, glass beakers, a polyethyelene pipette washing jar (flotation tower), a deionized water source, turbidimeter, an atomic absorption spectrophotometer, a pH meter, a conductivity meter, an autoclave, and a temperature controlled water bath.

4.0 Procedure:

4.1 Packing Preparation (item no. 11)
Packing preparation consists of (1) classifying silver chloride granules, (2) cleansing glass beads, and (3) mixing the silver chloride granules and glass beads in the ratio 1.25 parts glass beads to 1 part silver chloride.

4.1.1 Classify reagent grade "as-received" silver chloride granules in between 6 and 45 mesh (Tyler) screens under subdued lighting. Material that passes through the 45 mesh screen is rejected. Material that is retained by the 6 mesh screen may be reduced in size by "hammering" with a pestile or by "cutting-up" the lumps with a knife or razor.

4.1.2 Prepare glass beads, 0.42 to 0.59 mm diameter.

4.1.2.1 Wash "as-received" glass beads in an aqueous solution of detergent (Alconox or equivalent).

4.1.2.2 Decant the detergent solution and rinse the glass beads with hot tap water several times (about 5).

4.1.2.3 Wash the glass beads in concentrated chromic acid. Heat the chromic acid and glass beads to boiling and allow the mixture to simmer for one hour.

4.1.2.4 Allow the chromic acid and glass beads to cool. Decant the chromic acid and wash the glass beads repeatedly with deionized water, until the washings indicate no presence of chromic acid.

4.1.2.5 Dry the glass beads in an oven at 218^{o}F (103^{o}C) for 12 hours.

4.1.2.6 Allow the glass beads to cool to room temperature.

4.1.3 Blend the classified silver chloride granules and the prepared glass beads by weight in the ratio of 1.25 parts glass beads to one part silver chloride under subdued lighting. After weighing-out the proportions, add the glass beads and silver chloride granules to a common container (preferably glass) along with a volume of water just equal to the volume of the silver chloride and the glass beads. Stir the mixture manually with a spatula and distribute the glass beads and silver chloride particles uniformly. Approximately 12.1 in^3 (199 cm^3) of packing are required to fill the annular space in the biological filter canister. Prepare an additional 10 - 20% extra for contingencies, i.e., approximately 240 cm^3.

4.2 Charcoal Preparation (item no. 17)

Charcoal preparation consists of (1) treatment with dilute hydrochloric acid, (2) boiling deionized water extractions, (3) washing in deionized water, and (4) steam sterilization. Weigh-out 6 lbs of "as-received" Barnaby Cheney type 365 activated charcoal and treat as follows.

4.2.1 Place a pound of charcoal in a 4 l beaker and add deionized water equal to 5 times the charcoal volume. Stir the mixture and slowly add 25 ml of concentrated HCl per pound of charcoal. Addition of the acid results in the evolution of hydrogen sulfide which gradually diminishes with time. The gas is readily identified by its characteristic "rotten-egg" odor; perform the acid treatment in a well ventilated area. Decant-off the acid and wash the charcoal 5 times with deionized water, by adding deionized water equal to 5 times the charcoal volume, stirring, allowing the charcoal to settle, and decanting-off the supernatant liquid.

4.2.2 Perform five (5) extractions on the charcoal in boiling deionized water. Add deionized water equal to 5 times the charcoal volume to the acid treated charcoal. Boil the mixture vigorously for 5 minutes while constantly stirring the charcoal. Remove the beaker from the heat source, and allow the charcoal to settle. Decant the supernatant liquid and repeat the extraction process at least five times.

4.2.3 Wash the charcoal in a flotation tower to remove the fines. A standard polyethylene pipette washing jar which has a 6-inch diameter, and a height of 31 inches is used. The media (charcoal) is retained by 10 and 100 mesh screens mounted approximately three inches from the bottom. Washing water is introduced through the side by means of a 3/8-inch bulk-head tube fitting located approximately one inch from the bottom. Water flow rates of 1 - 2 gpm expand the charcoal to approximately 6 times the settled or compacted volume, and provide vigorous mixing with the incoming water. The fines in the charcoal are removed by flotation with the overflow wash.

About 3 pounds of acid treated and boiling deionized water extracted charcoal are backwashed per batch. Initially the charcoal is washed with 130 - 160°F tap water for 20 to 30 minutes at 1 - 2 gpm. The water is turned off and the water within the tower is allowed to drain back through the charcoal and out through the water inlet. The last 500 ml of the drainings are measured for pH and specific resistance. Wash with the tap water is continued until the drainings match the inlet washing tap water with respect to pH and specific resistance.

Repeat the backwashing with deionized water of at least one megaohm purity. Repeat until the charcoal draining match the inlet deionized water with respect to pH and specific resistance.

4.2.4 Steam sterilize the charcoal at 115°C (250°F), approximately 45 minutes per pound of charcoal.

4.2.5 Store the treated and sterile activated charcoal in sterile containers until assembly.

4.3 Prepare two Pyrex wools (item no. 10) for the activated charcoal canister.

4.3.1 Soak a roll of Pyrex wool in deionized water.

4.3.2 Wet down a working surface with deionized water, unroll, and fold over the wet Pyrex wool into a pile one-half inch thick

4.3.3 Sandwich the one-half inch thick wet Pyrex wool pile between two 316 stainless steel retaining screens (item no. 18).

4.3.4 Trim the Pyrex wool pile with a pair of scissors around the periphery of the screens, about one-sixteenth of an inch larger in radius than the retaining screens.

4.4 Prepare the lower Pyrex wool (item no. 10) for the biological filter canister, using the retaining screen (item no. 14) and the filter cartridge (item no. 15) to facilitate the preforming.

4.4.1 Soak a roll of Pyrex wool in deionized water.

4.4.2 Unroll and fold over the wet Pyrex wool over the retaining screen and the biological filter cartridge into a pile about one-half inch thick.

4.4.3 Trim the Pyrex wool pile with a pair of scissors conically, into a shape approximating the contour of the biological filter canister.

4.5 Prepare the upper Pyrex wool (item no. 10) for the biological filter canister.

4.5.1 Make two annular ring patterns from 1/16-inch thick aluminum sheet metal, 2-3/4 inches outside diameter and 2 inches inside diameter, to facilitate preforming the Pyrex wool.

4.5.2 Soak a roll of Pyrex wool in deionized water.

4.5.3 Wet down a working surface with deionized water, unroll, and fold over the wet Pyrex wool into a pile one-half inch thick

4.5.4 Sandwich the one-half inch thick wet Pyrex wool pile between the two patterns.

4.5.5 Trim the Pyrex wool pile with a pair of scissor around the periphery of the annular rings.

4.6 Biological Filter Cartridge Preparation (item no. 15)

4.6.1 Perform multiple extractions on the "as-received" filter cartridge to remove water-soluble manufacturing residues. Place the cartridge in a metal pan with 2 to 3 liters of deionized water and heat to boiling. Remove the pan from the heat source, drain off the water and air cool the cartridge. Repeat the extraction at least three times or until no visible color is detectable in the hot water.

4.6.2 Install the filter cartridge in Pall Trinity Corporation's commercial housing, connect to a deionized water source and flush at 0.25 to 0.5 gpm for 30 minutes. Shut-off the deionized water flow after 30 minutes and allow the unit to remain idle for 30 minutes. Drain-off the water in the housing and determine the drained water's pH and specific resistance. Repeat the flushing process until the pH and specific resistance of the drainings are in close agreement with the values obtained for the deionized water used in the flushing.

4.6.3 Remove the filter cartridge from the commercial housing, and steam sterilize the cartridge in an autoclave at 115°C for 15 minutes.

4.7 Assemble the Biological Filter Canister

4.7.1 Insert the O-ring spring (item 12). Place the O-ring over the hub within the biological filter canister body.

4.7.2 Insert the spacer (item 13). Place the spacer over the hub within the biological filter canister body.

4.7.3 Insert the preformed lower Pyrex wool for the biological filter canister; see 4.4. Adjust the fit of the Pyrex wool pile by adding more Pyrex wool or by trimming away the excess Pyrex wool.

4.7.4 Place the retaining screen (item 14) over the previously prepared biological filter cartridge (see 4.6) outlet.

4.7.5 Insert the biological filter cartridge and retaining screen subassembly (see 4.7.4). Put the filter cartridge outlet over the hub within the biological filter canister body and manipulate the cartridge down until it rests against the washer. Check to be sure that an O-ring is supplied with filter cartridge and that the O-ring is properly positioned in the O-ring groove on the filter cartridge outlet.

4.7.6 Load the annular space between the filter cartridge and biological canister body, under subdued lighting, with the previously prepared packing; see 4.1. Add the packing mixture in 50 to 100 ml increments while tapping the outlet against a hard surface and tapping the canister body with a stick. When the packing is near completion, gently ram the mixture with a rubber stopper (smaller in diameter than the annulus) fixed to a rod. Do not use any water in loading the canister; if the canister contains water, the silver chloride particles and glass beads will settle to the bottom at different rates and produce stratification. Record the volume of packing used to fill the annular space on the assembly log.

4.7.7 Place the preformed upper Pyrex wool on top of the packing; see 4.5. Insert additional Pyrex wool to cover areas around the pleats of the filter cartridge.

4.7.8 Insert the O-ring (item no. 9) into the O-ring groove on the flange of the biological filter canister body.

4.7.9 Compress the upper Pyrex wool (item no. 10) with the biological filter canister cover weldment (item no. 16), align and hold it in compression in the position shown, insert the six socket head cap screws (item no. 8), put-on the six washers (item no. 6) on the cap screws, screw-on the six self-locking nuts (item no. 5) and tighten to 19 $\pm$ 2 in-lb torque. Record the torques on the assembly log.

4.7.10 Connect the outlet of the biological filter canister to a deionized water source to backwash the "fines" out of the packing. The inlet pressure during backwashing should not exceed 3 psig. Analyze the effluent for silver content and turbidity, to check that the canister is saturating the deionized water with silver ions, and that the "fines" produced during the loading are backwashed-out. Continue backwashing until the effluent contains no "fines" and the Ag^+ content is 1.0 - 1.3 ppm. Record final backwashing turbidity and Ag^+content on the assembly log.

4.7.11 Disconnect the deionized water source from the outlet and reconnect it to the inlet of the biological filter canister. Shut-off the outlet and check for leaks at 30 psi. Should any leaks be found, they must be corrected. If the leak check test has been passed, record that fact on the assembly log. Depressurize, remove the water connections, and drain the subassembly.

4.8 Assemble the Activated Charcoal Canister

4.8.1 Prepare the lower Pyrex wool activated charcoal support subassembly by sandwiching a preformed Pyrex wool (see 4.3) between four retaining screens (item no. 18), two screens on each face of the Pyrex wool disc.

4.8.2 Insert the lower preformed Pyrex wool resin support subassembly (see 4.8.1) into the bottom of the activated charcoal canister body.

4.8.3 Load the activated charcoal canister body with the previously prepared activated charcoal; see 4.2. Add the activated charcoal in 50 to 100 ml increments while tapping the outlet against a hard surface and tapping the canister body with a rubber mallet. When the packing is near completion, gently ram the activated charcoal down with a rubber stopper.(smaller in diameter than the canister) fixed to a rod. Record the volume of activated charcoal used to fill the canister body on the assembly log.

4.8.4 Prepare the upper Pyrex wool resin support subassembly by sandwiching a preformed Pyrex wool (see 4.3) between two upper retaining screens (item no.19) and two lower retaining screens (item no.18).

4.8.5 Place the upper Pyrex wool activated charcoal support subassembly (see 4.8.4) on top of the activated charcoal bed.

4.8.6 Place the seal retainer (item no.20) on top of upper Pyrex wool activated charcoal support subassembly.

4.8.7 Insert the O-ring (item no.22) into the groove on the flange of the activated charcoal canister body.

4.8.8 Place the spring (item no.21) on top of the seal retainer.

4.8.9 Compress the spring with the activated charcoal canister cover subassembly (item no.2), align, hold in compression in the position shown, align and position the bracket (item no.3) with two holes as shown, insert the six socket head cap screws (item no.4), put on the six washers (item no.6) screw-on the six self locking nuts (item no.5) and tighten to 19 ± 2 in-lb torque. Record the torques on the assembly log.

4.8.10 Connect the inlet of the assembly to a deionized water source, shut-off the outlet, and check for leaks at 30 psi. Should any leaks be found, they must be corrected. If the leak check test has been passed, record that fact on the assembly log. Depressurize, remove the water connections, but do not drain the assembly.

4.8.11 Attach the identification label and flow direction label at the location shown on the drawing with adhesive No.EC2216.

NOTE: Perform the ACF Test Requirement (3098-TR-2500) at this point and then after completion continue with Biological Decontamination.

4.9 Biological Decontamination of the Assembly

Long term (18-24 hours) exposure to pasteurization temperatures is the decontamination technique. The equipment required is as follows: (1) a constant temperature water bath with an agitator, (2) a coil of 304 stainless steel, 1/4-inch OD tubing with an equivalent linear length of 30 ft, (3) a washed and sterilized biological filter, and (4) a length of steam sterilized silicone rubber tubing. The biological filter, silicone tubing and the coil are connected together and steam sterilized as a unit.

4.9.1 Connect the biological filter inlet to a deionized water source and connect the biological filter outlet to the coil with silicone rubber tubing. Run deionized water through the filter, silicone rubber tubing and the coil at about 0.5 gpm to displace any trapped air.

4.9.2 Connect the coil outlet to the canister assembly inlet with silicone rubber tubing and connect another length of silicone rubber tubing to the canister assembly outlet.

4.9.3 Immerse the coil and the canister assembly in the water bath, and route the silicone rubber tubing connected to the canister assembly outlet to a convenient drain.

4.9.4 Turn on the deionized water source, and regulate the water flow down to 35 ml/min. Adjust water bath controls to maintain a temperature of 180 ± 3°F.

4.9.5 After 24 hours of exposure, remove the coil and canister assembly from the water bath and allow the assembly to cool.

4.9.6 Record pasteurization (sterilization)time and temperature on the assembly log.

4.10 Weight & Storage Preparation

4.10.1 Weigh the assembled Activated Charcoal Filter and Bacteria Filter Assembly on a balance with accuracy of better than ± 0.1 lb. Record the weight on the assembly log.

4.10.2 Perform the acceptance test per Test Requirement Document No. 3098-TR-3200. Record completion of that test on the assembly log.

4.10.3 Place appropriate caps over the CPV, connector or MDV and put the assembly into finished-component storage.

4.10.4 Sign and date the assembly log.

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SSP ASSEMBLY LOG

ASSEMBLY PROCEDURE SPEC. NO 3098-AS-2500 | REV A | SERIAL NO 001 | COMPONENT 525

REF LINE	ASSY SPEC ¶	OPERATION OR PARAMETER	MIN.	MAX.	MEAS'D	REMARKS	COMPLETE BY	COMPLETE DATE
1	4.7.6	Volume of Packing	---	---	180 ml		EYA	7/26
2	4.7.9	Torque 6 screws	17 in-lb	21 in-lb	19-20 in lb		EYA	7/26
3	4.7.10	Turbidity, JTU	---	---	<.10 JTU		EYA	7/26
		Silver ion content, ppm	---	---	1.2 ppm		EYA	7/26
							EYA	7/26
4	4.7.11	Leak Check	---	Zero	Zero		EYA	7/26
5	4.8.3	Volume of Activated Charcoal	---	---	2740 ml		EYA	7/31
6	4.8.9	Torque 6 screws	17 in-lb	21 in-lb	19-20 in lb		EYA	7/31
7	4.8.10	Leak Check	---	Zero	Zero		EYA	7/31
8	4.9.6	Pasteurization Temperature & Time	177°F/ 18 hr	183°F/ 24 hr			EYA	8/2-8/3
9	4.10.1	Weigh	---	---		See Test Log		
10	4.10.2	Perform Acceptance Test	---	---		See Acceptance Test Requirement Document No 3098-TR-3200	EYA	8/1

INITIAL ASSY DATE 8/2/73 | REFURBISHMENT NO. ____ ASSY DATE ____ | SHEET 9 OF 9

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ORIGINAL DATE April 23, 1973

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TITLE

Assembly Procedure

DEIONIZER

(SSP Component No. 533)

CODE IDENT. NO.	SPEC. NO.	
14958	3098-AS-3300	A

REF ASSY. DWG: 3098-D - 3300

1.0 Scope: This procedure document describes the assembly of a deionizer and bacteria filter assembly which is designated SSP Component No. 533. The assembly is shown by Drawing No. 3098-D-3300.

2.0 Parts List: This assembly is comprised of the subassemblies and parts shown on P/L No. 3098-PL-3098.

3.0 Tools & Instruments: Only normal and customary tools are required for the assembly. Preparation of the packing, resins, and the assembly and checkout of the assembly requires a 6 mesh (Tyler) screen, a 45 mesh (Tyler) screen, chromic acid, glass beakers, a deionized water source, turbidimeter, an atomic absorption spectrophotometer, a pH meter, a conductivity meter, and a temperature controlled water bath.

4.0 Procedure:

4.1 Packing Preparation (item no. 3)
Packing preparation consists of (1) classifying silver chloride granules, (2) cleansing glass beads, and (3) mixing the silver chloride granules and glass beads in the ratio 1.25 parts glass beads to 1 part silver chloride.

4.1.1 Clasify reagent grade "as-received" silver chloride granules in between 6 and 45 mesh (Tyler) screens under subdued lighting. Material that passes through the 45 mesh screen is rejected. Material that is retained by the 6 mesh screen may be reduced in size by "hammering" with a pestile or by "cutting-up" the lumps with a knife or razor.

4.1.2 Prepare glass beads, 0.42 to 0.59 mm diameter.

4.1.2.1 Wash "as-received" glass beads in an aqueous solution of detergent (Alconox or equivalent).

4.1.2.2 Decant the detergent solution and rinse the glass beads with hot tap water several times (about 5).

4.1.2.3 Wash the glass beads in concentrated chromic acid. Heat the chromic acid and glass beads to boiling and allow the mixture to simmer for one hour.

4.1.2.4 Allow the chromic acid and glass beads to cool. Decant the chromic acid and wash the glass beads repeatedly with deionized water, until the washings indicate no presence of chromic acid.

4.1.2.5 Dry the glass beads in an oven at 218°F (103°C) for 12 hours.

4.1.2.6 Allow the glass beads to cool to room temperature.

4.1.3 Blend the classified silver chloride granules and the prepared glass beads by weight in the ratio of 1.25 parts glass beads to one part silver chloride under subdued lighting. After weighing-out the proportions, add the glass beads and silver chloride granules to a common container (preferably glass) along with a volume of water just equal to the volume of the silver chloride and the glass beads. Stir the mixture manually with a spatula and distribute the glass beads and silver chloride particles uniformily.

Approximately 12.1 in^3 (199 cm^3) of packing are required to fill the annular space in the biological filter canister. Prepare an additional 10 - 20% extra for contingencies, i.e., approximately 240 cm^3.

4.2 Resin Preparation (item no. 20)

Measure out 400 ml of "as-received" Amberlite IR-45 (hydroxyl form) and 450 ml of "as-received" Amberlite IR-120 (hydrogen form). Place each resin in a separate 4 l Pyrex glass beaker and treat as follows.

4.2.1 Perform multiple extractions on each resin separately in very high quality (2 to 3 megaohm) boiling deionized water. Add 5 volumes of deionized water (ca. 2 liters) to the resins in the Pyrex beakers and heat to boiling. Boil the mixture for five to ten minutes, remove the beakers from the heat source and allow the resins to settle. Decant the supernatant liquid and repeat the extraction process at least ten times or until all traces of color and taste are eliminated.

4.2.2 Mix the extracted resins, 47.5% by volume Amberlite IR-45 and 52.7% by volume Amberlite IR-120. Approximately 34.0 in^3 (567 cm^3) of resin are required to fill the deionizer. Prepare an additional 10-20% extra for contingencies, i.e., approximately 680 cm^3.

Mix 322 ml of Amberlite IR-120 and 358 ml of Amberlite IR-45 in a container (preferably glass) along with a volume of water just equal to the volume of resins. Stir the mixture manually with a spatula and distribute the resins uniformily.

4.3 Prepare two Pyrex wools (item no. 21) for the deionizer canister.

4.3.1 Soak a roll of Pyrex wool in deionized water.

4.3.2 Wet down a working surface with deionized water, unroll, and fold over the wet Pyrex wool into a pile onehalf inch thick.

4.3.3 Sandwich the one-half inch thick wet Pyrex wool pile between two 316 stainless steel retaining screens (item no. 13).

4.3.4 Trim the Pyrex wool pile with a pair of scissors around the periphery of the screens, about one-sixteenth of an inch larger in radius than the retaining screens.

4.4 Prepare the lower Pyrex wool (item no. 21) for the biological filter canister, using the retaining screen (item no. 22) and the filter cartridge (item no. 27) to facilitate the preforming.

4.4.1 Soak a roll of Pyrex wool in deionized water.

4.4.2 Unroll and fold over the wet Pyrex wool over the retaining screen and the biological filter cartridge into a pile about one-half inch thick.

4.4.3 Trim the Pyrex wool pile with a pair of scissors conically, into a shape approximating the contour of the biological filter canister.

4.5 Prepare the upper Pyrex wool (item no. 21) for the biological filter canister.

4.5.1 Make two annular ring patterns from 1/16-inch thick aluminum sheet metal, 2-3/4 inches outside diameter and 2 inches inside diameter, to facilitate preforming the Pyrex wool.

4.5.2 Soak a roll of Pyrex wool in deionized water.

4.5.3 Wet down a working surface with deionized water, unroll, and fold over the wet Pyrex wool into a pile one-half inch thick

4.5.4 Sandwich the one-half inch thick wet Pyrex wool pile between the two patterns.

4.5.5 Trim the Pyrex wool pile with a pair of scissors around the periphery of the annular rings.

4.6 Biological Filter Cartridge Preparation (item no. 27)

4.6.1 Perform multiple extractions on the "as-received" filter cartridge to remove water - soluble manufacturing residues. Place the cartridge in a metal pan with 2 to 3 liters of deionized water and heat to boiling. Remove the pan from the heat source, drain off the water and air cool the cartridge. Repeat the extraction at least three times or until no visible color is detectable in the hot water.

4.6.2 Install the filter cartridge in Pall Trinity Corporation's commercial housing, connect to a deionized water source and flush at 0.25 to 0.5 gpm for 30 minutes. Shut-off the deionized water flow after 30 minutes and allow the unit to remain idle for 30 minutes. Drain-off the water in the housing and determine the drained water's pH and specific resistance. Repeat the flushing process until the pH and resistance of the draining are in close agreement with the values obtained for the deionized water used in the flushing.

4.6.3 Remove the filter cartridge from the commercial housing, and steam sterilize the cartridge in an autoclave at 115°C for 15 minutes.

4.7 Assemble the Biological Filter Canister

4.7.1 Insert the O-ring spring (item no. 25). Place the O-ring over the hub within the biological filter canister body (item no. 16).

4.7.2 Insert the spacer (item no. 26). Place the spacer over the hub within the biological filter canister body.

4.7.3 Insert the preformed lower Pyrex wool for the biological filter canister; see 4.4. Adjust the fit of the Pyrex wool pile by adding more Pyrex wool or by trimming away the excess Pyrex wool.

4.7.4 Place the retaining screens (item no. 22) over the previously prepared biological filter cartridge (see 4.6) outlet.

4.7.5 Insert the biological filter cartridge and retaining screen subassembly (see 4.7.4). Put the filter cartridge outlet over the hub within the biological filter canister body and manipulate the cartridge down until it rests against the washer. Check to be sure that an O-ring is supplied with the filter cartridge and that the O-ring is properly positioned in the O-ring groove on the filter cartridge outlet.

4.7.6 Load the annular space between the filter cartridge and biological canister body, under subdued lighting, with the previously prepared packing; see 4.1. Add the packing mixture in 50 to 100 ml increments while tapping the outlet against a hard surface and tapping the canister with a rubber mallet When the packing is near completion, gently ram the mixture with a rubber stopper (smaller in diameter than the annulus) fixed to a rod. Do not use any water in loading the canister; if the canister contains water, the silver chloride particles and glass beads will settle to the bottom at different rates and produce stratification. Record the volume of packing used to fill the annular space on the assembly log.

4.7.7 Place the preformed upper Pyrex wool on top of the packing; see 4.5. Insert additional Pyrex wool to cover areas around the pleats of the filter cartridge.

4.7.8 Insert the O-ring (item no. 18) into the O-ring groove on the flange of the biological filter canister body.

4.7.9 Compress the upper Pyrex wool (item no. 21) with the biological filter canister cover weldment (item no. 17), align and hold it in compression in the position shown, insert the six socket head cap screws (item no. 19), put-on the six washers (item no. 10) on the cap screws, screw-on the six self-locking nuts (item no. 9) and tighten to 19 $\pm$ 2 in-lb torque. Record the torques on the assembly log.

4.7.10 Connect the outlet of the biological filter canister to a deionized water source to backwash the "fines" out of the packing The inlet pressure during backwashing should not exceed 3 psig. Analyze the effluent for silver content and turbidity, to check that canister is saturating the deionized water with silver ion, and that the "fines" produced during the loading are backwashed-out. Continue backwashing until the effluent contains no "fines" and the Ag^+ content is 1.0 - 1.3 ppm. Record the final backwashing turbidity and Ag^{+} content on the assembly log.

4.7.11 Disconnect the deionized water source from the outlet and reconnect it to the inlet of the biological filter canister. Shut-off the outlet and check for leaks at 30 psi. Should any leaks by found, they must be corrected. If the leak check test has been passed, record that fact on the assembly log. Depressurize, remove the water connections, and drain the assembly.

4.8 Assemble the Deionizer Canister

4.8.1 Prepare the lower Pyrex wool resin support subassembly by sandwiching a preformed Pyrex wool (see 4.3) between four retaining screens (item no. 13), two screens on each face of the Pyrex wool disc.

4.8.2 Insert the lower preformed Pyrex wool resin support subassembly(see 4.8.1)into the bottom of the deionizer canister body (item no. 1).

4.8.3 Load the deionizer canister body with the previously prepared resin mixture; see 4.2. Add the resin mixture in 50 to 100 ml increments while tapping the outlet against a hard surface and tapping the canister body with a rubber mallet. When the packing is near completion, gently ram the mixture down with a rubber stopper (smaller in diameter than the canister) fixed to a rod. Do not use any water in loading the canister; if the canister contains water, the Amberlite resins will settle to the bottom at different rates and produce stratification. Record the volume of resins used to fill the canister body on the assembly log.

4.8.4 Prepare the upper Pyrex wool resin support subassembly by sandwiching a preformed Pyrex wool (see 4.3) between two upper retaining screens (item no. 12) and two lower retaining screens (item no. 13).

4.8.5 Place the upper Pyrex wool resin support subassembly (see (4.8.4) on top of the resin bed.

4.8.6 Place the screen (item no. 7) on top of the upper Pyrex wool resin support subassembly.

4.8.7 Insert the O-ring (item no. 8) into the groove on the flange of the deionizer canister body.

4.8.8 Place the spring (item no. 29) on top of the screen.

4.8.9 Compress the spring with the deionizer canister cover (item no.3), align and hold in compression in the position shown, align and position the bracket (item no.4) with four holes as shown, insert the six socket head cap screws (item no. 11) put on the six washers (item no.10), screw-on the six self locking nuts (item no.9) and tighten to 19 $\pm$ 2 in-lb torque. Record the torques on the assembly log.

4.8.10 Connect the inlet of the assembly to a deionized water source, shut-off the outlet, and check for leaks at 30 psi. Should any leak be found, they must be corrected. If the leak check test has been passed, record that fact on the assembly log. Depressurized, remove the water connections but do not drain the assembly.

4.8.11 Attach the identification label and flow direction label at the location shown on the drawing with adhesive No. EC2216.

NOTE: Perform the Deionizer Test Requirement (3098-TR-3300) at this point and then after completion continue with Biological Decontamination.

4.9 Biological Decontamination of the Assembly

Long term (18-24 hours) exposure to pasteurization temperatures is the decontamination technique. The equipment required is as follows: (1) a constant temperature water bath with an agitator, (2) a coil of 304 stainless steel, 1/4-inch OD tubing with an equivalent linear length of 30 ft, (3) a washed and sterilized biological filter, and (4) a length of steam sterilized silicone rubber tubing. The biological filter, silicone tubing and the coil are connected together and steam sterilized as a unit.

4.9.1 Connect the biological filter inlet to a deionized water source and connect the biological filter outlet to the coil with silicone rubber. Run deionized water through the filter, silicone rubber tubing and the coil at about 0.5 gpm to displace any trapped air.

4.9.2 Connect the coil outlet to the canister assembly inlet with silicone rubber tubing and connect another length of silicone rubber tubing to the canister assembly outlet.

4.9.3 Immerse the coil and the canister assembly in the water bath, and route the silicone rubber tubing connected to the canister outlet to a convenient drain.

4.9.4 Turn on the deionized water source and regulate the water flow down to 35 ml/min. Adjust water bath controls to maintain a temperature 180 ± 3°F.

4.9.5 After 24 hours of exposure, remove the coil and canister assembly from the water bath, and allow the assembly to cool.

4.9.6 Record pasteurization (sterilization) time and temperature on the assembly log.

4.10 Weigh & Storage Preparation

4.10.1 Weigh the assembled Deionizer/Bacteria Filter Assembly on a balance with accuracy of better than ± 0.1 lb. Record the weight on the assembly log.

4.10.2 Perform the acceptance tests per Test Requirement Document No. 3098-TR-2500. Record completion of that test on the Assembly log.

4.10.3 Place appropriate caps over the CPV, connector or MDV and put the assembly into finished-component storage.

4.10.4 Sign and date the assembly log.

CHEMTRIC, Inc.

9330 WILLIAM STREET • ROSEMONT, IL. 60018

SSP ASSEMBLY LOG

ASSEMBLY PROCEDURE SPEC. NO 3098-AS-3300 | REV A | SERIAL NO 001 | COMPONENT 533

REF LINE	ASSY. SPEC. ¶	OPERATION OR PARAMETER	MIN.	MAX.	MEAS'D	REMARKS	COMPLETE BY	COMPLETE DATE
1	4.7.6	Volume of Packing	- -	- -	180ml		EA	7/31
2	4.7.9	Torque 6 screws	17 in-lb	21 in-lb	19+20 in-lb		EA	7/31
3	4.7.10	Turbidity, JTU	- -	- -	<.10 JTU		EA	7/31
		Silver ion content,ppm	- -	- -	1.26 ppm		EA	7/31
4	4.7.11	Leak Check	- -	Zero	Zero		EA	7/31
5	4.8.3	Volume of Resins	- -	- -	555 ml		EA	7/31
6	4.8.9	Torque 6 screws	17 in-lb	21 in-lb	20 in-lb		EA	7/31
7	4.8.10	Leak Check	- -	Zero	Zero		EA	7/31
8	4.9.6	Pasteurization Tempera-ture & Time	177°F/ 18 hr	183°F/ 24 hr	178-182°F 24 hrs.		EA	8/1-8/2
9	4.10.1	Weigh	- -	- -	19.0 lbs		TGS	9/14/73
10	4.10.2	Perform Acceptance Test	- -	- -		See Acceptance Test Requirement Document No. 3098-TR-2500	EA	8/1

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INITIAL ASSY DATE Aug 1, 73 | REFURBISHMENT NO. ___ ASSY DATE ___ | SHEET 9 of 9

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ORIGINAL DATE March 19, 1973

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CHEMTRIC, Inc.
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TITLE

ASSEMBLY PROCEDURE

LIQUID WASTE TANK

(SSP Component No. 561)

CODE IDENT. NO. 14958

ASSY SPEC. NO. 3098-AS-6100

REF ASSY. DWG: 3098-R - 6100

1.0 Scope: This procedure document describes the assembly of a bladder-type liquid-waste tank, which is designated SSP Component No. 561. The assembly is shown by Drawing No. 3098-R-6100.

2.0 Parts List: This assembly is comprised of the sub-assemblies and parts shown on P/L No. 3098-PL-6100.

3.0 Tools & Instruments: Only normal and customary assembly tools and measuring instruments are required. An air compressor with a tank and a regulator adjustable to maintain 6 ± 1 psi on an output tube is required.

4.0 Procedure:

4.1 Piston Assembly

4.1.1 Note the printed markings on the rolling diaphragm (item No. 14) to determine which side is to face the piston. Reverse the diaphragm if necessary to put the piston side in the cavity (or concave surface). Record orientation on assembly log.

4.1.2 Slip the diaphragm over the piston (item No. 13), and align the inner set of twelve holes with the piston holes.

4.1.3 Locate the ring (item No. 17) and the piston head (item No. 19) as shown on the assembly drawing.

4.1.4 Install twelve each of the following fasteners only finger tight and in the orientation shown:
- screws, (item No. 20)
- seals, (item No. 18)
- washers, (item No. 9)
- nuts, (item No. 16)

4.1.5 Measure, with a steel rule, the concentricity of the piston head with the O.D. of the diaphragm, by measuring the distance by which the head overlaps the diaphragm. Adjust the concentricity to within 1/64-inch and tighten two diametrically opposed screws to 10 in-lb torque. Recheck concentricity and record on assembly log.

4.1.6 Tighten all twelve screws to 19 ± 2 in-lb torque in the following sequence. Select one screw as the datum and mark it by placing a piece of drafting tape near its hole; tighten the datum screw to the specified torque. Count five screws clockwise and tighten the fifth screw. Repeat the five-screw count always moving clockwise from the last screw tightened until all twelve screws are tightened to the specified torque. Remove the tape identifying the datum screw. Record torque on the assembly log.

4.1.7 Slip the Teflon bearing (item No. 12) onto the guide rod weldment (item No. 4). Assemble the bearing retainer (item No. 11) cap screw and washer (items No. 9 & 10) to the guide rod as shown on the drawing. Tighten the screw to 19 ± 2 in-lb torque. Record torque on the assembly log.

4.1.8 Assemble the guide rod to the inner side of the piston head as shown on the assembly drawing. No particular orientation between the rod and head is necessary. Insert the rod into the head hole, place one of the two split rings (item No. 21) behind the head flange and engage two screws and washers (items No. 9 & 10) finger tight. Repeat for the other split ring and two fasteners. Tighten four screws to 19 ± 2 in-lb torque and record measured torque on the assembly log.

4.1.9 Check concentricity of rod to piston by measuring with a steel rule the radial distance from the rod O.D. to the piston O.D. at several locations at the plane of the piston open end. All measurements must be within 1/32-inch of each other. Record measurements.

4.1.9.1 Should the measured eccentricity fall within the tolerance, no further adjustment is necessary.

4.1.9.2 Should the eccentricity exceed the tolerance, mark the location of the shortest measurement, loosen the four flange screws and place stainless steel shims between the rod flange and head flange at the radial location corresponding to the minimum mark. Remeasure eccentricity and repeat, if necessary. Record only final (acceptable) eccentricity on assembly log, and the four-bolt tightening torque.

4.2 Body Assembly

4.2.1 Insert the piston assembly into the bottom cap weldment (item No. 3) in the orientation shown on the drawing; note that the MDV is located 90° from the centerline in which is located the two hooks on the rod assembly. Any minor angular adjustment between the head weldment and piston assembly to align the head flange holes with the diaphragm holes may be performed by rotating the head relative to the piston. (This adjustment will affect the perpendicularity of the quantity gage cables only).

4.2.2 Place the head/piston assembly onto the can body weldment (item No. 2) in the orientation shown on the drawing. Note that the MDV on the head is located parallel to the handle centerline. The bearing on the piston assembly will slip into the bore of the hexagonal bar centrally located with the body. Locate the diaphragm between the head and body flanges and insert twelve screws, washers and nuts (items No. 9, 15 & 16) in the orientation shown. Tighten the twelve screws to 19 ± 2 in-lb by the same sequence (every fifth screw counting clockwise from the datum screw) explained in 4.1.6. Record measured torque on the assembly log.

4.2.3 Reaching into the open end of the body grip the rod and move it full stroke against the stop formed by the rod flange and the hexagonal bar. Observe the convolution of the rolling diaphragm as the stroke is fully traversed several times; the convolution must remain smoothly formed and roll without binding in either direction. If binding occurs or if a non-uniform convolution develops as the piston is moved, a design modification might be necessary. Consultation with the project engineer is recommended. Record on the assembly log whether or not the piston motion was smooth originally, and if not, what corrective measures were taken.

4.2.4 Connect the compressed air line to the MDV and slowly pressurize the chamber between the head and the piston to 6 ± 1 psig. The piston will move away from the end with the MDV and stop at its full stroke. Submerge the tank in tap water and look for air bubbles indicating a leak. Fill the back side of the piston with water, up to the upper-most surface of the convolution and look for bubbles indicating a leak. Potential leak points are as follows, with corrective measures explained.

Leak Location	Correction
through diaphragm	replace diaphragm
at head/piston flange	inspect and/or replace diaphragm or head or piston
at head/body flange	inspect and/or replace diaphragm, check and remove dirt at interface, check flange flatness
through head/piston screws	replace seal (item No. 18)
through head	check head for cracks or fractures - replace head

Should any leaks be found they must be corrected before further assembly. When leak check has been successfully passed, record that fact on assembly log, empty and dry the tank and release the air pressure. Do not disconnect the air line from the MDV.

4.2.5 Install the cable assembly (item No. 5). Note that the female connector is to be sealed to the can boss, and that the male connector need not be sealed.

4.2.6 Wipe clean the large diameter groove in the body flange and lay-in the O-ring seal (item No. 8).

4.2.7 Place the end cap weldment (item No. 1) over the open end of tank; no particular circumferential orientation is necessary. Install the over-center latch (item No. 6) with the handle in the position shown on the drawing.

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4.2.8 Connect a tee from the compressed air line on the MDV to the CPV fitting protruding from the tank body, and increase the pressure inside the tank assembly to 6 ± 1 psig. Submerge the entire tank and look for air bubbles indicating a leak. Potential leak points are as follows, with corrective measures explained.

Leak Location	Correction
under latch	check and/or replace O-ring, re-check groove for nicks
around electrical connector	replace connector seal
through metallic wall	disassemble and re-weld

Should any leaks be found, they must be corrected before further assembly. When leak check has been successfully passed, record that fact on assembly log. Depressurize and remove air lines, then drain and dry the tank assembly.

4.2.9 Attach the identification label (item No. 7) at the location shown on the drawing, and with adhesive No. EC2216.

4.2.10 Assemble 4 captive fasteners (item No. 22) into the holes as shown on the drawing. Crimping tool from Deutch to be used according to manufacturer's instructions.

4.3 Weigh & Storage Preparation

4.3.1 Weigh the assembled tank on a balance with accuracy of better than ±0.1 lb. Record the weight on the assembly log.

4.3.2 Perform the acceptance tests per Test Requirement Document No. 3098-TR-6100. Record completion of that test on the assembly log.

4.3.3 Place appropriate caps over the CPV, connector and MDV and put assembly into finished-component storage.

4.3.4 Sign and date the assembly log.

CHEMTRIC, Inc.
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SSP ASSEMBLY LOG

ASSEMBLY PROCEDURE SPEC NO 3098-AS-6100 | REV | SERIAL NO. 001 | COMPONENT 561

REF LINE	ASSY SPEC ¶	OPERATION OR PARAMETER	MIN.	MAX.	MEAS'D	REMARKS	COMPLETE BY	COMPLETE DATE
1	4.1.1	Orientate Belofram (Piston Side to Piston)					BB	8-1-73
2	4.1.5	Set Concentricity	0	1/64-in	1/64-in		EA	8-2
3	4.1.6	Torque 12 Screws	17 in-lb	21 in-lb	20 in-lb		EA	8-2
4	4.1.7	Torque 1 Screw	17 in-lb	21 in-lb	20 in-lb		BB	8-3
5	4.1.8	Torque 4 Screws	17 in-lb	21 in-lb	20 in-lb		BB	8-6
6	4.1.9	Check Concentricity	0	1/32-in	1/32-in		BB	8-6
7	4.1.9.2	Final Eccentricity	0	1/32-in	1/32-in		BB	8-6
		Re-torque 4 Screws, if nec.	17 in-lb	21 in-lb	20 in-lb		BB	8-6
8	4.2.2	Torque 12 Screws	17 in-lb	21 in-lb	20 in-lb		EA	8-6
9	4.2.3	Smooth Piston Movement				Yes, smooth movement	EA	8-6
10	4.2.4	Leak Check, Liquid Side	-	Zero	Zero		EA	8-7
11	4.2.8	Leak Check, Gas Side	-	Zero	Zero		EA	8-7
12	4.3.1	Weigh	-	--		See Test Log		
13	4.3.2	Perform Acceptance Test	-	--	--		EA	8-10-73

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CHEMTRIC, Inc.
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TITLE

Assembly Procedure

VAPOR COMPRESSION VACUUM

DISTILLATION UNIT

(SSP Component 591)

CODE IDENT. NO. 14958

ASSY SPEC. NO. 3098-AS-9100

REF ASSY. DWG: 3098-R-9100

1.0 Scope: This procedure document describes the assembly of a Vapor Compression Vacuum Distillation Unit which is designated SSP Component No. 591. The assembly is shown by Drawing No. 3098-R-9100.

2.0 Parts List: This assembly is comprised of the sub-assemblies and parts shown on P/L No. 3098-PL-9100.

3.0 Tools & Instruments: The normal and customary assembly tools and measuring instruments are supplemented with special assembly fixtures and tools which are listed on the parts list. These tools can be distinguished from the regular parts by the addition of a "-T" suffix on the part number.

4.0 Procedure:

4.1 Compressor Assembly

4.1.1 Initial Assembly Only

Driver Compressor Rotor Assembly.

Assemble the compressor rotor,	(item No. 64)
Bearing,	(item no. 66)
Driver Timing Gear,	(item no. 70)
Square Key,	(item No. 71)
Timing Gear Retainer,	(item no. 73)
Drive Magnet,	(item no. 93)
Washer,	(item no. 126)
Spacer,	(item no. 127)
Coupling,	(item no. 129)
Screw,	(item no. 130)
Four Screws,	(item no. 131)
and Roll Pin	(item No. 157)

as shown in the assembly drawing. Tighten the four screws (item no. 131) to 80-90 in-lbs torque. Record torques on the assembly log. Tighten the screw (itme no. 130) to 50-60 in-lbs torque. Record torque on the asembly log. Dynamically balance this assembly to $\pm$ 0.1 gm-cm @ 3300 rpm by removing material from the flats on the compressor rotor. Record the balance on the assembly log. Mark the location of the drive magnet with respect to the compressor rotor shaft extension. Disassemble and clean.

4.1.2 Press the compressor rotor bearings (item no. 66) into the motor end compressor cover (item no. 67).

4.1.3 Press the short compressor rotor (item no. 65) and washer (item no. 126) into the bearing bracketed by four lubrication ports in the motor end compressor cover assembly as shown on the assembly drawing. Press the long compressor rotor (item no. 64) and washer into the remaining bearing of the cover assembly as shown on the assembly drawing.

4.1.4 Install the compressor housing (item no. 63) to the motor end compressor cover assembly. Align the lubrication ports in the cover and housing. As viewed from the housing end, with the lubrication ports on the lower half of the assembly, the compressor outlet (i.e., square hole in housing) should face right. Install four screws (item no. 53) through the cover into the housing and loosely tighten.

4.1.5 Initial Assembly Only

Place 1-5/8 inch square shims between the compressor rotors and housing as shown in Figure AS-591-1. Install the shaft end compressor cover (item no. 49), aligning the lubrication ports, with four screws (item no. 53) and loosely tighten. Press the compressor rotor bearings (item no. 50) into the compressor cover and rotor assembly as shown on the assembly drawing. Tighten all screws (both sides) to 40 - 50 in-lbs torque. Mask the bearings to keep out metal chips. Drill 15/64 diameter through four existing 7/32 diameter holes in the cover/plates (two holes in each plate placed diagonally). Drill to 3/8 depth in the housing. Ream the four holes to .250/.251 diameter. Press in four dowel pins (item no. 54).

Install timing gear retainer (item no. 73), driver timing gear (item no. 70) and the driven timing gear (item no. 72) onto the keyed stub shafts of the compressor rotors as shown in figure AS-591-2. Note locations of keyways with respect to gear timing marks. Install keys (item no. 71) in the shafts as shown on the assembly drawing. Check gear timing marks and locate the matching teeth on center. Install four screws (item no. 131) in the driven timing gear as shown in the assembly drawing. Torque to 80 - 90 in-lbs. mask the gear and bearing faces. Drill a 3/32 diameter hole by 9/16 min. deep - do not drill thru - in the driven timing gear in the location shown on Figure AS-591-2. Insert roll pin (item no. 160) in the hole. Disassemble to the level of paragraph 4.1.4 except leave the dowel pins in the housing. Remove the bearing masking and shims. Clean out all metal filings from the drilling operations.

4.1.6 Place "O" ring (item no. 56) in the groove of the relief valve poppet (item no. 55).

4.1.7 Install sleeve bearing (item no. 153) in the relief valve body (item no. 57). Lubricate the i.d. of the sleeve bearing with a thin layer of Krytox 240 AC (Item no. 158). Insert the spring (item no. 58) and poppet assembly into the valve body assembly and install in the shaft end compressor cover (item no. 49) with two screws (item no. 59). Tighten the screws (2) to 10 - 12 in-lbs torque. Record torques on the assembly log. Place the cover assembly in a position such that it is horizontal and the relief valve poppet is exposed. Place weights on the poppet to determine the cracking pressure of the valve. Should the valve notcrack within the specified limits (ref. Assembly log), disassemble and adjust the spring or replace. Record weights needed to crack the valve on the assembly log and also screw torques if it was disassembled for spring adjustment.

4.1.8 Install the shaft end compressor cover assembly to the compressor housing assembly aligning the dowel pins and matching holes. Press the compressor rotor bearings (item no. 50) into the compressor cover and rotor assembly as shown on

COMPRESSOR SHIM PLACEMENT

(Ref. Para. 4.1.5)

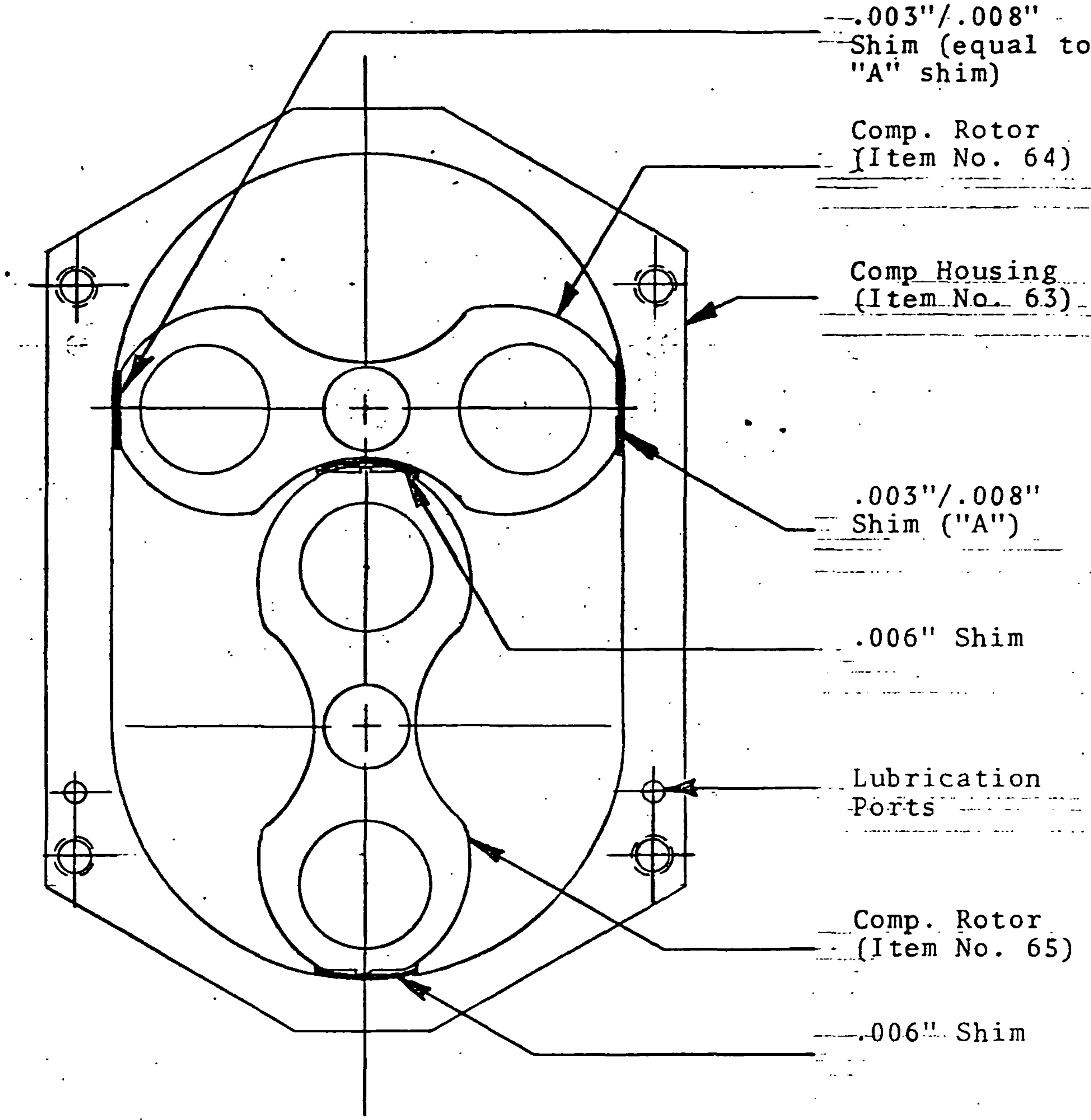

Figure AS-591-1

GEAR TIMING PROCEDURE

(Ref. Para. 4.1)

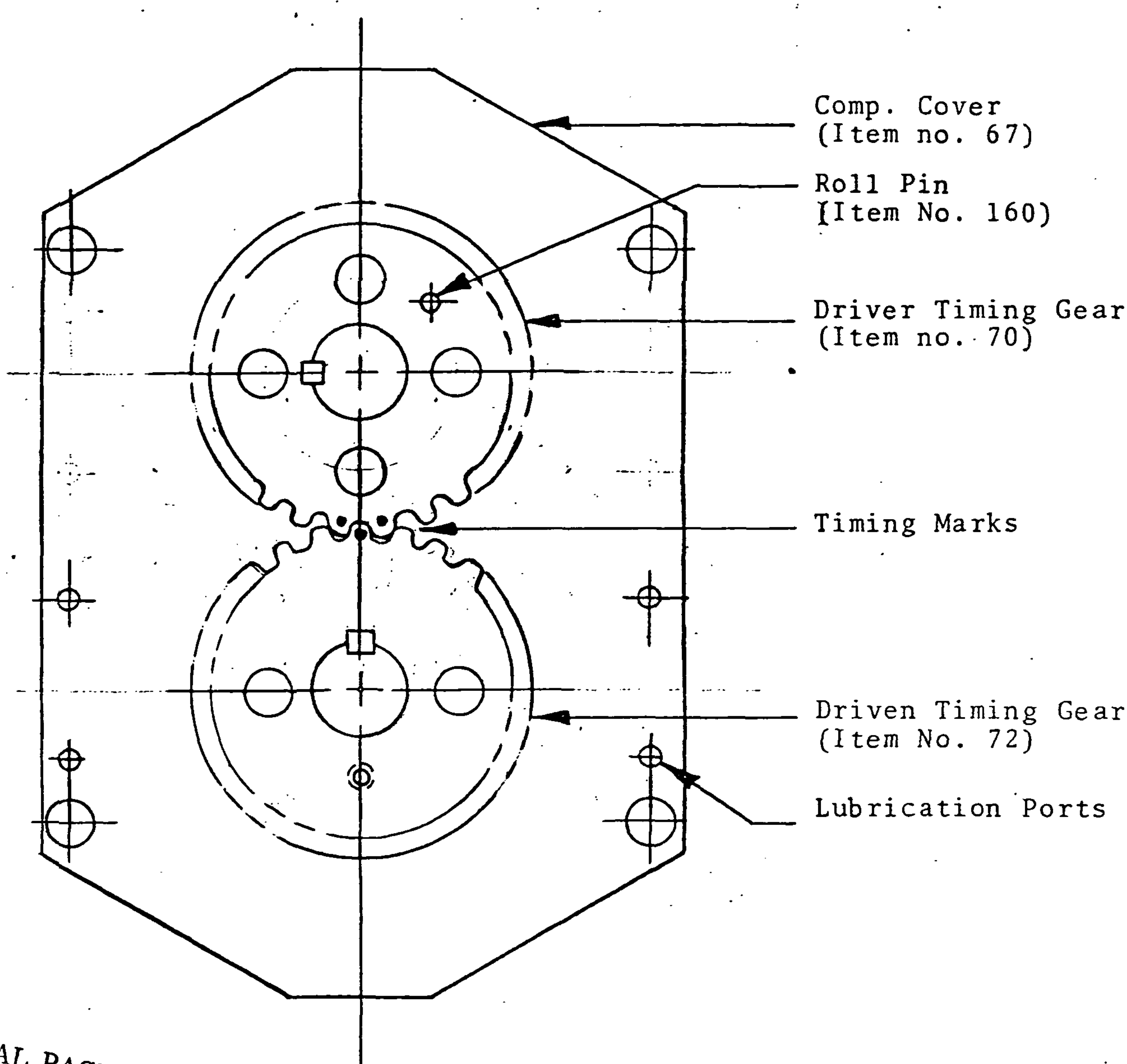

Figure AS-591-2

the assembly drawing. Install four screws (item no. 53) and tighten to 40 - 50 in lbs torque. Tighten the screws (4) on the motor end compressor cover to 40 - 50 in lbs torque. Record torques on the assembly log.

4.1.9 Lubricate the four compressor rotor bearings with the specified lubricant (item no. 159).

4.1.10 Rotate the compressor rotors by hand to check for any binding If one or both rotors do not seem to rotate freely, disassemble to the level of paragraph 4.1.7. Check individual bearings for possible binding and replace them if necessary. If binding or scraping occurs between the rotor and housing and/or cover consult with the project engineer for corrective action to be taken. Record on the assembly log when they are running freely.

4.1.11 Install the bearing covers (item no. 51) on the shaft end compressor cover with six screws (item no. 52) tightened to 5 - 6 in lbs torque. Record torques on the assembly log.

4.1.12 Install the bearing covers (item no. 68) on the motor end compressor cover with six screws (item no. 52) tightened to 5 - 6 in lbs torque. Record torques on the assembly log.

4.1.13 Assemble the long compressor rotor (item no. 64) in the compressor assembly with the driver timing gear (item no. 70),

square key	(item no. 71).
timing gear retainer	(item no. 73),
drive magnet	(item no. 93),
spacer	(item no. 127),
coupling	(item no. 129),
screw	(item no. 130),
four screws	(item no. 131),
and roll pin	(item no. 157)

as shown on the assembly drawing. Align the mark for the drive magnet with a corresponding mark on the compressor rotor shaft extension. Tighten the four screws (item no. 131) to 80 - 90 in lbs torque. Record torques on the assembly log. Tighten the screw (item no. 130) to 50 - 60 in lbs torque. Record torque on the assembly log.

4.1.14 Rotate the compressor rotors by hand to check for any binding. If one or both rotors do not seem to rotate freely, check for proper seating of all bearings and the correct torque on the screws. If binding and/or rotor lobe scraping still remains consult the project engineer for corrective action.

4.2 Magnetic Drive Assembly

4.2.1 Press bearing (item no. 97) into the compressor side of the drive magnet housing (item no. 99). Lubricate the bearing with fluorinated grease (item no. 158). Screw in the retaining ring (item no. 109) such that the raised lip faces the bearing. Tighten with a spaner to 120 - 130 in-lbs torque. Record torque on the assembly log.

4.2.2 Install bearing retainer (item no. 96) into the magnetic housing assembly as shown in the assembly drawing.

4.2.3 Install the drive magnet (item no. 103) into the magnetic housing assembly as shown in the assembly drawing.

4.2.4 Install the bearing/magnet retainer (item no. 98) into the magnetic housing assembly as shown in the assembly drawing. Align the screw holes in the bearing/magnet retainer and the bearing retainer. Align the rollpin hole with the groove in the drive magnet and install the roll pin (item no. 157) being careful not to damage the drive magnet during installation. Install three screws (item no. 104) in the bearing/magnet retainer and loosely tighten.

4.2.5 Press bearing (item no. 97) into the magnetic housing assembly as shown on the assembly drawing. Lubricate the bearing with fluorinated grease (item no. 158).

4.2.6 Remove the screws in the bearing/magnet retainer and install the bearing plate (item no. 134) and re-install the screws as shown on the assembly drawing. Tighten the screws to 5 - 6 in-lbs torque. Record torques on the assembly log.

4.3 Demister Assembly

4.3.1 Install three pieces of threaded rod (item no. 10) into the demister housing (item no. 4) and fasten with self locking nuts (item no. 8) as shown in the assembly drawing.

4.3.2 Pierce 1/8 diameter holes in the demister mesh (items nos. 17, 145, 146 & 147) corresponding to the threaded rod in the demister housing. Place the mesh and the baffle plates (items nos. 5, 6, 7 & 111) in alternate layers over the threaded rod in the demister housing as shown in the assembly drawing.

4.3.3 Install three lock nuts (item no. 8) on the threaded rod and tighten until mesh layering is snug. Place the demister end housing (item no. 11) on the demister assembly and check for interference. Tighten the threaded rod nuts on the end housing side if necessary. Loosen the threaded rod nuts on the main housing side if necessary to maintain the approximate clearances shown on the assembly drawing. Remove the demister end housing slightly and install "O" ring (item no. 21) in the main housing. Install demister housing and clamp to main housing with eight screws (item no. 9) and nuts (item no. 8). Tighten screws to 5 - 6 in-lbs torque. Record torques on assembly log.

4.3.4 Install sleeve bearing (item no. 19) and retainer nut (item no. 12) to the demister assembly as shown on the assembly drawing. Tighten nut to 90 - 100 in-lbs torque. Record torque on assembly log.

4.4 Bowl Drive Assembly

4.4.1 Install washer (item no. 126), driven timing gear (item no. 72), and key (item no. 71) on stub shaft of compressor rotor (item no. 65). Match timing marks on the driven timing gear with the driver timing gear as shown on figure AS-591-2.

4.4.2 Install the locating flange (item no. 74), bowl drive pinion (item no. 75), holding plate (item no. 149) and screws (items nos. 150 & 151). Tighten the two holding plate screws to 3 - 4 in-lbs torque. Record torques on the assembly log. Align the locating flange screw clearance hole with the tapped hole on the timing gear. The locating flange should be tightened to a maximum of 40 in-lbs torque. Release and back off to align holes. Do not over tighten to match holes.

4.4.3 Install two transmission plates (item no. 79) to the compressor assembly (ref para 4.1), aligning the lubrication ports, with four screws (item no. 80) and loosely tighten.

4.4.4 Lubricate the gears with Unitemp grease (item no. 159).

4.4.5 Install the two spacer plates (item no. 77) to the compressor assembly with four screws (item no. 78) and tighten to 5 - 6 in-lbs torque. Record torques on the assembly log. Tighten the screws (4) holding the transmission plates to the compressor assembly to 40 - 50 in-lbs torque. Record torque on the assembly log.

4.4.6 On the bowl drive support (item no. 83) find the face on the hub that is flush with the same face on the support's spacer block. Press a bearing (item no. 138) into that face. Assemble the rotating shaft (item no. 135), gear belt pulley (item no. 137) and clamp plate (item no. 142), with four screws (item no. 141) as shown on the assembly drawing. Tighten the screws to 3 - 4 in-lbs torque. Record torques on assembly log. Lubricate the bearing in the support assembly with Unitemp grease (item no. 159). Press the rotor assembly into the support assembly. Install the bearing spacer (item no. 139) as shown in the assembly drawing and press the other bearing (item no. 138) onto the assembly as shown on the assembly drawing. Lubricate this bearing with Unitemp grease (item no. 159). Also install washer (Item no. 125), O-ring pulley (item no. 136) and key (item no. 163) and tighten together with nut (item no. 140). Tighten the nut to 17 - 21 in-lbs torque. Record torque on assembly log.

4.4.7 Attach the bowl driver assembly (ref. para 4.4.6) to the transmission plate portion of the compressor assembly with two screws (item no. 82). Align the faces of the two assemblies so that they are flush. Tighten the screws to 40 - 50 in-lbs torque. Record torques on the assembly log.

4.4.8 Install the gear belt (item no. 84) onto the gear belt pulley and bowl drive pinion as shown on the assembly drawing.

4.4.9 Install "O" ring (item no. 95) in the stationary bowl locating manifold (item no. 86) as shown on the assembly drawing.

4.4.10 Position the magnetic coupling sleeve (item no. 92) over the magnetic drive assembly (ref. para 4.2) as shown on the assembly drawing. Install this subassembly on the stationary bowl locating manifold (ref. para 4.4.8) with six screws (item no. 94) as shown on the assembly drawing and tighten loosely. Assemble the compressor/bowl drive assembly (ref. para 4.4.7) to the opposite side of the locating manifold as shown on the assembly drawing with four screws (item no. 81) and sealing washers (item no. 128) and tighten loosely. Position the long compressor rotor/magnetic drive shaft in the magnetic coupling sleeve by movement of either or both subassemblies so that there is equal clearance of the rotor shaft in the coupling sleeve for one full revolution. Tighten the magnetic drive assembly screws to 17-21 in-lbs torque. Tighten the compressor/bowl drive assembly screws to 40-50 in lbs torque. Record both torques on the assembly log.

Rotate the drive rotor of the magnetic drive assembly slowly. The compressor should rotate now also. If the compressor does not rotate check for the following case/remedy relationships.

Fault	Remedy
Binding in Compressor	See para 4.1.14
Binding of Rotor-Shaft in Sleeve Coupling	Place a .010 shim in the gap between the rotor shaft and coupling sleeve. If the shim does not fit, loosen the main subassembly screws and reposition the rotor shaft. If binding still occurs, remove and check dimensional parameters for part compatibility.
Lack of Drive Coupling	Check for engagement of drive locking pins (item no. 157)

Reassemble the magnetic/drive compressor/bowl drive assembly recording screw torques on the assembly log as indicated.

4.5 Bowl Assembly

4.5.1 Position the magnetic drive/compressor/bowl drive assembly such that the stationary bowl locating manifold is horizontal with the magnetic drive assembly facing down. Remove the seals on the bowl bearing (item no. 46) and lubricate with fluorinated grease (item no. 158). Replace the seals and install on the still stationary shaft (item no. 1). Install the bearing retaining nut (item no. 3) on the stationary shaft as shown on the assembly drawing and tighten to 120 ft lbs maximum. Record torque on the assembly log.

4.5.2 Position the still stationary shaft onto the compressor cover plate as shown on the assembly drawing. The evaporator pressure tap (1/8 dia right angle tube) should be placed over the compressor outlet. Align the clearance holes and install six screws (item no. 48) and tighten to 40 - 50 in lbs torque. Check for perpendicularity (and proper seating) of the shaft and locating manifold with a level gauge. Record screw torques on the assembly log.

4.5.3 Assemble the bowl (item no. 24), speed sensor pickup (item no. 121) and bowl follower (item no. 61) with screws and lock nuts (items nos. 123 & 124) as shown on the assembly drawing. Do not tighten the screws. Insert an "O" ring (item no. 47) on the i.d. groove of the bowl. Place three bowl drive "O" rings (item no. 62) over the compressor and lay on the locating manifold. Lower the bowl assembly over the stationary shaft and onto the main shaft bearing so that the "O" ring seats on the bearing O.D. as shown on the assembly drawing.

4.5.4 Place an "O" ring (item no. 13) on the O.D. of the bowl inner hub as shown on the assembly drawing. Lower the demister assembly (ref para 4.3) over the stationary shaft and position on the bowl hub as shown on the assembly drawing. Align the demister clearance holes with the hub and install three screws (item no. 9). Tighten the screws to 5 - 6 in-lbs torque. Record torques on the assembly log.

4.5.5 Install a male connector (item no. 144) in the stationary shaft as shown on the assembly drawing. Tighten the nut to 140 - 160 in-lbs torque. Record torque on the assembly log.

4.5.6 Install a roll pin (item no. 162) in the stationary shaft as shown on the assembly drawing.

4.5.7 Assemble three "O" rings (item no. 161) in the feed liquid distributor (item no. 22) as shown on the assembly drawing. Be careful to install the "O" rings in their proper groove and not a feed line passage. Install the liquid distributor over the stationary shaft, seating on the shaft step and aligning the roll pin (ref para 4.5.6) with a groove in the distributor hub.

4.5.8 Install an "O" ring (item no. 110) in the recycle coupling (item no, 148) as shown on the assembly drawing. Install the recycle coupling into the liquid distributor (ref. para . 4.5.7) and position as shown on the assembly drawing. Install three screws (item no. 102) and tighten to 5 - 6 in-lbs torque. Record torque on the assembly log.

4.5.9 Install connecting tubing (item no. 143) to the male connector on the stationary shaft and the recycle coupling as shown on the assembly drawing. Secure it with a spring clamp (item no. 122) at each end.

4.5.10 Install an "O" ring (item no. 26) in the top face of the bowl collection trough as shown on the assembly drawing.

4.5.11 Lubricate a bearing (item no. 23) with the specified lubricant (item no. 158) and press into the bearing collar (item no. 29). Press the bearing collar assembly onto the stationary shaft assembly as shown on the assembly drawing.

4.5.12 Attach the bearing collar retainer (item no. 27) to the bearing collar (ref. para. 4.5.11) and secure with screws (item no. 28) tightened to 5 - 6 in lbs torque. Record torques on the assembly log.

4.5.13 Place the condneser bowl (item no. 39) over the stationary shaft and onto the inner bowl assembly as shown on the assembly drawing. Be certain that the lower condenser bowl portion is completely over its mating portion on the inner bowl. Align the clearance holes of the bearing collar with those of the condenser bowl and install six screws (item no. 25) through to the inner bowl collection trough. Tighten to 5 - 6 in-lbs torque. Record torque on the assembly log.

4.5.14 Install tubing (item no. 101) on the evaporator pressure tap (ref. para 4.5.2) and the matching tap on the locating manifold. Secure with a spring clamp (item no. 122) at each end.

4.6 Speed Pickup Assembly

4.6.1 Place a height guage with a dial indicator on the locating manifold face and adjust the speed sensor pickup (ref. para. 4.5.3) so that it is concentric to the bowl rotation ±.003. Tighten the twelve screws and nuts to 5-6 in-lbs torque. Record concentricity and torques on the assembly log.

4.6.2 Place the three drive "O" rings (ref. para. 4.5.3) over their respective grooves in the bowl follower and "O" ring pulley assemblies as shown on the assembly drawing.

4.6.3 Initial Assembly Only. Cut the lead wires of the magnetic speed sensor (item no. 112) to 4-1/2 ± 1/2 inches. Trim and crimp onto the proper connections of the connector (item no. 117) according to drawing no. 3098-B-7301.

4.6.4 Install the speed sensor mounting bracket (item no. 154) to the locating manifold with four screws (item no. 155) as shown on the assembly drawing. Tighten the screws to 5-6 in-lbs torque. Record torques on the assembly log.

4.6.5 Place a gasket (item no. 116) under the flange of the connector assembly (ref. para. 4.6.3) and install the connector to the motor side face of the locating manifold as shown on the assembly drawing. Tab positioning of the connector is irrelevant. Secure the connector with four screws (item no. 115) tightened to 3-4 in-lbs torque. Record torques on the assembly log.

4.6.6 Twist the magnetic speed sensor clockwise approximately six turns to allow for reverse twist while installing. Screw the speed sensor into the speed sensor mounting bracket as shown on the assembly drawing. Install a jam nut (item no. 114) to the magnetic speed sensor. Tighten the speed sensor so that it is .002/.005 inch from the closest tooth on the speed sensor pickup. Tighten the jam nut to 40-50 in-lbs torque. Record torque and clearance on the assembly log.

4.7 Outer Bowl Assembly

4.7.1 Place the spacer (item no. 31) over the stationary shaft onto the bearing.

4.7.2 Install four "O" rings (item no. 33) in the distributor hub (item no. 32) as shown on the assembly drawing. Be careful to install the "O" rings in their proper groove and not a liquid line passage.

4.7.3 Install the distributor hub assembly onto the still stationary shaft as shown on the assembly drawing. Slightly compress the condensate pickup tube so that it fits into the condensate collection trough.

4.7.4 Place the end plate (item no. 40) onto the collection trough of the condenser bowl with the condensate pickup facing out. Align the clearance holes and secure with twelve screws (item no. 41). No mounting orientation is required. Tighten the screws uniformly to 5-6 in-lbs torque. Record torque on the assembly log.

4.7.5 Place an "O" ring (item no. 85) in the manifold face of the staionary bowl (item no. 42) as shown on the assembly drawing.

4.7.6 Place an "O" ring (item no. 37) in the o.d. groove of the distributor hub as shown on the assembly drawing.

4.7.7 Assembly the stationary bowl over the distributor hub as shown on the assembly drawing. Position the bowl so that, with respect to View C-C of the assembly drawing, the mounting feet on the bowl face towards the "SSP floor". Align the hub mounting clearance holes and secure with six screws (item no. 38) tightened to 5-6 in lbs torque. Record torque on the assembly log.

4.7.8 Place the clamp (item no. 108) on the mating flanges of the locating manifold and stationary bowl. Position the bowl to the locating manifold as shown on the assembly drawing. Secure the clamp with its nuts (2) and tighten loosely.

4.8 External Assembly

4.8.1 Attach the right hand rail (item no. 213) to the stationary bowl as shown on the assembly drawing. Secure with two screws, washers and nuts (items no 44, 69 & 60). Tighten the nuts loosely.

4.8.2 Attach the left hand rail (item no. 212) to the locating manifold with two spacers and lock nuts (items no. 152 & 89) as shown on the assembly drawing. Loosely tighten the nuts.

4.8.3 Attach the MDV mounting assembly (item no. 215) to the stationary bowl as shown on the assembly drawing. Secure with three screws and lock nuts (items nos. 255 & 256). Loosely tighten the nuts.

4.8.4 Install six "O" ring male connectors (item no. 36) into the distributor hub as shown on the assembly drawing. Tighten the connectors to 100 ft-lbs maximum torque. Record torque on the assembly log.

4.8.5 Install the hub/condensate tubing (item no. 241) into its corresponding fitting on the distributor hub. Tighten the hub fitting nut to 30 ft-lbs maximum torque. Record torque on the assembly log.

4.8.6 Install the hub/feed tubing (item no. 228) into its corresponding fitting on the distributor hub. Tighten the hub fitting nut to 30 ft-lbs maximum torque. Record torque on assembly log.

4.8.7 Install the hub/purge tubing (item no. 227) into its corresponding fitting on the distributor hub. Tighten the hub fitting nut to 30 ft-lbs maximum torque. Record torque on assembly log.

4.8.8 Install the hub/recycle tubing (item no. 231) into tis corresponding fitting on the distributor hub. Tighten the hub fitting nut 30 ft-lbs maximum torque. Record torque on assembly log.

4.8.9 Align the condensate, feed, purge and recycle tubing assemblies from the distributor hub to their matching CPV fittings on the MDV mounting assembly. Loosely tighten the CPV union nuts.

4.8.10 Install component 571, the liquid level switch (item no. 259) to the transducer mounting bracket as shown on the assembly drawing. Secure with four screws (item no. 254) tightened to 17-21 in-lbs torque. Record torque on the assembly log.

4.8.11 Install component 910, the absolute pressure transducer (item no. 260) to the transducer mounting bracket as shown on the assembly drawing. Secure with two transducer mounting brackets (item no. 252), two mounting gaskets (item no. 253) and four screws (item no. 254). Loosely tighten the screws.

4.8.12 Install component 911, the differential pressure transducer (item no. 261) to the transducer mounting bracket as shown on the assembly drawing. Secure with four screws (item no. 254) tightened to 17-21 in-lbs torque. Record torque on the assembly log.

4.8.13 Install three adapters (item no. 249) to components 910 and 911 as shown on the assembly drawing. Tighten to 50 ft-lbs maximum torque. Record torque on assembly log. Assemble a right angle elbow (item no. 246) to the outer fitting on component 911 and connect it to the 910/911 tubing (item no. 245). Assemble a tee (item no. 247) to the fitting on component 910 and connect to the tubing from component 911. Tighten the nuts (4) on the 910/911 tubing connection to 50 ft-lbs maximum torque. Record torque on the assembly log. Tighten the mounting screws on component 910 to 17-21 in-lbs torque. Record torque on the assembly log.

4.8.14 Install the hub/Pc tubing (item no. 229) into its corresponding fitting on the distributor hub. Tighten the hub fitting nut to 30 ft-lbs maximum torque. Record torque on assembly log. Install the CPV/910 tubing (item no. 232) to the tee on component 910 and align the CPV fitting to its hub/Pc tubing mate. Tighten the tee nut to 50 ft-lbs maximum torque. Record torque on assembly log. Loosely tighten the CPV nut.

4.8.15 Install the hub/571 tubing (item no. 224) into the remaining fitting on the distributor hub. Connect the opposite end to the inner fitting on component 571. Tighten the hub fitting nut to 30 ft-lbs maximum torque. Tighten the 571 fitting nut to 50 ft-lbs torque maximum. Record torques on the assembly log.

4.8.16 Position the mounting rails of the stationary bowl so that the 13.875 ± 015 assembly runner locations to surfaces A and B along with a horizontal (±020) hub/571 tubing line (ref. para 4.8.15) are met. When these tolerances are met, tighten the four rail mounting nuts (ref. paras. 4.8.1 - 2) to 40-50 in-lbs torque. Also tighten the two clamp nuts (ref. para. 4.7.8) to 40-50 in-lbs torque. Record the runner locations, tubing line horizontal tolerance and screw torques on the assembly log.

4.8.17 Tighten the five CPV interface nuts (ref. paras. 4.8.9 & 4.8.14) to 50 ft-lbs torque maximum. Tighten the three MDV assembly mounting screws (ref. para 4.8.3) to 17-21 in-lbs torque. Record torques on the assembly log.

4.8.18 Install a jam nut (item no. 43) on still stationary shaft as shown on the assembly drawing. Tighten to 150 ft-lbs maximum torque. Record torque on the assembly log.

4.8.19 Place four "O" rings (item no. 156) in the grease fittings (item no. 90) and install in the locating manifold as shown on the assembly drawing. Tighten the fittings to 30 ft-lbs maximum torque. Record torque on the assembly log. Attach tool 3098-B-9160-T (item no. 300) to the grease fittings and pump enough grease to only fill the lubrication lines within the compressor. Do not over lubricate and only use the proper lubricant (item no. 159). Remove tool and place four plugs (item no. 91) on the grease fittings. Tighten to 30 ft-lbs maximum torque. Record torque on the assembly log.

4.8.20 Place an "O" ring (item no. 107) in the Pe CPV fitting on the locating manifold. Install a tee (item no. 247) to the inner fitting of component 911 as shown on the assembly drawing. Install the Pe/911 tubing (item no. 243) to the locating manifold CPV and the 911 tee. Loosely tighten the fitting nuts.

4.8.21 Install the 911/571 tubing (item no. 244) between the 911 tee and the outer fitting on component 571. Tighten the three tee nuts to 50 ft-lbs maximum torque. Tighten the Pe fitting(ref para 4.8.20) and the 911/571 fitting to 30 ft-lbs maximum torque. Record torques on the assembly log.

4.8.22 Apply a small amount of epoxy (item no. 251) to the faces of the small legs on the flexible spider (item no. 105) and place into the drive end of the bearing magnet retainer (ref para. 4.2.4). Hold in place until initial setting of the epoxy occurs.

4.8.23 Attach identification labels (items no. 250, 262-264) to components 591, 910, 911 and 571 at the locations shown on the drawing and with adhesive No. EC2216 (item no. 251).

4.8.24 Initial Assembly Only. Assemble two captive fasteners (items nos. 212-213) into the holes as shown on the assembly drawing. Crimping tool from Deutsch to be used according to the manufacturer's instructions.

4.8.25 Connect a tee from a vacuum pump to the purge line fitting on the still. Close the three MDVs. Decrease the still internal pressure to 20 $\pm$ 2 mm Hg. Leakage from the still should be no more than 2mm/hr. Potential leak points are as follows, with corrective measures explained.

Leak Location	Correction
Under flange clamp	Check and/or replace O-ring, recheck groove for nicks.
Around electrical connector	Replace connector gasket
Through hub fittings	Check fitting torques or "O" ring seals.
Through hub	Check and/or replace O-ring, recheck groove for nicks.
Through CPV fittings	Check and/or replace O-ring, recheck groove or face for nicks.
Through Swagelok fittings	Check screw torques.
Through transducers	Check and/or replace.
Through metallic wall	Disassemble and reweld.
Through tubing	Disassemble and reweld.

Should any leaks be found, they must be corrected before further assembly. When leak check has been successfully passed record the fact on the assembly log. Repressurize and remove vacuum lines.

4.9 Weigh and Storage Preparation

4.9.1 Weigh the assembled still on a scale with accuracy better than ± 0.25 lbs. Record the weight on the assembly log.

4.9.2 Perform the acceptance tests per Test Requirement Document No. 3098-TR-9100. Record completion of that test on the assembly log.

4.9.3 Place appropriate caps over the CPV, connector, MDV and drive assembly and put assembly into finished-component storage.

4.9.4 Sign and date the assembly log.

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SSP ASSEMBLY LOG

ASSEMBLY PROCEDURE SPEC. NO. 3098-AS-9100 | REV | SERIAL NO 001 | COMPONENT 591

REF. LINE	ASSY. SPEC. ¶	OPERATION OR PARAMETER	MIN.	MAX.	MEAS'D	REMARKS	COMPLETE BY	COMPLETE DATE
1	4.1.1	Torque 4 Screws	80 in-lb	90 in-lb	85 in lb		BB	6/27/73
2	4.1.1	Torque 1 Screw	50 in-lb	60 in-lb	55 in lb		BB	6/27/73
3	4.1.1	Dynamic Balance @ 3300 rpm	-0.1gm-cm	+0.1gm-cm	+.1 gm cm		BB	6/28/73
4	4.1.7	Torque 2 screws	10 in-lb	12 in-lb	12 in lb		AM	6/28/73
5	4.1.7	Valve Cracking Wt	127 gm	171 gm	160 gm		AM	6/28/73
		Retorque 2 screws if necessary	10 in-lb	12 in-lb	12 in lb		AM	6/28/73
6	4.1.8	Torque 8 screws	40 in-lb	50 in-lb	50 in lb		AM	6/28/73
7	4.1.10	Free Running Compressor			OK		AM	7/2/73
8	4.1.11	Torque 6 screws	5 in-lb	6 in-lb	6 in lb		AM	7/2/73
9	4.1.12	Torque 6 screws	5 in-lb	6 in-lb	6 in lb		AM	7/2/73
10	4.1.13	Torque 4 screws	80 in-lb	90 in-lb	90 in lb		AM	7/2/73
11	4.1.13	Torque 1 screw	50 in-lb	60 in-lb	60 in lb		AM	7/2/73
12	4.2.1	Torque 1 Retaining Ring	120 in-lb	130 in-lb	120 in lb		AM	8/10/73
13	4.2.6	Torque 3 screws	5 in-lb	6 in-lb	6 in lb		AM	8/10/73
14	4.3.3	Torque 8 screws	5 in-lb	6 in-lb	—	Deleted	[illegible]	
15	4.3.4	Torque 1 Retainer Nut	90 in-lb	100 in-lb	90 in lb		BB	8/8/73
16	4.4.2	Torque 2 screws	3 in-lb	4 in-lb	4 in lb		AM	7/6/73

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SSP ASSEMBLY LOG

ASSEMBLY PROCEDURE SPEC. NO. 3098-AS-9100 REV

SERIAL NO. 001

COMPONENT 591

REF. LINE	ASSY. SPEC. ¶	OPERATION OR PARAMETER	MIN.	MAX.	MEAS'D	REMARKS	COMPLETE BY	COMPLETE DATE
17	4.4.3	Torque 4 screws	40 in-lb	50 in-lb	50 in lb		AM	7/6/73
18	4.4.5	Torque 4 screws	5 in-lb	6 in-lb	6 in lb		AM	7/6/73
19	4.4.5	Torque 4 screws	40 in-lb	50 in-lb	50 in lb		AM	7/6/73
20	4.4.6	Torque 4 screws	3 in-lb	4 in-lb	4 in lb		AM	7/10/73
21	4.4.6	Torque 1 nut	17 in-lb	21 in-lb	20 in lb		AM	7/10/73
22	4.4.7	Torque 2 screws	40 in-lb	50 in-lb	45 in lb		AM	7/10/73
23	4.4.10	Torque 6 screws	17 in-lb	21 in-lb	20 in lb		AM	7/10/73
24	4.4.10	Torque 4 screws	40 in-lb	50 in-lb	45 in lb		AM	7/10/73
25	4.5.1	Torque 1 nut	--	120 ft lb	120 ft lb		AM	7/10/73
26	4.5.4	Torque 3 screws	5 in-lb	6 in-lb	6 in lb		BB	8/28/73
27	4.5.5	Torque 1 nut	140 in-lb	160 in-lb	150 in lb		BB	8/28/73
28	4.5.8	Torque 3 screws	5 in-lb	6 in-lb	6 in lb		TGS	8/30/73
29	4.5.12	Torque 6 screws	5 in-lb	6 in-lb	6 in lb		AM	7/10/73
30	4.5.13	Torque 6 screws	5 in-lb	6 in-lb	6 in lb		TGS	8/30/73
31	4.6.1	Concentricity to bowl	.003 in	+.003 in	±.006 in	OK	TGS	8/30/73
32	4.6.1	Torque 12 screws	5 in-lb	5 in-lb	6 in lb		TGS	8/30/73
33	4.6.4	Torque 4 screws	5 in-lb	6 in-lb	6 in lb		AM	8/15/73
34	4.6.5	Torque 4 screws	3 in-lb	4 in-lb	4 in lb		AM	8/15/73

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CHEMTRIC, Inc.
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SSP ASSEMBLY LOG

ASSEMBLY PROCEDURE SPEC. NO 3098-AS-9100 | REV | SERIAL NO 001 | COMPONENT 591

REF. LINE	ASSY. SPEC. ¶	OPERATION OR PARAMETER	MIN.	MAX.	MEAS'D	REMARKS	COMPLETE BY	COMPLETE DATE
35	4.6.6	Torque Jam Nut	40 in-lb	50 in-lb	50 in lb		AM	8/15/73
36	4.6.6	Sensor Clearance	.002 in	.005 in	.006 in	OK	TGS	8/30/73
37	4.7.4	Torque 12 screws	5 in-lb	6 in-lb	6 in lb		TGS	8/30/73
38	4.7.7	Torque 6 screws	5 in-lb	6 in-lb	6 in lb		TGS	8/30/73
39	4.8.4	Torque 6 connector	-----	100 ft-lb	100 ft lb		TGS	8/30/73
40	4.8.5	Torque fitting	-----	30 ft-lb	30 ft lb		TGS	8/30/73
41	4.8.6	Torque fitting	-----	30 ft-lb	30 ft lb		TGS	8/30/73
42	4.8.7	Torque Fitting	-----	30 ft-lb	30 ft lb		TGS	8/30/73
43	4.8.8	Torque Fitting	-----	30 ft-lb	30 ft lb		TGS	8/30/73
44	4.8.10	Torque 4 screws	17 in-lb	21 in-lb	20 in lb		TGS	8/30/73
45	4.8.12	Torque 4 screws	17 in-lb	21 in-lb	20 in lb		TGS	8/30/73
46	4.8.13	Torque 3 fittings	-----	50 ft-lb	50 ft lb		TGS	8/30/73
47	4.8.13	Torque 4 nuts	-----	50 ft-lb	50 ft lb		TGS	8/30/73
48	4.8.14	Torque fitting	-----	30 ft-lb	30 ft lb		TGS	8/30/73
49	4.8.14	Torque fitting	-----	50 ft-lb	50 ft lb		TGS	8/30/73
50	4.8.15	Torque fitting	-----	30 ft-lb	30 ft lb		TGS	8/30/73
51	4.8.15	Torque fitting	-----	50 ft-lb	50 ft lb		TGS	8/30/73

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SSP ASSEMBLY LOG

ASSEMBLY PROCEDURE SPEC. NO 3098-AS-9100 | REV | SERIAL NO 001 | COMPONENT 591

REF. LINE	ASSY. SPEC. ¶	OPERATION OR PARAMETER	MIN.	MAX.	MEAS'D	REMARKS	COMPLETE BY	COMPLETE DATE
52	4.8.16	"A" Runner Location	13.860	13.890	OK	Level	TGS	8/30/73
53	4.8.16	"B" Runner Location	13.860	13.890	—	Deleted	TGS	
54	4.8.16	Horizontal Tolerance	-.020	+.020	OK	Level	TGS	8/30/73
55	4.8.16	Torque 6 screws	40 in-lb	50 in-lb	50 in lb		TGS	8/30/73
56	4.8.17	Torque 5 nuts	-----	50 ft-lb	—	Deleted	TGS	
57	4.8.17	Torque 3 screws	17 in-lb	21 in-lb	20 in lb		TGS	8/30/73
58	4.8.18	Torque Jam Nut	-----	150 ft-lb	150 ft lb		TGS	8/30/73
59	4.8.19	Torque 4 nuts	-----	30 ft-lb	30 ft lb		TGS	8/30/73
60	4.8.21	Torque 3 nuts	-----	50 ft-lb	50 ft lb		TGS	8/30/73
61	4.8.21	Torque 2 fittings	-----	30 ft-lb	30 ft lb		TGS	8/30/73
62	4.8.25	Leak check	0	2mm/hr	< 2 mm/hr		TGS	8/30/73
63	4.9.1	Weight			130.5 lb	W/O 539, 570, 910 OR 911, but w/ all lines, MPVs & fittings	[illegible]	9/17/73
64	4.9.2	Test Requirement Completion			OK		TGS	9/12/73

INITIAL ASSY DATE 8/30/73 | REFURBISHMENT NO. | ASSY DATE

SHEET 20 of 24

CHEMTRIC, Inc.
9330 WILLIAM STREET • ROSEMONT, IL 60018

SSP ASSEMBLY LOG

ASSEMBLY PROCEDURE SPEC. NO 3098-AS-9100 | REV | SERIAL NO 002 | COMPONENT 591

REF. LINE	ASSY. SPEC. ¶	OPERATION OR PARAMETER	MIN.	MAX.	MEAS'D	REMARKS	COMPLETE BY	COMPLETE DATE
1	4.1.1	Torque 4 Screws	30 in-lb	90 in-lb	85 in lb		BB	6/27/73
2	4.1.1	Torque 1 Screw	50 in-lb	60 in-lb	55 in lb		BB	6/27/73
3	4.1.1	Dynamic Balance @ 3300 rpm	-0.1gm-cm	+0.1gm-cm	+.1gm-cm		BB	6/28/73
4	4.1.7	Torque 2 screws	10 in-lb	12 in-lb	12 in lb		AM	7/3/73
5.	4.1.7	Valve Cracking Wt	127 gm	171 gm	160 gm		AM	7/3/73
		Retorque 2 screws if necessary	10 in-lb	12 in-lb	12 in lb		AM	7/3/73
6	4.1.8	Torque 8 screws	40 in-lb	50 in-lb	50 in lb		AM	7/6/73
7	4.1.10	Free Running Compressor			OK		AM	7/10/73
8	4.1.11	Torque 6 screws	5 in-lb	6 in-lb	6 in lb		AM	7/10/73
9	4.1.12	Torque 6 screws	5 in-lb	6 in-lb	6 in lb		AM	7/10/73
10	4.1.13	Torque 4 screws	30 in-lb	90 in-lb	90 in lb		AM	7/10/73
11	4.1.13	Torque 1 screw	50 in-lb	60 in-lb	60 in lb		AM	7/10/73
12	4.2.1	Torque 1 Retaining Ring	120 in-lb	130 in-lb	120 in lb		AM	8/20/73
13	4.2.6	Torque 3 screws	5 in-lb	6 in-lb	6 in lb		AM	8/20/73
14	4.3.3	Torque 8 screws	5 in-lb	6 in-lb	—	Deleted	TGS	
15	4.3.4	Torque 1 Retainer Nut	90 in-lb	100 in-lb	90 in lb		BB	8/8/73
16	4.4.2	Torque 2 screws	3 in-lb	4 in-lb	4 in lb		AM	7/7/73

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INITIAL ASSY DATE 10/22/73 | REFURBISHMENT NO. — | ASSY DATE

CHEMTRIC, Inc.
9330 WILLIAM STREET • ROSEMONT, IL 60018

SSP ASSEMBLY LOG

ASSEMBLY PROCEDURE SPEC. NO 3098-AS-9100 | REV | SERIAL NO 002 | COMPONENT 591

REF. LINE	ASSY. SPEC. ¶	OPERATION OR PARAMETER	MIN.	MAX.	MEAS'D	REMARKS	COMPLETE BY	COMPLETE DATE
17	4.4.3	Torque 4 screws	40 in-lb	50 in-lb	50 in lb		AM	7/9/73
18	4.4.5	Torque 4 screws	5 in-lb	6 in-lb	6 in lb		AM	7/9/73
19	4.4.5	Torque 4 screws	40 in-lb	50 in-lb	50 in lb		AM	7/9/73
20	4.4.6	Torque 4 screws	3 in-lb	4 in-lb	4 in lb		AM	7/14/73
21	4.4.6	Torque 1 nut	17 in-lb	21 in-lb	20 in lb		AM	7/14/73
22	4.4.7	Torque 2 screws	40 in-lb	50 in-lb	50 in lb		AM	7/14/73
23	4.4.10	Torque 6 screws	17 in-lb	21 in-lb	20 in lb		AM	7/14/73
24	4.4.10	Torque 4 screws	40 in-lb	50 in-lb	50 in lb		AM	7/14/73
25	4.5.1	Torque 1 nut	--	120 ft-lb	120 ft lb		AM	7/14/73
26	4.5.4	Torque 3 screws	5 in-lb	6 in-lb	6 in lb		TGS	10/26/73
27	4.5.5	Torque 1 nut	140 in-lb	160 in-lb	150 in lb		TGS	10/26/73
28	4.5.8	Torque 3 screws	5 in-lb	6 in-lb	6 in lb		TGS	10/26/73
29	4.5.12	Torque 6 screws	5 in-lb	6 in-lb	6 in lb		TGS	10/26/73
30	4.5.13	Torque 6 screws	5 in-lb	6 in-lb	6 in lb		TGS	10/26/73
31	4.6.1	Concentricity to bowl	.003 in	+.003 in	±.006 in	OK	TGS	10/26/73
32	4.6.1	Torque 12 screws	5 in-lb	6 in-lb	6 in lb		TGS	10/26/73
33	4.6.4	Torque 4 screws	5 in-lb	6 in-lb	6 in lb		AM	8/15/73
34	4.6.5	Torque 4 screws	3 in-lb	4 in-lb	4 in lb		AM	8/15/73

INITIAL ASSY DATE 10/26/73 REFURBISHMENT NO. ___ ASSY DATE ___ SHEET 22 OF 24

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SSP ASSEMBLY LOG

ASSEMBLY PROCEDURE SPEC. NO. 3098-AS-9100 | REV | SERIAL NO .002 | COMPONENT 591

REF. LINE	ASSY. SPEC. ¶	OPERATION OR PARAMETER	MIN.	MAX.	MEAS'D	REMARKS	COMPLETE BY	COMPLETE DATE
35	4.6.6	Torque Jam Nut	40 in-lb	50 in-lb	50 in lb		TGS	10/26/73
36	4.6.6	Sensor Clearance	.002 in	.005 in	.005 in		TGS	10/26/73
37	4.7.4	Torque 12 screws	5 in-lb	6 in-lb	6 in lb		TGS	10/26/73
38	4.7.7	Torque 6 screws	5 in-lb	6 in-lb	6 in lb		TGS	10/26/73
39	4.8.4	Torque 6 connector	-----	100 ft-lb	100 ft lb		TGS	10/26/73
40	4.8.5	Torque fitting	-----	30 ft-lb	30 ft lb		TGS	10/26/73
41	4.8.6	Torque fitting	-----	30 ft-lb	30 ft lb		TGS	10/26/73
42	4.8.7	Torque Fitting	-----	30 ft-lb	30 ft lb		TGS	10/26/73
43	4.8.8	Torque Fitting	-----	30 ft-lb	30 ft lb		TGS	10/26/73
44	4.8.10	Torque 4 screws	17 in-lb	21 in-lb	20 in lb	Filled on OK & then replaced on #001	TGS	8/29/73
45	4.8.12	Torque 4 screws	17 in-lb	21 in-lb	20 in lb	" " " " " "	TGS	8/29/73
46	4.8.13	Torque 3 fittings	-----	50 ft-lb	50 ft lb	" " " " " "	TGS	8/29/73
47	4.8.13	Torque 4 nuts	-----	50 ft-lb	50 ft lb	" " " " " "	TGS	8/29/73
48	4.8.14	Torque fitting	-----	30 ft-lb	30 ft lb		TGS	10/26/73
49	4.8.14	Torque fitting	-----	50 ft-lb	50 ft lb		TGS	10/26/73
50	4.8.15	Torque fitting	-----	30 ft-lb	30 ft lb		TGS	10/26/73
51	4.8.15	Torque fitting	-----	50 ft-lb	50 ft lb		TGS	10/26/73

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INITIAL ASSY DATE 10/26/73 | REFURBISHMENT NO. ____ ASSY DATE ____ | SHEET 23 OF 24

CHEMTRIC, Inc.

9330 WILLIAM STREET • ROSEMONT, IL. 60018

SSP ASSEMBLY LOG

ASSEMBLY PROCEDURE SPEC. NO: 3098-AS-9100 | REV | SERIAL NO 002 | COMPONENT 591

REF. LINE	ASSY. SPEC. ¶	OPERATION OR PARAMETER	MIN.	MAX.	MEAS'D	REMARKS	COMPLETE BY	COMPLETE DATE
52	4.8.16	"A" Runner Location	13.860	13.890	OK	Level	KS	9/6/73
53	4.8.16	"B" Runner Location	13.860	13.890	–	Deleted	KS	
54	4.8.16	Horizontal Tolerance	-.020	+.020	OK	Level	KS	9/6/73
55	4.8.16	Torque 6 screws	40 in-lb	50 in-lb	50 in lb		KS	9/6/73
56	4.8.17	Torque 5 nuts	-----	50 ft-lb	–	Deleted	KS	10/26/73
57	4.8.17	Torque 3 screws	17 in-lb	21 in-lb	20 in lb		KS	10/26/73
58	4.8.18	Torque Jam Nut	-----	150 ft-lb	150 ft lb		KS	10/26/73
59	4.8.19	Torque 4 nuts	-----	30 ft-lb	30 ft lb		KS	10/26/73
60	4.8.21	Torque 3 nuts	-----	50 ft-lb	50 ft lb		KS	10/26/73
61	4.8.21	Torque 2 fittings	-----	30 ft-lb	30 ft lb		KS	10/26/73
62	4.8.25	Leak check	0	2mm/hr	<2 mm/hr		KS	10/26/73
63	4.9.1	Weight			130.5 lb	w/o 539, 570, 910 or 911 but with all Lines HDWe & fittings	KS	10/26/73
64	4.9.2	Test Requirement Completion						

INITIAL ASSY DATE 10/26/73 | REFURBISHMENT NO. ___ ASSY DATE ___ | SHEET 24 OF 24

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CHEMTRIC, Inc.
9330 WILLIAM STREET • ROSEMONT, IL 60018

ORIGINAL DATE: April 23 1973

DRAFTSMAN: W. J. Jasionowski

CHECKER: P. P. Nuccio (signature)

ENGINEER: P. P. Nuccio

APPROVED: R. A. Barnbeck (signature)

DESIGN ACTIVITY APPROVAL:

OTHER APPROVAL:

TITLE:

Assembly Procedure

SILVER ION STERILIZER
(SSP Component No. 597)

CODE IDENT. NO.: 14958

ASSY SPEC. NO.: 3098-AS-9700

REF ASSY. DWG: 3098- D-9700

1.0 Scope: This procedure document describes the assembly of a silver sterilizer assembly which is designated SSP Component No. 597. The assembly is shown by Drawing No. 3098-D-9700

2.0 Parts List: This assembly is comprised of the subassemblies and parts shown on P/L No. 3098-D-9700

3.0 Tools & Instruments: Only normal and customary tools are required for the assembly. Preparation of the packing and check-out of the assembly requires a 6 mesh (Tyler) screen, a 45 mesh (Tyler) screen, chromic acid, glass beakers, a deionized water source, turbidimeter, and an atomic absorption spectrophotometer.

4.0 Procedure:

4.1 Packing Preparation (item no. 8)

Packing preparation consists of (1) classifying silver chloride granules, (2) cleaning glass beads, and (3) mixing the silver chloride and glass beads in the ratio 1.25 parts glass beads to 1 part silver chloride.

4.1.1 Classify reagent grade "as-received" silver chloride granules in between 6 and 45 mesh (Tyler) screens under subdued lighting. Material that passes through the 45 mesh screen is rejected. Material that is retained by the 6 mesh screen may be reduced in size by "hammering" with a pestle or by "cutting-up" the lumps with a knife or razor.

4.1.2 Prepare glass beads, 0.42 to 0.59 mm diameter

4.1.2.1 Wash "as-received" glass beads in an aqueous solution of detergent (Alconox or equivalent).

4.1.2.2 Decant the detergent solution and rinse the glass beads with hot tap water several times (about 5).

4.1.2.3 Wash the glass beads in concentrated chromic acid. Heat the chromic acid and glass beads to boiling and allow the mixture to simmer for one hour.

4.1.2.4 Allow the chromic acid and glass beads to cool. Decant the chromic acid and wash the glass beads repeatedly with deionized water, until the washings indicate no presence of chromic acid.

4.1.2.5 Dry the glass beads in an oven at 218°F (103°C) for 12 hours.

4.1.2.6 Allow the glass beads to cool at room temperature.

4.1.3 Blend the classified silver chloride granules and the prepared glass beads by weight in the ratio of 1.25 parts glass beads to one part silver chloride under subdued lighting. After weighing-out the proportions, add the glass beads and silver chloride granules to a common container (preferably glass) along with a volume of water just equal to the volume of silver chloride and the glass beads. Stir the mixture manually with a spatula and distribute the glass beads and silver chloride particles uniformily.

Approximately 13.2 in^3 (216 cm^3) of packing are required to fill the canister body. Prepare an additional 10 - 20%

extra for contingencies, i.e., approximately 260 cm^3.

4.2 Prepare Two Pyrex Wools

4.2.1 Soak a roll of Pyrex wool in deionized water.

4.2.2 Wet down a working surface with deionized water, unroll, and fold over the wet Pyrex wool into a pile on-half inch thick.

4.2.3 Sandwich the one-half inch thick wet Pyrex wool pile between two 10 x 20 mesh 316 stainless steel retaining screens (item no. 10)

4.2.4 Trim the Pyrex wool pile with a pair of scissors around the periphery of the screens, about one-sixteenth of an inch larger in radius then the retaining screens.

4.3 Prepare the lower Pyrex wool packing support subassembly by sandwiching the Pyrex wool (item no. 9) between four lower retaining screens (item no. 10), two screens on each face of the Pyrex wool disc.

4.4 Assemble the Silver Sterilizer

4.4.1 Insert the lower preformed Pyrex wool packing support subassembly (see 4.3) into the bottom of the canister body (item no. 1), see 4.2.

4.4.2 Load the canister body under subdued lighting with the previously prepared packing; see 4.1. Add the packing mixture in 50 to 100 ml increments while tapping the outlet against a hard surface and tapping the canister body with a rubber mallet. When the packing is near completion, gently ram the mixture down with a rubber stopper (smaller in diameter than the canister) fixed to a rod. Do not use any water in loading the canister, if the canister contains water, the silver chloride particles and glass beads will settle to the bottom at different rates and produce stratification. Record volume of packing used to fill the canister on the assembly log.

4.4.3 Prepare the upper Pyrex wool packing support subassembly by sandwiching the upper Pyrex wool (item no. 7) between two upper retaining screens (item no. 6) and two lower retaining screens (item no. 10).

4.4.4 Place the upper Pyrex wool packing support subassembly (see 4.4.3) on top of the packing.

4.4.5 Place the upper sieve (item no. 5) over the upper Pyrex wool packing support assembly.

4.4.6 Insert the O-ring (item no. 3) into the groove on the flange of the canister body.

4.4.7 Place the spring (item no. 4) on top of the upper sieve (item no. 5).

4.4.8 Compress the spring (item no.4) with the canister cover (item no. 2), align and hold it in compression, in the position shown, insert the six socket head cap screws (item no. 12) into the holes of the canister cover and flange of the canister body, put-on the six washers (item no. 14) on cap screws, screw-on the six self locking nuts (item no. 14), and tighten to 19 ± 2 in-lb torque. Record torques on the assembly log.

4.4.9 Connect the assembly to a deionized water source and flush at 0.5 gpm for 10 minutes. Analyze the effluent for silver content and turbidity, to check that the canister is saturating the deionized water with silver ions, and that the "fines" produced during the loading are flushed-out. Repeat flushing until effluent contains no "fines" and Ag^+ content is 1.0 - 1.3 ppm. Record final turbidity and Ag^+ content on the assembly log.

4.4.10 With the assembly connected to a deionized water source, shut-off the outlet and check for leaks at 30 psi. Should any leaks be found, they must be corrected. If the leak check test has been passed, record that fact on the assembly log. Depressurize, remove the water connections, but do not drain the assembly.

4.4.11 Attach the identification label and the flow direction label at the location shown on the drawing with adhesive no. EC 2216.

4.5 Weigh & Storage Preparation

4.5.1 Weigh the assembled Silver Sterilizer Assembly on a balance with accuracy of better than ± 0.1 lb. Record the weight on the assembly log.

4.5.2 Perform the acceptance tests per Test Requirement Document No. 3098-TR-9700. Record completion of that test on the assembly log.

4.5.3 Place appropriate caps over the CPV connector or MDV and put the assembly into finished-component storage.

4.5.4 Sign and date the assembly log.

CHEMTRIC, Inc.

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SSP ASSEMBLY LOG

ASSEMBLY PROCEDURE SPEC. NO 3098-AS-9700 | REV | SERIAL NO | COMPONENT 597

REF LINE	ASSY. SPEC. ¶	OPERATION OR PARAMETER	MIN.	MAX.	MEAS'D	REMARKS	COMPLETE BY	COMPLETE DATE
1	4.4.1	Volume of Packing	---	---	220cc		EIA	7/25
2	4.4.8	Torque 6 screws	17 in-lb	21 in-lb	19-20in-lb		EIA	7/25
3	4.4.9	Turbidity, JTU	---	---	<.10JTU		EIA	7/25
		Silver ion Content ppm	---	---	1.24ppm		EIA	7/25
4	4.4.10	Leak Check	---	Zero	Zero		EIA	7/26
5	4.5.1	Weigh	---	---	3.35 lb	(1521.7g)	EIA	7/27
6	4.5.2	Perform Acceptance Test	---	---		See Acceptance Test Document No. 3098-TR-9700	EIA	8/1

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INITIAL ASSY DATE 8-1-73 REFURBISHMENT NO. ______ ASSY DATE ______

SHEET 5 OF 5

TEST REQUIREMENTS

This section is comprised of documents written to define the acceptance tests and testing procedures to be performed on the assembled components and on the assembled VCD module. A test log is included with each document in which is entered the test results. The test results are the following documents included:

Component Name & Number	Document No.
Activated Charcoal Filter, 525	3098-TR-2500
Deionizer, 533	3098-TR-3300
Purge Pump, 544	3098-TR-4400
Liquid Pump, 548	3098-TR-4800
Waste Tank and Quantity Gage, 561 & 576	3098-TR-6100
Recycle Tank, 562	3098-TR-6200
Distillation Unit, Motor and Level Switch, 591 & 571	3098-TR-9100
Silver-Ion Sterilizer	3098-TR-9700
Module Assembly, SSP-WWMS	3098-TR-9800

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May 10 1973

DRAFTSMAN
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ENGINEER
P. P. Nuccio

APPROVED
R A Barnbank

DESIGN ACTIVITY APPROVAL

OTHER APPROVAL

CHEMTRIC, Inc.
9330 WILLIAM STREET • ROSEMONT, IL. 60018

TITLE

TEST REQUIREMENTS

ACTIVATED CHARCOAL/BIOLOGICAL FILTER
(SSP Component No. 525)

CODE IDENT. NO. 14958

SPEC. NO. 3098-TR-2500 A

REF. ASSY. DWG: 3098-R - 2500

SHEET 1 of 4

1.0 Scope: This document describes the test requirements for the SSP Activated Charcoal/Biological Filter (Component No. 525)

2.0 Applicable Documents: These test requirements are drawn to verify that the assembly meets the important requirements set forth in the documents listed below;

3098-MS-2500, ACF/BF Mini-Spec
3098-R-2500, ACF/BF Assembly Drawing
3098-AS-2500, ACF/BF Assembly Procedure

3.0 Examination of Product: Inspect for general appearance and for conformance with the pictorial presentation shown by the assembly drawing. Check to confirm that workmanship is of acceptable quality and that no incompletions are apparent.

4.0 Performance: This series of tests is to be performed on Component No. 525 after it is assembled per Assembly Proceedure 3098-AS-2500 Sections 4.1 through 4.8 and before Biological Decontamination, Section 4.9 of that proceedure.

4.1 Proof Pressure:
With the same set-up applied in paragraph 4.8.10 of 3098-AS-2500 increase the internal pressure to 48±2PSIG (the proof pressure). Pump only deionized water (no air) into the canister assembly. While holding that pressure check the canisters, tube joints and flanges for leaks; should any be found they must be repaired before proceeding further. Record the results on the test log, and release the pressure. Do not drain the assembly.

4.2 Pressure Drop:

With plastic tees, connect a 5 psid differential pressure gage across the component inlet and outlet ports. Dwyer gage Model No. 2205 may be used, but theinlet connection (high pressure tap, at the BF) must be connected with a 1-liter sealed flask in the line. The flask must contain only air prior to initiating the test. The Dwyer gage must be mounted higher than either of the plastic tees at the component 525 ports. (The above precautions are suggested to prevent the entry of water into the gage sensitive elements.)

4.2.1 Connect the inlet port (on the BF) to a source of deionized water and adjust the flow rate to 5 lb /hr (38±3cc/min); read and record the pressure differential.

4.2.2 Adjust the flow rate to 10 lb/hr (76±5cc/min) read and record the pressure differential.

4.2.3 Repeat at 30 lb/hr (227±5 cc/min).

4.2.4 Repeat at 60 lb/hr (454±10 cc/min).

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4.2.5 Repeat at 90 lb/hr (681±15 cc/min). Disconnect the manometer and plumbing lines. Do not drain the canisters.

4.3 Burst Pressure:
With the outlet port blocked by a 0 to 100 psig pressure gage, pump deionized water into the inlet port until the gage reads 66±2 psi. Inspect the assembly for ruptures while holding that pressure and enter observations onto the test log. Should a rupture or leak occur the assembly shall be rejected. (Repairs shall be made and the entire assembly and test proceedures repeated.)

4.4 Sign and date the assembly log, and proceed with "Biological Decontamination" (3098-AS-2500, Section 4.9).

CHEMTRIC, Inc.
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5.0 TEST LOG

TEST REQUIREMENT No. 3098-TR-2500 | REV A | SERIAL 001 | COMPONENT 525

REF. LINE	TR ¶	TEST DESCRIPTION	TEST RESULTS OR MEASUREMENTS	PERFORMED BY	PERFORMED DATE
1	4.1	Proof Pressure (Record Pressure and Observations)	50 psig - No Leaks	ETA	7/26/73
2	4.2.1	Pressure Drop @ 5 lb/hr	0.15 psid	ETA	8/1/73
3	4.2.2	@ 10 lb/hr	0.21 psid	ETA	8/1/73
4	4.2.3	@ 30 lb/hr	0.70 psid	ETA	8/1/73
5	4.2.4	@ 60 lb/hr	1.32 psid	ETA	8/1/73
6	4.2.5	@ 90 lb/hr	2.16 psid	ETA	8/1/73
7	4.3	Burst Pressure (Record Pressure and Observations)	65 psig - No Leaks	ETA	7/26/73
		Wt. As Installed	17.9 Lb	[illegible]	8-3-73

TEST COMPLETED BY: ETA DATE 8/1/73 APPROVED BY: [signature] DATE 8/3/73 SHEET 4 OF 4

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APPROVED R A Bambenek

DESIGN ACTIVITY APPROVAL

OTHER APPROVAL

CHEMTRIC, Inc.
9330 WILLIAM STREET • ROSEMONT, IL 60018

TITLE

TEST REQUIREMENTS

DEIONIZER
(SSP Component No. 533)

CODE IDENT. NO. 14958

SPEC. NO. 3098-TR-3300

A

REF. ASSY. DWG: 3098-D - 3300

SHEET 1 of 4

1.0 Scope: This document describes the test requirements for the SSP Deionizer (Component No.533).

2.0 Applicable Documents: These test requirements are drawn to verify that the assembly meets the important requirements set forth in the documents listed below:

3098-MS-3300, Deionizer Mini-Spec
3098-D-3300, Deionizer Assembly Drawing
3098-AS-3300, Deionizer Assembly Procedure

3.0 Examination of Product: Inspect for general appearance and for conformance with the pictorial presentation shown by the assembly drawing. Check to confirm that workmanship is of acceptable quality and that no incompletions are apparent.

4.0 Performance: This series of tests is to be performed on Component No.533 after it is assembled per assembly proceedure 3098-AS-3300 sections 4.1 through 4.8 and before Biological Decontamination, section 4.9 of that proceedure. For all following tests, install the housing with the canister centerlines in a vertical orientation (MDVs "up") to simulate final installation.

4.1 Proof Pressure:
With the same set-up applied in paragraph 4.8.10 of 3098-AS-3300 increase the internal pressure to 48 ± 2 psig (the proof Pressure). Pump only deionized water (no air) into the canister assembly. While holding that pressure check the canisters, tube joints and flanges for leaks; should any be found they must be repaired before proceeding further. Record the results on the test log, and release the pressure. Do not drain the assembly.

4.2 Pressure Drop:
With plastic tees, connect a 0 to 10 psid differential pressure gage across the component inlet and outlet ports. Dwyer gage Model No. 2210 may be used, but the inlet connection (high pressure tap, at the BF) must be connected with a 1-liter sealed flask in the line. The flask must be mounted higher than either of the plastic tees at the component 533 ports. (The above precautions are suggested to prevent the entry of water into the gage sensitive elements.)

4.2.1 Connect the inlet port (on the BF) to a source of deionized water and adjust the flow rate to 5 lb/hr (38 ± cc/min); read and record the pressure differential.

4.2.2 Adjust the flow rate to 10 lb/hr (76 ± 5 cc/min); read and record the pressure differential.

4.2.3 Repeat at 30 lb/hr (227 ± 5 cc/min).

4.2.4 Repeat at 60 lb/hr (454 ± 10 cc/min).

4.2.5 Repeat at 90 lb/hr (681 ± 15 cc/min).

4.2.6 Repeat @ 170 lb/hr (908 ± 20 cc/min). Disconnect the manometer and plumbing lines. Do not drain the canisters.

4.3 Burst Pressure:

With the outlet port blocked by a 0 to 100 psig pressure gage, pump deionized water into the inlet port until the gage reads 66±2 psi. Inspect the assembly for ruptures while holding that pressure. Enter observations onto the test log, Should a rupture or leak occur the assembly should be rejected (Repairs shall be made and the entire assembly and test proceedures repeated.)

4.4 Sign and date the assembly log, and proceed with "Biological Decontamination". (3098-AS-3300, Section 4.9).

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5.0 TEST LOG

TEST REQUIREMENT No. 3098-TR-3300 | REV A | SERIAL 001 | COMPONENT 533

REF. LINE	TR #	TEST DESCRIPTION	TEST RESULTS OR MEASUREMENTS	PERFORMED BY	PERFORMED DATE
1	4.1	Proof Pressure (Record Pressure and observations)	50 psi - No apparent leaks	ETA	7/31
2	4.2.1	Pressure Drop @ 5 lb/hr	0.12 psid	ETA	8/1
3	4.2.2	@ 10 lb/hr	0.21 psid	ETA	8/1
4	4.2.3	@ 30 lb/hr	0.78 psid	ETA	8/1
5	4.2.4	@ 60 lb/hr	1.56 psid	ETA	8/1
6	4.2.5	@ 90 lb/hr	2.38 psid	ETA	8/1
7	4.2.6	@ 120 lb/hr	3.42 psid	ETA	8/1
8	4.3	Burst Pressure (Record Pressure and observations)	65 psi - No apparent leaks or ruptures	ETA	7/31

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TEST COMPLETED BY: ETA DATE 8/1/73

APPROVED BY: [signature] DATE 8/1/73

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May 8, 1973

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DESIGN ACTIVITY APPROVAL

OTHER APPROVAL

CHEMTRIC, Inc.
9330 WILLIAM STREET • ROSEMONT, IL. 60018

TITLE

TEST REQUIREMENTS

PURGE PUMP
(SSP Component No. 544)

CODE IDENT. NO. 14958

SPEC. NO. 3098-TR-4400 A

REF. ASSY. DWG: 3098-E-4400

SHEET 1 of 5

1.0 Scope: This document describes the test requirements for the SSP Purge Pump (Component No- 544). Two series of tests must be performed. First the adequacy of the pump as purchased, must be verified in this application; second, the characteristics of the fully assembled SSP component (mounting hardward and fittings included) must be measured for conformance with established performance criteria.

2.0 Applicable Documents: These test requirements are drawn to verify that the purge pump meets the important requirements set forth in the documents listed below:

3098-MS-4400, Purge Pump Mini-Spec
3098-D-4400, Purge Pump Assembly Drawing
LR-3610, Performance Curve, Published by Lear Siegler
Model RR10900, Data Sheet, Lear Siegler

3.0 Examination of Product: Inspect for general appearance and for conformance with the pictorial presentation shown by applicable drawings.

4.0 Performance:

4.1 Pump Design Verification Test:
This test shall be performed with the pump as received from the manufacturer. No modifications or assembly subsequent to that by Lear Siegler is permitted.

4.1.1 Ultimate Pressure:
With a short length of tubing, connect an absolute manometer directly to the pump inlet port (blocking the inlet). The inlet port is closest to the larger of the two cylinders. Connect a 115/208 V, 3 phase, 400 HZ power supply of at least 400 W capacity, to the pump motor. Operate the pump until the manometer reading remains constant for one minute. The manometer reading must be lower than 30 MM Hg. Abs. If the absolute pressure is greater than 30 MM Hg check for and repair any leaks in the evacuated line between the pump and the manometer. Should the pressure not fall below the limit stated above within 10 minutes of operation after verifying that no vacuum leaks exist, direct a 100-watt (minimum) lightbulb on the manometer line and pump cylinders to augment drying of the evacuated chambers. After one hour of heating with the pump operating, remove the light bulb, continue pump operation for 10 additional minutes and read the manometer. Should the absolute pressure continue higher than 30 mm Hg the pump shall be rejected for non-conformance with specifications. Record on the test log the lowest absolute pressure reading, and whether the pump is thus far acceptable or rejected.

NOTE: While the above test is essentially a design verification test and the results should apply to all serial numbers of the same pump model, the importance of ultimate pressure capacity is so great that any future pumps purchased for this application should be exposed to the same test procedure described above.

4.1.2 Water Vapor/Droplet Transfer:

Connect a vacuum flask of approximately 2-liter capacity, to the pump inlet with 30 inches of 3/8 OD x 3/16 ID silicone rubber tubing. Move the absolute manometer to a tee located as near as possible to the flask outlet port. Fit the flask stopper with a thermometer located such that its bulb is in the upper half of the flask volume. Fill the flask to between 40% and 50% of its volume with tap water (thermometer bulb out of the water), and close the flask with the stopper. Attach a similar length of silicone tubing to the pump output port and direct it downward.

Orientate the vacuum pump with its ports upward (motor down) and energize the motor. Read the pressure and temperature in the flask; they should correspond to each other at a saturation point. It might be necessary to add heat to the water. (Do not direct a light to the thermometer bulb and generate an erroneous reading.) Several minutes after the onset of saturation within the flask some water vapor condensation should begin forming on the output tube inner walls. Listen to the pump to detect any irregularities in operating sound. Note any apparent slowing or knocking on the test log, or that none is detectable.

When the condensation inside the output tube forms into water droplets, elevate the tube outlet at least 24 inches higher than the pump output port - so that the water droplets cannot "fall" out of the tube. Operate the pump in that test configuration for at least 2 hours, or until water droplets spurt from the open end of the elevated output tube. Listen for operating irregularities and record any irregularities on the log.

Should the pump malfunction, or be suspected of malfunctioning, during this test, contact the project engineer for an evaluation and possible re-direction of the test.

4.1.3 Ultimate Pressure Re-Check:

After exposure to water vapor repeat the test desribed in 4.1.1. Record the ultimate absolute pressure attained, and notify the project engineer of any degradation (or improvement) in that reading.

4.2 Assemble the pump and the parts shown on the assembly drawing to produce SSP Component No. 544.

4.2.1 Leak Check:

Attach an absolute manometer to the inlet CPV fitting and a short length (approx 6 inches) of plastic tubing to the outlet CPV fitting. Operate the pump to verify the ultimate absolute pressure reading measured earlier. Pinch the short outlet tube closed with a clamp, stop the pump and read the manometer after one minute. Record the rate of pressure rise on the test log in terms of MM Hg/ Minute over a 5-Minute period. Disconnect plumbing and electrical cable at the interfaces to component 544.

4.2.2 Weight:

Weigh the pump assembly in the configuration shown by the assembly drawing and record that weight on the log.

4.3 Clean the assembly and place into tested-component storage.

4.4 Sign & date the assembly log.

CHEMTRIC, Inc.

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TEST LOG

TEST REQUIREMENT No. 3098-TR-4400 | REV A | SERIAL 001 | COMPONENT 544

REF. LINE	TR ¶	TEST DESCRIPTION	TEST RESULTS OR MEASUREMENTS	PERFORMED BY	DATE
11	4.1.1	Ultimate Pressure (30 mm HgA)	26 MM Abs (OK)	AM	8-10-73
2	4.1.2	Flask Pressure	29 mm Abs	AM	8-11-73
		Vapor Temperature	28 °C (82°F)	AM	8-11-73
3	4.1.2	Observations: Outlet downward	OK, WATER DROPLETS PASSED OUTWARD		8-11-73
		Outlet Upward	OK, WATER DROPLETS PRESENT & NO INTERFERANCE W/ NORMAL OP'N		8-11-73
4	4.1.3	Ultimate Pressure Recheck	26 MM Abs SAME	AM	8-11-73
			t= 0 26 mm		
5	4.2.1	Leak Check	Abs Press. @ t= 1 min. 42 mm		
			t= 2 min. 59 "		
			t= 3 min. 74 "		
			t= 4 min. 90 "		
			t= 5 min. 114 "	AM	8-10-73
6	4.2.2	Weight	9.5 lb		8-11-73
7	4.3	Storage Preparation	OK		9-8-73

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TEST COMPLETED BY: AM DATE 8/11/73 | APPROVED BY: [signature] DATE 8/11/73 | SHEET 5 OF 5

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DRAFTSMAN
T.G.Studt

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OTHER APPROVAL

CHEMTRIC, Inc.
9330 WILLIAM STREET • ROSEMONT, IL. 60018

TITLE

TEST REQUIREMENTS
LIQUID PUMP
(SSP COMPONENT 548)

CODE IDENT. NO. 14958

SPEC. NO. 3098-TR-4800 A

REF ASSY. DWG: 3098-R-4800

SHEET 1 of 8

1.0 Scope: This document describes the test requirements for the SSP Liquid Pump (Component No. 548). The component consists of three individual gear pumps which are to be tested together and either accepted or rejected as an assembly. Three series of tests must be performed. First, the performance parameters of the three pumps under operating conditions using tap water, 30% solids recycle liquor and 50% solids recycle liquor must be verified; second, a 100 hour life test of all three pump stages using 50% solids recycle liquor must be run for operating capability and; third, a proof pressure test of the pump must be run to insure structural integrity.

2.0 Applicable Documents: These test requirements are drawn to verify that the assembly meets the important requirements set forth in the following documents.

3098-MS-4800, Liquid Pump Mini-Spec
3098-AS-4800, Liquid Pump Assembly Procedure
3098- R-4800, Liquid Pump Assembly Drawing

3.0 Examination of Product: Inspect for general appearance of the assembly and for conformance with the pictorial presentation shown by the assembly drawings. Check to confirm that workmanship is of acceptable quality and that no incompletions are apparent.

4.0 Performance:

4.1 Preparation: Install the MDV mounting adapters to both banks of the pump manifold. Connect the feed outlet MDV to a simulated distillation evaporator as shown in figure TR-548-1 (Test Schematic). Connect the evaporator to an ice trap and then a vacuum pump. The vacuum pump should have a pumping capability of at least 20 mm Hg. Tee the evaporator-trap line and connect to an absolute manometer. Connect the evaporator outlet to a restrictor valve and then, to the recycle inlet MDV. Install a line to the feed inlet MDV. Connect the line to a valve, 0-300 CC/min flow meter and the outlet of a simulated recycle tank as shown in figure TR-548-1. Install a pressure gauge in the recycle tank and tee to a relief valve with a cracking pressure of 8 ± 2 psig. Connect the recycle tank inlet to a 0-300 CC/min flow meter and the recycle outlet MDV. Connect the recycle tank to a compressed gas source capable of 5 psig.

Connect the condensate inlet MDV to a restrictor valve and the outlet of a simulated distillation condenser. Tee the above absolute manometer and connect to the condenser. Install a line from the condenser inlet to a NC solenoid valve. Connect the other side of the valve to the outlet of a storage tank. Install a float valve in the storage tank and wire it to the solenoid valve so that when the level within the tank becomes excessive the valve opens thus lowering the level. Connect a 0-200 CC/min flowmeter to the storage tank inlet and the condensate outlet MDV. Connect the storage tank to a compressed gas source capable of 30 psig. Install a pressure gauge and tee to a relief valve with a cracking pressure of 35 ± 2 psig.

4.2 Test:

4.2.1 Zero Check: With all tanks empty and all power off, read all gauges, flowmeters, and manometer. Record on the test log.

4.2.2 Calibration:

4.2.2.1 Condensate Stage: Fill the condenser tank with an appropriate amount of tap water. Fill the ice trap with a mixture of dry ice and acetone. Turn on the vacuum pump and pressurize the storage tank to 30 psig. Turn on the power supply for the solenoid valve subsystem. Close the recycle and feed control valves. When the absolute pressure reaches 20 mm Hg turn on the 400 Hz 3Ø power supply to the liquid pump. Open the condensate restrictor valve and adjust to allow 15-30 CC/min flow on the condensate flowmeter. Allow to run after adjustment for at least 10 solenoid valve cycles. Record flowmeter reading (Qc), storage tank pressure (Ps), absolute pressure (Pa) and storage tank pressure (Ps) on the test log. Turn off liquid pump and vacuum pump power.

4.2.2.2 Zero Solids: Fill the recycle tank and evaporator tank with an appropriate amount of tap water. Pressurize the recycle tank to 5 psig. Start the vacuum pump. When Pa reaches 20 mm Hg, turn on a 400 Hz 3Ø power supply to the liquid pump connector and open the feed and recycle valves. When the recycle and feed flowmeters stabilize (maintain repetitive readings for about 5 minutes), record the recycle and feed flowmeter readings (Qr, Qf), Pa and the recycle tank pressure (Pr). Turn off all power, depressurize and drain.

4.2.2.3 30% Solids: Repeat 4.2.2.2 only with a recycle liquor containing 30% solids. After draining run the recycle and feed pumps with tap water to clean out the system. Pressurization is not necessary.

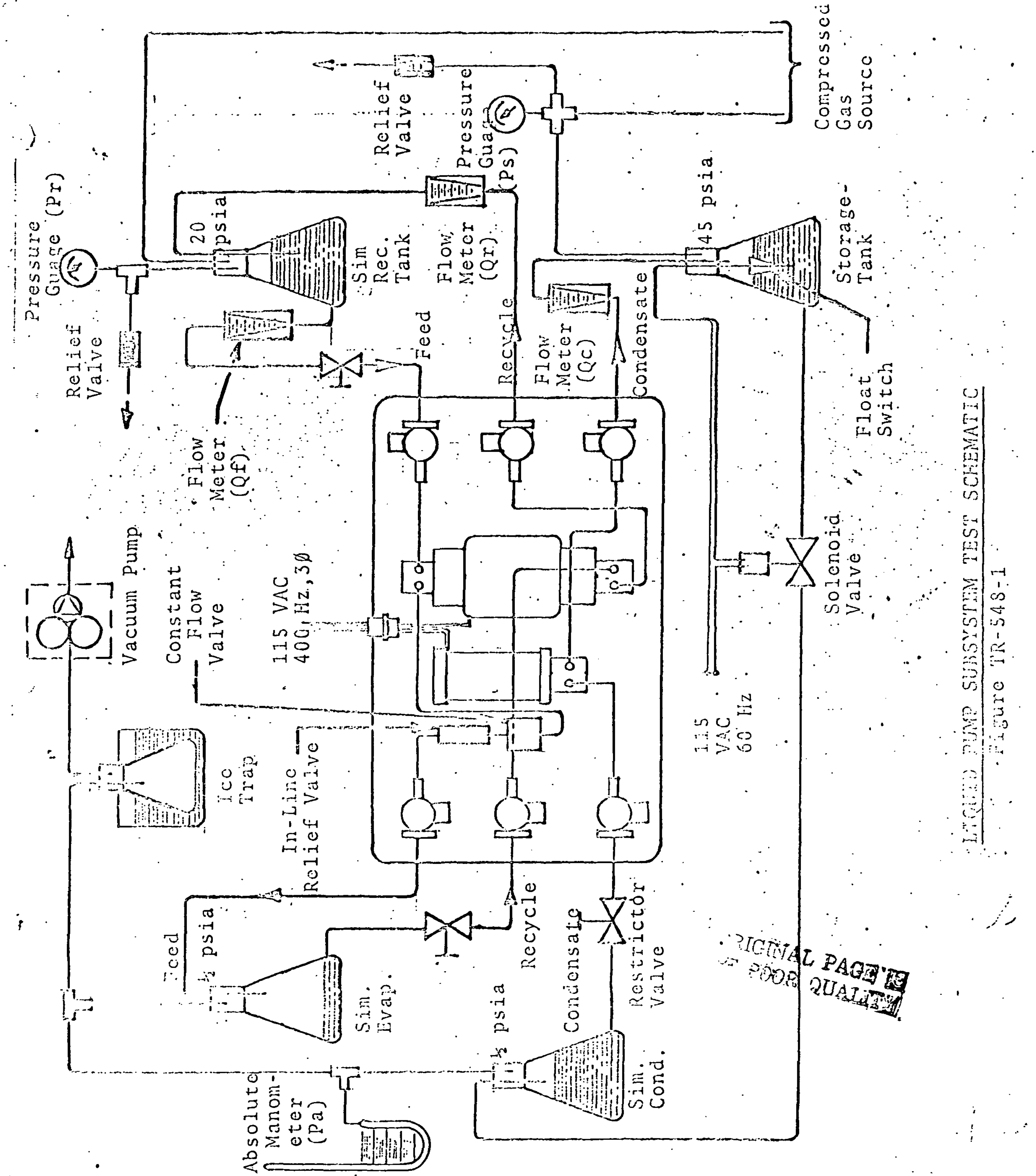
4.2.3 Life Test: Repeat the procedure of 4.2.2.2 only with a recycle liquor containing 50% solids.

One Time Only: Continue the above test along with the tap water filled condensate stage (ref. para. 4.2.2.1) under test conditions for 100 hours. Monitor and record the time and day, Qr, Qf, Qc, Pr, Ps, Pa, and cumulative operating hours on the test log. Make at least two recordings per day, equally spaced.

After draining run the recycle and feed pumps with tap water to clean out the system. Pressurization is not necessary.

4.2.4 Recalibration: Rerun 4.2.2.2 and record results on test log.

4.2.5 Proof Pressure: Remove all accessory equipment from the component and connect the pump adapter manifold to a compressed gas source. Place a wooden barrier between the pump and any personnel who might be endangered by a potential explosion of the pump assembly. Increase the gas pressure to 40 psig, hold that pressure for one minute then decrease pressure to 39 psig. Any observable gas leaks at this pressure must be rectified by the same procedures detailed in 3098-AS-4800. Record results on test log.



LIQUID PUMP SUBSYSTEM TEST SCHEMATIC
Figure TR-548-1

CHEMTRIC, inc.
5350 WILLIAM STREET • ROSEMONT, IL 60018

TEST LOG

TEST REQUIREMENT No. 3098-TR-4800 | REV | SERIAL 001 | COMPONENT 548

REF. LINE	TR §	TEST DESCRIPTION		TEST RESULTS OR MEASUREMENTS	PERFORMED BY	DATE
1	3.0	Examination of Product		OK, Some Roughness Around Mav welds	DK	9/9/73
22	4.2.1	Zero Check: Recycle Tank Pressure Pr		0 PSIG	TWB	10Sep73
		Storage Tank Pressure Ps		0 PSIG	TWB	10Sep73
		Recycle Flowmeter Qr		0 cc/min.	TWB	10Sep73
		Feed Flowmeter Qr		0 cc/min.	TWB	10Sep73
		Condensate Flowmeter Qf		0 cc/min.	TWB	10Sep73
		Absolute Pressure Pa		atmospheric	TWB	10Sep73
3	4.2.2.1	Calibration: Qc	cc/min	50 | 200 | 40 | 0 | 100 | 190 | 100 | 0 | 50	TWB	10Sep73
		Ps	PSIG	0 | 0 | 0 | 0 | 0 | 30 | 30 | 30 | 30	TWB	10Sep73
		Pa	mm Hga	36 | 64 | 50 | 33 | 45 | 100 | 94 | 75 | 85	TWB	10Sep73
		~~Ps~~		Cavitates @ Pa = 33 to 75 torr		
4	4.2.2.2	Calibration: 0% Solids				
		(w/ by-pass spring out) Qr	cc/min	0 | 200+ | 200+ | Cannot pump	TWB	10Sep73
		Qf	cc/min	150 | 150 | 150 | Vapor if suction	TWB	10Sep73
		Pa	mm Hga	20 | 35 | 26 | pressure is less	TWB	10Sep73
		Pr	PSIG	5 | 5 | 5 | than 50 mmHga	TWB	10Sep73
5	4.2.2.3	Calibration: 30% Solids				
		Qr				
		Qf				
		Pa				
		Pr				
6	4.2.3	50% Solids Life Test				
		Time				
		Day				
		Qr				
		Qf				
		Qc				
		Pr				
		Ps				
		Pa				
		Cumulative Hours				

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TEST COMPLETED BY: RAB DATE 9/11/73 | APPROVED BY: D. Nuccio DATE 9/11/73 | SHEET 6 OF 5

CHEMTRIC, Inc.
9330 WILLIAM STREET • ROSEMONT, IL. 60018

TEST LOG

TEST REQUIREMENT No.	REV	SERIAL	COMPONENT
3098-TR-4800		001	548

REF. LINE	TR ¶	TEST DESCRIPTION	TEST RESULTS OR MEASUREMENTS	PERFORMED BY	DATE
		Time			
		Day			
		Qr			
		Qf			
		Qc			
		Pr			
		Ps			
		Pa			
		Cumulative hours			
7	4.2.4	Recalibration: 0% Solids			
		Qr			
		Qf			
		Pa			
		Pr			
8	4.2.5	Proof Pressure: Hold 40 psig then 59 psig	Pressure Tested to 30 psig in Assy, and 40 psig each line (To verify no leak)	[illegible]	9/10/73
		Weight, E/S installed	47.2 Lb	[illegible]	9/12/73

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STREET • ROSEMONT, IL 60018 | TEST REQUIREMENT NO. 3098-TR-1800 | REV 1 | SERIAL 002 | 548

TR ¶	TEST DESCRIPTION	TEST RESULTS OR MEASUREMENTS	PERFORMED BY	DATE
3.0	Examination of Product			
4.2.1	Zero Check: Recycle Tank Pressure Pr	5.5 PSIG		
	Storage Tank Pressure Ps	23. PSIG	[illegible]	2/7/74
	Recycle Flowmeter Qr	190 ml/min		
	Feed Flowmeter Qr	175 ml/min		
	Condensate Flowmeter Qf	~175 ml/min		
	Absolute Pressure Pa	16 mm Hg Abs		
4.2.2.1	Calibration: Qc	175 ml/min		
	Ps	23 PSIG		
	Pa	16 mm Hg Abs		
	Ps	23 PSIG		
4.2.2.2	Calibration: 0% Solids			
	Qr			
	Qf			
	Pa			
	Pr			
4.2.2.3	Calibration: 30% Solids			2/7/74
	Qr			
	Qf			
	Pa			
	Pr			
4.2.3	Calibration: 50% Solids			
	Or			
	Qf			
	Pr			
	Pa			
4.2.5	Proof Pressure: Hold 40 psig then 39 psig			

Handwritten across results: "Settling No. 2 Tests Postponed – will be done under NAS9-13774 [illegible] 2/8/74 Witnessed: William [illegible]"

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COMPLETED BY: TSB & PN. DATE 2/8/74 | APPROVED BY: D. [illegible] DATE 2/8/74 | SHEET 8 OF 8

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ORIGINAL DATE
March 20, 1973

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DESIGN ACTIVITY APPROVAL

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CHEMTRIC, Inc.
9330 WILLIAM STREET • ROSEMONT, IL. 60018

TITLE

TEST REQUIREMENTS

LIQUID WASTE TANK & QUANTITY GAGE

(SSP Components 561 & 576)

CODE IDENT. NO. 14958

SPEC. NO. 3098-TR-6100

A

REF ASSY. DWG: 3098-R-6100

1.0 Scope: This document describes the test requirements for the SSP Waste Storage Tank (Component No. 561) assembled with its quantity sensor, (Component No. 576). These two components are to be tested together and either accepted or rejected as an assembly of two components.

2.0 Applicable Documents: These test requirements are drawn to verify that the assembly meets the important requirements set forth in the following documents:

3098-MS-6100, Waste Tank Mini-Spec
3098-MS-7600, Q-Sensor Mini-Spec
3098-R-6100, Waste Tank Assembly Drawing
3098-D-7600, Q-Sensor Assembly Drawing
3098-AS-6100, Waste Tank Assembly Procedure

3.0 Examination of Product: Inspect for general appearance of the assembly, and for conformance with the pictorial presentation shown by the assembly drawings. Open the over-center latch on the tank to inspect the quantity sensor. Check that both cables from the sensor are attached to the hooks on the back side of the piston. Check to confirm that workmanship is of acceptable quality and that no incompletions are apparent. Re-close the tank and over-center latch.

4.0 Performance:

4.1 Preparation: Connect a compressed air line regulated to 5 ± 1 psig to the CPV on the tank. Connect a Cole-Parmer/Barnant peristaltic pump to the MDV so that it delivers its output to the tank and it draws its intake from a graduated cylinder. Connect a 0 to 30 psi pressure gage to the pump output line and connect two ohm meters to the electrical connector located on the tank wall to read the resistance between pins A & B and between pins E & F. Set the meters to a scale on which 1000 ohms can be read on the upper 40 percent of full scale. Apply 5 psig to the CPV, flood the pump inlet with tap water and operate the pump to deliver 1 liter of water to the tank. Open the pump output line and let the water escape to purge any gas from the tank. Repeat the purge operation until each liter of water is expelled without containing gas.

4.2 Test:

4.2.1 Zero Check: With the tank empty of water, except for that trapped in the liquid end, read the ohm meters and record on the test log.

4.2.2 Calibration: Deliver one liter (±5 cc) of water, without air, to the tank and read the ohm meters; record readings on the test log. Repeat one-liter deliveries, meter readings and recordings until 17 liters have been added to the tank.

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4.2.3 Proof Pressure: Close the water input line with a pinch clamp or a shut-off valve. Place a wooden barrier between the tank and any personnel who might be endangered by a potential explosion of the tank. Increase the gas pressure to 22 psig, hold that pressure for one minute then decrease pressure to 21 psig. Observe the tank for leaks. The tank assembly was checked for leaks at a lower pressure during assembly, Any observable liquid or gas leaks at this pressure must be rectified by the same procedures detailed in 3098-AS-6100.

4.2.4 Liquid Capacity, Maximum: Decrease the gas pressure to 5 psig and resume pumping water into the tank, recording the volume pumped (in excess of the contained 17 liters) on the test log. Continue pumping until the pressure gage in the pump output line begins to show a pressure higher than the gas pressure, indicating that the tank's liquid capacity has been reached. Stop the pump when the pressure reaches 6 psig. Record the ohm meter readings and total volume pumped (including the contained 17 liters) on the test log. Open the liquid line and drain the tank into a graduated cylinder. Measure and record the quantity of water expelled. Disconnect the fittings and electrical attachments. Clean and dry the tank.

CHEMTRIC, Inc.

9330 WILLIAM STREET • ROSEMONT, IL 60018

5.0 TEST LOG

TEST REQUIREMENT No. 3098-TR-6100 | REV | SERIAL 001 | COMPONENT 561/576

REF. LINE	TR ¶	TEST DESCRIPTION	TEST RESULTS OR MEASUREMENTS	PERFORMED BY	PERFORMED DATE
1	3.0	Examination of Product			
2	4.2.1	Zero Check, Resistance Pins A&B, E&F	A→B E→F 1.2Ω .8Ω	TB	2/7/74
3	4.2.2	Calibration, 1 Liter Pins A&B, E&F	84 Ω 80Ω		
		2 Liters " " "	180 Ω 180Ω		
		3 " " " "	240 Ω 245Ω		
		4 " " " "	320 Ω 325Ω		
		5 " " " "	420 Ω 420Ω		
		6 " " " "	520 Ω 510Ω		
		7 " " " "	600 Ω 600Ω		
		8 " " " "	700 Ω 700Ω		
		9 " " " "	750 Ω 770Ω		
		10 " " " "	840 Ω 880Ω		
		11 " " " "	920 Ω 940Ω		
		12 " " " "	960 Ω 1040 Ω		
		13 " " " "	1130 Ω 1150 Ω		
		14 " " " "	1250 Ω 1290 Ω		
		15 " " " "	1360 Ω 1400 Ω		
		16 " " " "	1460 Ω 1475 Ω		
		17 " " " "	1500 Ω 1500 Ω		
		18 " " "	1590 Ω 1600 Ω		
4	4.2.3	Proof Pressure, hold 22 psig, then 21 psig			
5	4.2.4	Liquid Capacity, Resistance Pins A&B, E&F	1600		
6	4.2.4	Liquid Quantity Expelled, Liters	18		

[signatures] William F. Remley 2/8/74

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TEST COMPLETED BY: TED BOBICZ DATE 2/7/74 | APPROVED BY: [signature] DATE 2/7/74 | SHEET 4 OF 4

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May 4, 73

DRAFTSMAN
P. Nuccio

CHECKER
R A Bambenek

ENGINEER
P. Nuccio

APPROVED
R A Bambenek

DESIGN ACTIVITY APPROVAL

OTHER APPROVAL

CHEMTRIC, Inc.
9330 WILLIAM STREET • ROSEMONT, IL. 60018

TITLE

TEST REQUIREMENTS
RECYCLE TANK

(SSP Component No. 562)

CODE IDENT. NO. 14958

SPEC. NO. 3098-TR-6200

A

REF. ASSY. DWG: 3098-R-6200

SHEET 1 of 4

1.0 Scope: This document describes the test requirements for the SSP Recycle Tank (Component No. 562).

2.0 Applicable Documents: These test requirements are drawn to verify that the assembly meets the important requirements set forth in the documents listed below;

3098-MS-6200, Recycle Tank Mini-Spec
3098-R-6200, Recycle Tank Assembly Drawing

3.0 Examination of Product: Inspect for general appearance and for conformance with the pictorial presentation shown by the assembly drawing. Check to confirm that workmanship is of acceptable quality and that no incompletions are apparent.

4.0 Performance: Measurements of certain performance criteria must be made, some of which are to be simply recorded on the Test Log. Other more critical parameters must be within a specified range for acceptance of the assembly.

4.1 Dry Weight
Weigh the dry tank on a balance of accuracy better than ± .5 lb, and record that weight on the test log.

4.2 Pressure Drop at Rated Flow
Place the tanks in a vertical orientation with the MDVs at the top. Connect a tap water line to the inlet MDV (inlet is off-center, outlet is on-center), and direct the outlet to a sink or drain. Fill the tank with water and continue water flow for 10 minutes after the drain connection flows free of air. The water flow rate should be between 2 & 3 gpm during the 10-minute flush.

Attach a water manometer, at least 24-inches high, between the inlet & outlet MDVs. (Plastic tees may be applied in the lines to facilitate this connection.)

Adjust the tap water flow rate to 15 lb/hr (114 ± 5 cc/min) and read the manometer to the nearest 1/4-inch. Record the manometer reading on the test log.

Adjust the water flow rate to 20 lb/hr (152 ± 5 cc/min). Read and record the pressure drop registered on the manometer.

Adjust flow rate to 25 lb/hr (190 ± 5 cc/min). Read & record the pressure drop.

Adjust flow rate to 30 lb/hr (228 ± 5 cc/min). Read & record the pressure drop.

4.3 Leak Check and Proof Pressure Check:
Close the outlet MDV & disconnect that line. Replace the manometer at the inlet tee with a 0-60 psi pressure gage. Disconnect the tap water line and place a Barnant peristaltic pump in the inlet line (pump outlet discharging to tank inlet and pump inlet drawing from a 1-liter beaker of tap water). Operate the pump

until the pressure gage reads 30 ± 2 psi. Stop the pump and inspect the tank for water leaks - while it is holding that pressure. Any leaks must be repaired and the test repeated before proceeding. The potential leak locations are (1) at the weld joints and (2) at the flange interface, which is sealed by an O-ring. Leaky seams must be re-welded; a leaky flange requires inspection of the seal-faces and/or replacement of a faulty seal. Record on the test log that the leak and proof pressure checks have been passed.

4.5 Wet Weight:
Close the inlet MDV, disconnect the plumbing and weigh the assembly while it is full of water. Record the weight on the test log.

4.6 Storage Preparation:
Drain the water from the tank through both MDVs, tip the tank so that both MDVs are downward.

Connect the Silver-Ion Sterilizer (Comp. No. 597) into the tank inlet line and refill the tank with de-ionized water which has passed through the sterilizer - by the procedure described in 4.2. Continue the flow of Ag+ dosed water for 10 minutes after flow begins to exit the outlet MDV, but at a rate between 0.2 and 0.5 gpm. After the flush cycle has been completed close both MDVs, disconnect all plumbing, dry the exterior of the tank and place components 597 and 562 into finished-component storage. Enter on the log that the tank has been prepared for storage.

4.7 Sign & Date the Test Log.

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5.0 TEST LOG

TEST REQUIREMENT NO. 3098-TR-6200 | REV A | SERIAL 001 | COMPONENT 562

REF. LINE	TR ¶	TEST DESCRIPTION	TEST RESULTS OR MEASUREMENTS	PERFORMED BY	PERFORMED DATE
1	4.1	Dry Weight	22 LB	PN	8-20
2	4.2	Pressure Drop @ 15 lb/hr	0.3 IN. H_2O	PN	8/20
3	4.2	Pressure Drop @ 20 lb/hr	0.45		
4	4.2	Pressure Drop @ 25 lb/hr	0.65		
5	4.2	Pressure Drop @ 30 lb/hr	0.8 IN H_2O		
6	4.3	Leak Check	34. PSIG, (NO LEAKS)		
7	4.3	Proof Pressure (Record Pressure)	34 PSIG, NO LEAKS OR DEFORMATION		
9	4.5	Wet Weight	67 LB	PN	8/29/73
10	4.6	Storage Preparation	OK	PN	8/29/73

TEST COMPLETED BY: P. Nuccio DATE 8/20/73

APPROVED BY: P. Nuccio DATE 8/29/73

SHEET 4 OF 4

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[illegible] May 2, 1973

[illegible] T. G. Studt

[illegible] (signature)

ENGINEER T. G. Studt

APPROVED [illegible] (signature)

[illegible]

TITLE

TEST REQUIREMENTS
VAPOR COMPRESSION VACUUM DISTILLATION UNIT
DRIVE MOTOR & LIQUID LEVEL SWITCH

(SSP Components 591, 539 & 571)

DESIGN ACTIVITY APPROVAL

OTHER APPROVAL

CODE IDENT. NO. 14958

SPEC. NO. 3098-TR-9100

A

REF ASSY. DWG: 3098-R-9100

SHEET 1 of 10

1.0 Scope:

This document describes the test requirements for the SSP Vapor Compression Vacuum Distillation Unit (Component No. 591) assembled with its drive motor (Component No. 539) and its liquid level sensor (Component No. 571). These three components are to be tested together and either accepted or rejected as an assembly of three components.

2.0 Applicable Documents:

These test requirements are drawn to verify that the assembly meets the important requirements set forth in the following documents:

3098-MS-9100	Distillation Unit Mini-Spec
3098-MS-3900	Drive Motor Mini-Spec
3098-MS-7100	Liquid Level Sensor Mini-Spec
3098-R-9100	Distillation Unit Assembly Drawing
3098-D-3900	Drive Motor Assembly Drawing
3098-C-7100	Liquid Level Sensor Assembly Drawing
3098-AS-9100	Distillation Unit Assembly Procedure

3.0 Examination of Product:

Inspect for general appearance of the assemblies and for conformance with the pictorial presentation shown by the assembly drawings. Rotate the drive pinions on the still and drive motor for free running operation. Check to confirm that the workmanship is of acceptable quality and that no incompletions are apparent.

4.0 Performance:

4.1 Preparation: Install the assembled still (Comp. 591) in the slide rails of its module. Secure the captive screws (2) on the rails. Install the MDV/CPV mounting adapter to the matching MDVs and CPV. Secure the adapter to the MDVs with twelve screws (MS 16996-11) and tighten the matching CPV fitting. Install the still drive motor (Comp. 539), aligning the drive pinion with its mate in the magnetic drive housing. Position the connector "forward". Secure the three drive motor captive screws. Connect and secure the harness-side connectors to Components 591, 571, and 539.

Connect the purge CPV to (respectively) a valve, ice trap, and vacuum pump with a minimum capability of pumping to 20 mm Hg, As shown in figure TR-591-1 (Test Schematic). Connect the feed MDV adapter to a restrictor valve and a Cole-Parmer/Barnant peristaltic pump so that the pump delivers its output thru the valve to the still. On the inlet side of the pump, install a flowmeter (0-300 cc water/min). Connect the condensate MDV adapter to a Cole-Parmer/Barnant peristaltic pump so that the pump delivers its output to a holding tank. Make provisions on this holding tank for draining and measurement of the drainings. Connect the recycle MDV adapter to another Cole-Parmer/Barnant peristaltic pump so that its output is delivered to a valve and then a storage tank. Gang the three peristaltic pumps described to a drive motor capable of driving the pumps at 140 rpm, install a feed capability to the storage tank, and connect the tank's outlet to the restrictor valve inlet on the feed line.

Connect an absolute manometer to one outlet of the condenser pressure line. Connect the other outlet to one side of a differential manometer. Connect the other side of the differential manometer to the evaporator pressure line tee (i.e. near Component 571). The absolute manometer should be capable of reading to 20 mm Hg while the differential manometer should have a 0 - .50 psi (or equivalent) scale.

Connect the still connector harness (i.e. speed sensor) to the appropriate terminals on a Tektronix 545 (or equivalent) oscilloscope. Connect the drive motor connector harness to a 115 VAC, 400 Hz, 3Ø, Wye power supply. Connect the liquid level switch connector harness to a VOM.

Install an insulation barrier (i.e. cabinet) completely surrounding the distillation unit and drive motor as shown on figure TR-591-1. Do not enclose any equipment that has to be adjusted or read. Install a thermometer in the insulated cabinet in such a way as to be either read directly or capable of being withdrawn without opening of the cabinet.

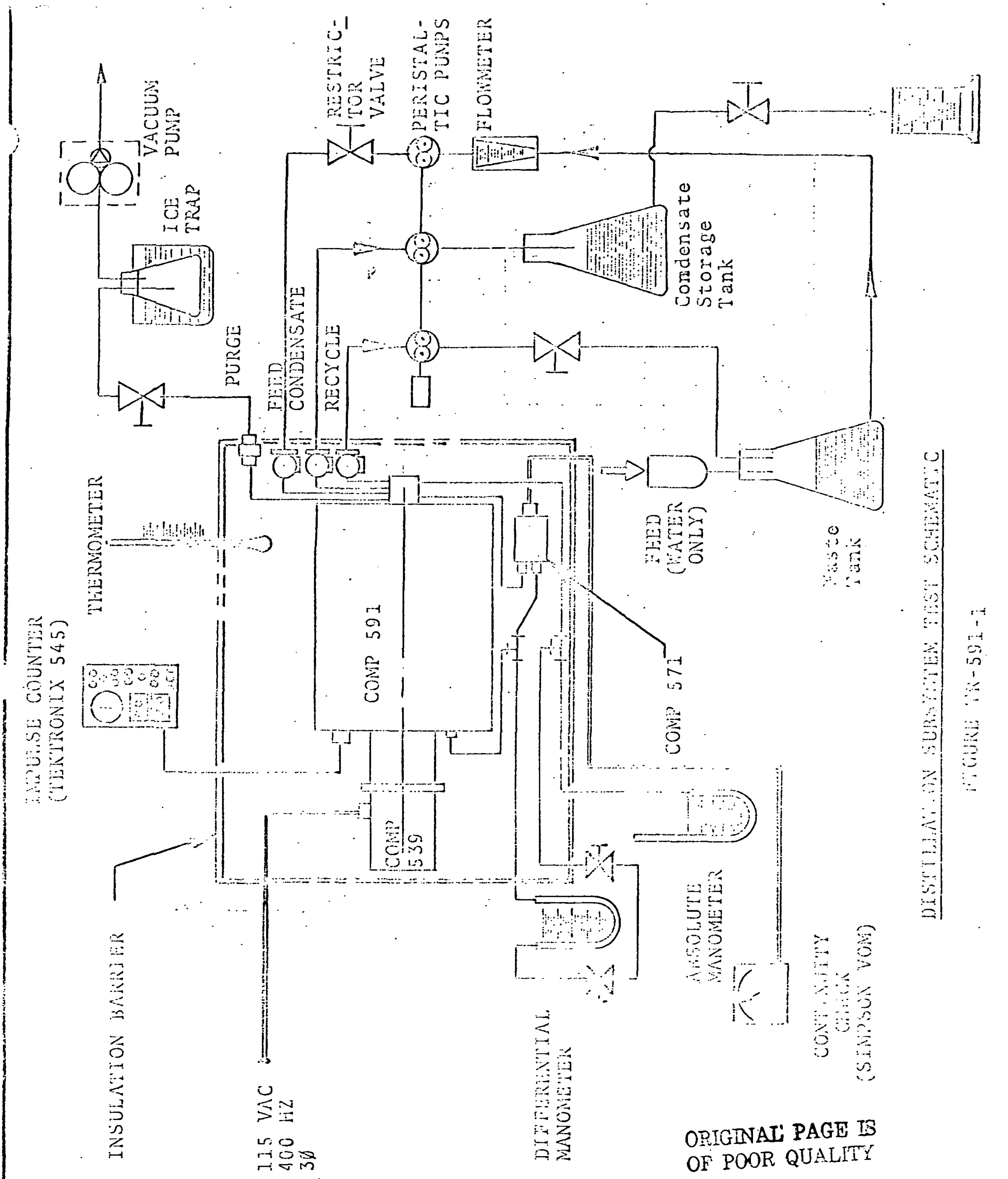
4.2 Test:

4.2.1 Zero Check: With the drive motor power supply and the vacuum pump both in off conditions, read:

impulse counter
differential manometer
absolute manometer
thermometer
flowmeter
and the VOM

The VOM should be set to the 10 K-R scale and on DC. Record these readings on the test log.

4.2.2 Proof Pressure: Isolate the differential manometer from the still. Close the purge line, feed line and recycle line valves. Place a pinch clamp on the condensate line and close. Remove the line to the absolute manometer and connect to a compressed air line. Place a wooden barrier between the still and any personnel who might be endangered by a potential explosion of the still. Increase the gas pressure to 15 psig, hold that pressure for one minute, then decrease pressure to 14 psig. Observe the liquid level switch housing and still for any leaks. Any observable gas leaks at this pressure must be rectified before proceeding. Record on test log. If no gas leaks are detected, decrease the gas pressure to atmospheric and isolate the liquid level switch. Increase the gas pressure to 22 psig and hold for one minute. Decrease the pressure to 21 psig and observe for gas leaks on the still. The still was checked for leaks at a lower pressure during assembly. Any observable gas leaks at this pressure must be rectified by the same



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CHEMTRIC, Inc. 9330 WILLIAM STREET • ROSEMONT, IL 60018	CODE IDENT. NO. 14958	SHEET 4 OF 10
TITLE TEST REQUIREMENTS DISTILLATION UNIT, DRIVE MOTOR & LIQ. LEVEL SWITCH (591, 539, 571)	SPEC. NO. 3098-TR-9100	REV A DATE 8/14/73

procedures detailed in 3098-AS-9100. If no leaks are detected, record on test log and decrease pressure to atmospheric. Reconnect the two manometers and liquid level switch and open the four previously closed liquid line valves.

4.2.3 Startup: Open the purge line valve, fill the ice trap with a mixture of dry ice and acetone and start the vacuum pump. When the pressure decreases to 20 mm Hg on the absolute manometer, start the drive motor and peristaltic pump motor. Open the feed and recycle line valves and deliver 500±5 ml of tap water to the feed storage tank. Adjust the feed restrictor valve to allow 225±5 cc/min to be shown on the flowmeter. Record the thermometer temperature (T), absolute manometer pressure (Pa), differential manometer pressure (P), impulse counter (N), time (t) and amount of feed water delivered to the storage tank (V) on the test log.

4.2.4 Operational Performance: As the feed is used up in the storage tank, deliver 500±5 ml more feed to the tank. Do not allow to run dry. Record volume and time delivered on the test log. Continue this method of delivery until there is an output in the holding tank or a maximum of 2500 ml is delivered, whichever comes first. After approximately 100 ml of condensate accumulates in the holding tank, withdraw it, measure and record along with the time on the test log. Also record T, Pa, Pd, P, Q and N on the test log.

At thirty minutes after the initial withdrawal of condensate, empty the holding tank, measure and record on the test log along with t, T, Pa, Pd, P, Q and N. Repeat every thirty minutes thereafter to 2½ hours after initial withdrawal. Continue adding 500±5 ml quantities of feed (tap water) to the storage tank as more condensate is produced causing a resultant decrease in the storage tank reserve. Record volumes added and time at addition on test log.

4.2.5 Liquid Level Switch Operation: After the 2½ hour condensate removal period is concluded, close the recycle line valve and continue adding feed to the storage tank as required. Observe the Component 571 continuity check meter and record the time at which the continuity changes (switch reverses).

At an indication of a continuity change in the liquid level switch, stop adding feed, close the restrictor valve and open the recycle line valve. Run until no recycle or condensate are produced, then close all valves and shut off power.

4.2.6 Condensate Quality: Add an amount of salt (NaCl) to a suitable amount of tap water to achieve a mixture resistivity of 100-1000 ohms. Record the resistivity on the test log. Use this mixture as feed and repeat the tests conducted in 4.2.3 - 4.2.4 with the exception being that the 2½ hour condensate withdrawal time is reduced to 1 hour. Repeat readings and recordings on the test log. After the 1 hour time limit, take a sample of condensate and recycle liquor and measure the resistivity of each and record on the test log.

4.2.7 Shutdown: After the resistivity readings are taken, connect the feed line to tap water, the recycle line to a drain and run as before for one hour. Measure the resistivity of the feed water and fresh condensate and record on the test log. Stop addition of feed and close the restrictor valve. Run until no recycle or condensate are produced, then close all valves and shut off power.

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TEST LOG

TEST REQUIREMENT NO. 3098-TR-9100 | REV A | SERIAL 001 | COMPONENT 591, 550, 571

REF LINE	TR ¶	TEST DESCRIPTION	TEST RESULTS OR MEASUREMENTS						PERFORMED BY	PERFORMED DATE
1	3.0	Examination of Product	OK						RB	9/12/73
2	4.2.1	Zero Check:								
		Impulse Counter	OK						TGS	9-11-73
		Differential Manometer	OK						TGS	
		Absolute Manometer	OK						TGS	
		Thermometer	OK						TGS	
		Flowmeter	OK						TGS	
		VOM	OK						TGS	
3	4.2.2	Proof Pressure: Hold 15 psig, then	OK						[illegible]	9-10-73
		14 psig (Comp 571)	OK						[illegible]	9-10-73
4	4.2.2	Proof Pressure: Hold 22 psig, then	OK						TGS	9-10-73
		21 psig (Comp 591)	OK						TGS	9-10-73
5	4.2.3	Startup: Temperature (T) °F	73°F						TGS	9-11-73
		Absolute Pressure (Pa) mm Hg	23 mm Hg TGS						[illegible]	
		Differential Pressure (Pd) mm Hg	6 mm Hg [illegible]						[illegible]	
		Flowmeter (Q) cc/min	195 ml/min						[illegible]	
		Impulse Counter (N) rpm	274 rpm						TGS	
		Time (t) Min	8:35 PM						TGS	
		Feed Volume (V) ml	500 ml						TGS	
6	4.2.4	t	8:40pm	9:55					TGS	
		V	500	500					TGS	
7	4.2.4	Condensate (Vc) ml	140	350	360	750	560	480	TGS	
		t	9:00pm	9:30	9:50	10:30	11:00	11:30	TGS	
		Pa	23	24	25	25	25	25	TGS	
		Pd	6	5	6	6	5	7	TGS	
		Q	180	180	180	180	180	0	TGS	
		N	274	274	274	274	274	274	TGS	

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TEST COMPLETED BY: [illegible] DATE 9/11/73 | APPROVED BY: RGG DATE 9-12-73 | SHEET 7 OF 10

TEST LOG

CHEMTRONICS (?) 9330 WILLIAM STREET • ROSEMONT, IL 60018

TEST REQUIREMENT NO. 2098-TR-9100 | REV A | SERIAL 001 | COMPONENT 591 539

REF LINE	TR #	TEST DESCRIPTION	TEST RESULTS OR MEASUREMENTS					PERFORMED BY	DATE
8	4.2.4	t	9:23	9:50	10:20	[illegible]	11:10	TGS	9/11/73
		V	500	500	500	500	500	TGS	9/11/73
9	4.2.5	t	1=12 min Blast (Change Blown Tube Height)					TGS	9/11/73
		Continuity Change (VOM)	OK - But Lower Tube					TGS	9/11/73
			Finished 9/12/73						
10	4.2.6	Feed Resistivity (Rf) ohms	1000					TGS	9/12/73
11	4.2.6	Startup: T	72°F					TGS	9/12/73
		Pc	19 mm Hg					TGS	9/12/73
		Pd	9 mm Hg					TGS	9/12/73
		Q	180 cc/min					TGS	9/12/73
		N	274 rpm					TGS	9/12/73
		t	6:17 pm					TGS	9/12/73
		V	920 cc					TGS	9/12/73
12	4.2.6	t	6:21					TGS	9/12/73
		V	500 cc					TGS	9/12/73
13	4.2.6	Vc	100	550	970	1150	1585	TGS	9/12/73
		t	6:39	7:07	7:38	7:50	8:21	TGS	9/12/73
		Pc	20	20	20	20	20	TGS	9/12/73
		Pd	8	7	7	7	7	TGS	9/12/73
		Q	180	150	150	150	150	TGS	9/12/73
		N	274	274	274	274	274	TGS	9/12/73
14	4.2.6	t	6:37	6:50	7:27	8:00		TGS	9/12/73
		V	500	500	500	500		TGS	9/12/73
15	4.2.6	Condensate Resistivity (Rc) ohms	170,000 @ 8:21 pm					TGS	9/12/73
		Recycle Resistivity (Rr) ohms	450 Ω @ 8:00 pm					TGS	9/12/73
16	4.2.7	Shutdown: Feed Resistivity (Rf)	1000 Ω					TGS	9/12/73
		Condensate Resistivity (Rc)	170,000 Ω					TGS	9/12/73

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TEST COMPLETED BY: [illegible] DATE [illegible] APPROVED BY: RAB DATE 9-12-73 SHEET 6 OF 10

TEST LOG

9330 WILLIAM [illegible] ROSEMONT, [illegible]

TEST REQUIREMENT No. 3098-TR-9100 | REV A | SERIAL 002 | COMPONENT 591, 539, 571

REF LINE	TR ¶	TEST DESCRIPTION	TEST RESULTS OR MEASUREMENTS					PERFORMED BY	DATE
1	3.0	Examination of Product	OK					[illegible]	11/2/73
2	4.2.1	Zero Check:							
		Impulse Counter	OK, No Signal					[illegible]	11/6/73
		Differential Manometer	OK, Zero ΔP						
		Absolute Manometer	OK, [illegible] Checked Prev.						
		Thermometer	OK, [illegible]						
		Flowmeter	OK, Zero Flow						
		VOM	OK, ∞ Ω						
3	4.2.2	Proof Pressure: Hold 15 psig, then 14 psig (Comp 571)	OK OK						
4	4.2.2	Proof Pressure: Hold 2[illegible] psig, then 21 psig (Comp 591)	OK OK	(Comps 571, 910 [illegible] Not Present. All were prev. checked w/ 571-001)					
5	4.2.3	Startup: Temperature (T) °F	7[illegible] °F						
		Absolute Pressure (Pa) mm Hg	25 mm Hg Abs						
		Differential Pressure (Pd) mm Hg	4 mm Hg Δ						
		[illegible] (Q) cc/min	175 ml/min						
		Impulse Counter (IC) rpm	7[illegible] RPM						
		Time ([illegible]) Min	1[illegible] HRS						
		Feed Volume (V) ml	1000 ml						
6	4.2.4	[illegible]	1510						
		V	1000	(Σ = 2000)					
7	4.2.4	Condensate (Vc) ml	0	320	555	2[illegible]5	1310		
		[illegible]	[illegible]	1[illegible]55	1510	1[illegible]25	1540		
		[illegible]	27	28	28	28	28		
		[illegible]	2½	2½	2½	2½	2½		
		[illegible]	175	175	175	175	175		
		[illegible]	292	294	292	294	294		

TEST COMPLETED BY: [illegible signature] DATE: Nov. [illegible], 1973

APPROVED BY: R. G. B[illegible] DATE: 7 Nov 73

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CHEMTRIC, INC.

9330 WILLIAM STREET • ROSEMONT, IL 60018

TEST LOG

TEST REQUIREMENT No. 3098-TR-9100 | REV A | SERIAL 002 | COMPONENT 591 539 571

REF LINE	TR ¶	TEST DESCRIPTION	TEST RESULTS OR MEASUREMENTS		PERFORMED BY	DATE
8	4.2.4	t	1549	1620	PN	Nov 6,73
		V	1000	1000		
9	4.2.5	t	TEST OF 571 WAS RUN ON STILL SN001			
		Continuity Change (VOM)	(NO DUPLICATE 571 WAS BUILT FOR STILL SN002)			
		Modify test, SN002	RECYCLE FLOW HALTED BY CLOSING VALVE, 8 MIN			
10	4.2.6	Feed Resistivity (Rf) ohms = 160 Ω	AFTER, WATER WAS VISIBLE IN HI-LEVEL LINE FROM			
			STILL ∴ IMPACT TUBE & LINE TO 571 LOCATION IS OK			
11	4.2.6	Startup: T	76°F			
		Pa	28 mm Hg Abs			
		Pd	2½ mm Hg			
		Q	100 ml/min			
		N	294 RPM			
		t	1625 Hrs			
		V				
12	4.2.6	t	1625			
		V	~1000 Feed Resistivity = 160 Ω/cm			
13	4.2.6	Vc	≈ 500	≈ 750		
		t	1645	1658		
		Pa	28	28		
		Pd	2½	2½		
		Q	185	185		
		N	294	294		
14	4.2.6	t				
		V	~~No Additional Feed Req'd~~			
15	4.2.6	Condensate Resistivity (Rc) ohms	155,000 Ω/cm } > 10³			
		Recycle Resistivity (Rr) ohms	138 Ω/cm			
16	4.2.7	Shutdown: Feed Resistivity (Rf)	138 Ω/cm			
		Condensate Resistivity (Rc)	155,000 Ω/cm			

TEST COMPLETED BY: P. Nuccio DATE: Nov 6 1973

APPROVED BY: R. O. Bramlund DATE: 7 Nov 73

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[illegible]
May 12, 1973
[illegible]
P. P. Nuccio
[illegible]
ENGINEER
P. P. NUccio
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DESIGN ACTIVITY APPROVAL
OTHER APPROVAL

[illegible]
[illegible] WILLIAM [illegible]

TITLE

TEST REQUIREMENTS
SILVER-ION STERILIZER

(SSP Component No. 597)

CODE IDENT. NO. 14958

SPEC. NO. 3098-TR-9700 A

REF ASSY. DWG: 3098-D - 9700

SHEET 1 of 4

1.0 Scope: This document describes the test requirements for the SSP Silver-Ion Sterilizer (Component No. 597).

2.0 Applicable Documents: These test requirements are drawn to verify that the assembly meets the important requirements set forth in the documents listed below:

3098-MS-9700, Ag^+ Sterilizer Mini-Spec
3098-D-9700, Ag^+ Sterilizer Assembly Drawing
3098-AS-9700, Ag^+ Sterilizer Assembly Procedure

3.0 Examination of Product: Inspect for general appearance and for conformance with the pictorial presentation shown by the assembly drawing. Check to confirm that workmanship is of acceptable quality and that no incompletions are apparent.

4.0 Performance: This series of tests is to be performed on Component No. 597 after it is assembled per Assembly Proceedure 3098-AS-9700, Sections 4.1 through 4.4, and before "Weigh and Storage Preparation", Section 4.5 of that proceedure.

4.1 Proof Pressure:
With the same set-up applied in paragraph 4.4.10 of 3098-AS-9700, increase the internal pressure to 48±2 psig (the proof pressure). Pump only deionized water (no air) into the canister assembly. While holding that pressure check the canister tube joints and flange for leaks; should any be found they must be repaired before proceeding further. Record the results on the test log, and release the pressure. Do not drain the assembly.

4.2 Pressure Drop:
With plastic tees, connect a 0 to 5 psid differential pressure gage across the component inlet and outlet ports. Dwyer gage Model No. 2205 may be used, but the inlet connection (high-pressure tap) must be connected with a 1-liter sealed flask in the line. The flask must contain only air prior to initiating the test. The Dwyer gage must be mounted higher than either of the plastic tees at the Component 597 ports. (The above precautions are suggested to prevent the entry of water into the gage sensitive elements.)

4.2.1 Connect the inlet port (on the BF) to a source of deionized water and adjust the flow rate to 5 lb/hr (38±3cc/min); read and record the pressure differential.

4.2.2 Adjust the flow rate to 10 lb/hr (76±5 cc/min), read and record the pressure differential.

4.2.3 Repeat at 15 lb/hr (114±5 cc/min)

4.2.4 Repeat at 30 lb/hr (227±5 cc/min)

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4.2.5 Repeat at 45 lb/hr (341 ±10 cc/min)

4.2.6 Repeat @ 60 lb/hr (454±10 cc/min). Disconnect the manometer and plumbing lines. Do not drain the canister.

4.3 Burst Pressure:
With the outlet port blocked by a 0 to 100 psig pressure gage pump deionized water into the inlet port until the gage reads 66±2 psi. Inspect the assembly for ruptures while holding that pressure and enter observations onto the test log. Should a rupture or leak occur, the assembly shall be rejected. (Repairs shall be made and the entire assembly and test procedures repeated.)

4.4 Sign and date the assembly log and proceed with "Weigh and Storage Preparation" (3098-AS-9700, Section 4.5).

50 TEST LOG

9300 WILLIAM STREET - ROSEMONT, IL 60018

TEST REQUIREMENT NO.	REV	SERIAL	COMPONENT
3098-TR-9700		001	597

REF LINE	TR ¶	TEST DESCRIPTION	TEST RESULTS OR MEASUREMENTS	PERFORMED BY	PERFORMED DATE
1	4.1	Proof Pressure (Record Pressure and Observations)	50 psig - No Leaks	FTA	7/21/73
2	4.2.1	Pressure Drop @ 5 lb/hr	0.11 psid	FTA	8/1
3	4.2.2	@ 10 lb/hr	0.17 psid	FTA	8/1
4	4.2.3	@ 15 lb.hr	0.25 psid	FTA	8/1
5	4.2.4	@ 30 lb/hr	0.45 psid	FTA	8/1
6	4.2.5	@ 45 lb/hr	0.78 psid	FTA	8/1
7	4.2.6	@ 60 lb/hr	1.03 psid	FTA	8/1
8	4.3	Burst Pressure (Record Pressure and Observations)	65 psig - No Leaks	FTA	7/26/73
		Wt. As Installed	3.2 lb	[illegible]	8-3-73

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TEST COMPLETED BY: [illegible] DATE 8/1/73 APPROVED BY: [signature] SHEET 4 OF 4

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ORIG. DATE May 31, 1973
DRAFTSMAN P. Nuccio
CHECKER R A Bambenek
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APPROVED R A Bambenek
DESIGN ACTIVITY APPROVAL
OTHER APPROVAL

CHEMTIC, INC.
9330 WILLIAM STREET • ROSEMONT, IL 60018

TITLE

TEST REQUIREMENTS

VAPOR COMPRESSION DISTILLATION ASSEMBLY

(SSP-WWMS)

CODE IDENT. NO. 14958

SPEC. NO. 3098-TR-9800

REV A

REF ASSY. DWG: SVSK 86552

SHEET 1 of 16

1.0 Scope: This document describes the test requirements for the SSP-VCD Assembly. Two series of tests are necessary. The first series will verify the functional and operational adequacy of the assembly. The second series will be run to maximize performance through minor adjustments of certain parameters.

2.0 Applicable Documents: These test requirements are drawn to verify that the VCD Assembly meets the important requirements set forth in the documents listed below.

3098-MS-9800; VCD Mini-Spec
SVSK-86535; Interface Control Spec (HSD)
SVHS-5134; Water & Waste Mgmt. Spec (HSD)
SVSK-86552; VCD Assembly Drawing (HSD)
SVSK-DR-86421; VCD Controller Requirements (HSD)
SVSK-86700;(Sh. 2 of 2) SSP Subsystem Schematic (HSD)
SVSK-H585552 VCD Interface Dwg. (HSD)

3.0 Examination of Product: Inspect the assembly for conformance with the Assembly Drawing. Check that the four fluid interfaces are appropriately marked and are properly located according to the Interface Control Spec. Verify that the electrical connection from the bus to the controller is marked with the necessary identification. Check that no incompletions are apparent and that testing may proceed without electrical or undue mechanical hazard.

4.0 Performance:

4.1 Leak Test: A test to verify that no leaks are present is to be conducted by separating the system into five sections and checking each section independently. Adjacent sections overlap (usually at MDVs) so that every element in the assembly is checked for leaks - including the mating faces between elements.

4.1.1 Attach a laboratory vacuum pump at the inlet to purge pump (544) with an absolute manometer at a tee in that line. Close MDVs Nos. 421-10, 421-09 and 421-06. Start the pump and run until pressure is lower than 35 mm Hg Abs. Stop the pump and hold for 15 minutes, observe the manometer. Should the pressure not change during that period the following components are verified as leak tight: 591, 910, 911, 571 and the 4 lines to 548 and 544. Should the pressure increase over that period those components and/or lines must be investigated for leaks, and all leaks corrected.

4.1.2 Place a cap over WM2-W1, and a 0 to 15 psig pressure gage between 421-20 and 548 (condensate inlet to 548), open 503 and close 421-24, 421-13, 421-19 and 421-20. Apply gas pressure at WM3-W1, read that pressure on the temporary gage, hold 9 to 11 psig for 15 minutes. Should the pressure not decrease over that period the following components and their interconnecting lines are verified as leak tight: 501, 562, 548, 570, 503, 525, 509 and [illegible]. Should the pressure decrease over that period those components and lines must be examined for a leak and the leak(s) corrected.

4.1.3 With the same set-up used above uncap the third port of MDV 421-09 and look for water flowing or dribbling from that opening. Should no water flow after the initial emptying of the line check valve 501 is not leaking internally. If water continues to flow from that hole at a steady rate 501 must be repaired internally.

4.1.4 Remove the internal plug from 501 and install up-side-down (reverse flow/check direction). Close 421-19 and 421-05, cap WM3-W1 and apply gas pressure to WM3-G1 (with a tee to a pressure gage on the pressurizing line). Apply and hold 9 to 11 psig for 15 minutes. Should the pressure remain constant no leaks exist on either side of 561, through the recycle pump portion of 548 nor in any interconnecting lines. A pressure decay requires leak location and rectification

4.1.5 Cap WM2-G1 and evacuate purge line from the pump end; hold 30 mmHg (Abs) for 15 minutes or repair leaks.

4.2 Deleted

4.3 Operational Check Out:

4.3.1 Preparation: Connect a 25 to 30 psid in-line relief valve to the water-out port (WM2-W1) and a source of compressed air to the waste tank gas port (WM3-G1). Connect a 115/208 V, 3-phase, 400 Hz power supply of 1KW min. capacity to the controller (Component No. 573). Install a temporary tee into the distillation unit condenser pressure port (to component No. 910-91), and connect an absolute pressure gage (or manometer) to the branch of that tee. Connect a differentialpressure gage (or two-legged manometer) across the differential pressure transducer (Component No. 911). Put a thermometer or thermocouple junction near the distillation unit at the manifold end-opposite the motor end. Apply 5±1 psi to the waste tank gas port, and discard all water which is driven out of the waste water input port. When the flow of water stops connect a Barnant peristaltic pump which has been filled with deionized water, to the waste input port.

4.3.2 Start-Up: Turn-on the main switch on the controller. Put the peristaltic pump inlet tube into a graduated cylinder containing deionized water and begin pumping water to the waste tank. Do not permit air to pass through the pump and enter the tank. At some water quantity greater than 3 liters the purge pump should begin operating- read the graduated cylinder when that event occurs to determine the quantity of water delivered at that point. Record that quantity on the test log. Do not deliver more than 12 liters to the tank. Should the pump not start before 12 liters have been delivered to the tank a malfunction has occured either in the tank quantity gage (576), the controller (573), the purge pump (544) or in the power supply -- or an open circuit exists in the wiring harness. Contact the project engineer for resolution before proceeding.

In addition to the quantity at which the purge pump begins operating deliver an additional 4 liters of water into the tank and pinch the peristaltic tubing closed to absolutely prevent back leakage.

Watch the absolute manometer, which is reading condenser pressure; at some pressure lower than 45mm HgAbs the following events should occur. Record the manometer reading at which they take place (all should occur simultaneously).

4.3.2.1 Valve No. 503-11 is driven to the "open" position.

4.3.2.2 Valve No. 509-01 is driven to the 525 line.

4.3.2.3 Motor No. 539 is energized and drives the distillation unit.

4.3.2.4 Pump No. 548 is energized.

Should any of those four events fail to occur check the component in question for proper electrical operation by applying external power to its connector. If it operates normally with an external power source check the wiring harness for continuity. If the harness is proven to be uninterupted or otherwise faulty the problem lies within the controller; consult the project engineer for resolution.

4.3.3 Operation: Read and record the condenser pressure (absolute manometer) and the compressor pressure rise (two-legged manometer) at fifteen-minute intervals until condensate is delivered through the inline relief valve located at interface port No. WM2-W1.

4.3.3.1 High Liquid Level Shut Down: With the subsystem operating and while it is distilling water close MDV 421-19 to stop recycle liquor transfer from the evaporator. After a period of time the evaporator level will rise and the following events will occur

A. Valve No. 509-01 is driven to deliver condensate to the recirculation loop.

B. Motor No. 539 and pump No. 544 are stopped when either the condenser pressure exceeds 40mm Hg Abs or the compressor pressure rise exceeds 15mm Hg. Should neither of these conditions occur within 60 minutes the motor and pump will be stopped by a timer.

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Record on the test log whether event A, above, occurs and after what time period, after the MDV is closed, it occurs, and at what pressure levels (Pc & ΔP) event B occurs - or if it occurs when the maximum time has elapsed. Record both pressures at 10 minute intervals during the period between events A&B.

4.3.3.2 Normal Shut Down: Remove the shunt on the 571 connector, replace it on the mating receptacle and restart the sub-system. It might be necessary to add deionized water to the waste tank contents to achieve a start; limit the quantity of water added to that measured in 4.3.2. above, or 4 liters whichever quantity is lesser. With the subsystem operating normally, as established by:

1. $P_c < 40$ mm Hg Abs

2. $\Delta P < 15$ mm Hg, and

3. Condensate Flowing From WM2-W1.

Open the waste tank input port SLOWLY and drain the water contained therein. No measure of that quantity is necessary. When all of the water has been drained the subsystem will have begun the shut-down sequence described in 4.3.3.1. Events A & B should occur in the same sequence. Record whether or not they are repeated, and the pressure readings, at 15 minute intervals, during the 60-minute (maximum) period between events A & B.

4.3.3.3 Conductivity Recycling: Install CHEMTRIC tool No. 3098-T-9891 between the two halves of the MDV at the Liquid Pump (component 548) condensate output port (the lowest of the three MDV's on the right side of Component 548, facing the installation, is the condensate output MDV.) Connect the tube on tool 3098-T-9891 which faces Component 548 to drain; condensate will flow from that tube. Connect the other tube on that tool to the output line of a Barnant peristaltic pump. With another peristaltic pump deliver the quantity of water determined in 4.3.2, to the tank, and restart the subsystem. While waiting for the operating parameters to reach equilibrium, prepare one liter of each solution listed below.

A. NaCl in deionized water - with electrical conductivity of 35 ± 5 micro-mhos/cm (2.50×10^4 to 3.33×10^4 ohms-cm)

B. NaCl in deionized water - with electrical conductivity of 60 ± 5 micro-mhos/cm (1.54×10^4 to 1.82×10^4 ohms-cm)

With the subsystem in normal operation deliver one liter of deionized water through the tool between the component 548 MDV halves. The water will flow through the conductivity meter (570), through the post treatment cells and out the inline relief valve at WM2-W1. Check that water pumped into the loop follows that path and record the observation on the test log.

Pump solution A into the same inlet tube (between the MDV halves); do not permit air to enter the lines. Observe the in-line relief valve; approximately one liter of water should be driven out that valve. Record whether that event occurs.

Pump solution B into the same inlet tube; do not permit air to enter the lines. Solution B should cause valve 509-01 to be driven to the opposite position and divert the water flow to the recirculation loop rather than the post treatment loop. Verify that the valve position has changed when solution B is passed through the conductivity cell (570). Enter observation on the test log. Should the valve not change position prepare one liter of NaCl in deionized water, with electrical conductivity of 80 ± 5 micro-mhos (1.33×10^4 to 1.18 ohms-cm) and pass that solution through the same condensate circuit. Record the conductivity of the solution which affects a change in valve position. Should the valve position not change with any of the salt solutions contact the project engineer for resolution.

Finally deliver ten liters of deionized water through the condensate circuit to flush the highly conductive liquid through

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This water will terminate in the waste tank; therefore, to avoid overloading that tank deliver the ten liters in five 2-liter batches. Between each delivery drain 2 liters from the tank. When the loop has been flushed manually reverse valve no. 509-01 back to the post-treat loop. Should the valve again be driven electrically back to the recirculation loop, repeat the ten-liter flush sequence with deionized water until the valve can be manually reset to the post-treat loop. Record on the test log that the valve has been manually reset - or that it cannot be manually reset. In that case a malfunction has occurred and the project engineer must be contacted for resolution.

Remove the tool between the MDV halves and recouple the MDV; continue operation of the subsystem until water is delivered through the in-line relief valve on WM2-W1.

4.3.3.4 Manual Shutdown: When it is established that the subsystem is in normal operation activate the MANUAL-SHUTDOWN OVER RIDE switch on the controller. The shut-down sequence described in 4.3.3.1 should be repeated automatically. Record that it has - or that a malfunction has occurred.

4.4 Final Check: The checkout and operational tests, having been completed per the above paragraphs, have established that the subsystem can be "fine-tuned" for maximum performance. Some subjectivity is necessary on the part of the test personnel to observe, record and report any suspected areas where product improvement is warranted. No list of what to report as a deficiency can be a complete list; some observations which should be reported are: potential hazards, odors, hot spots, vibrations excessive noise, irregular sounds, smoke, leaks, rattles, discolorations and, of course, any deformations which resulted from the previous series of tests.

5.0 Calibration:

5.1 Recovery Rate: Drain the waste tank and refill with 16 ± 1 liters of deionized water. Close the insulated compartment in which the distillation unit is mounted, keeping the manometers and thermometer located so that they can be read from outside the closed compartment. Apply the electrical power and start the subsystem. While it is approaching equilibrium provide a means to measure water distillation rate within ± 5 cc in 15 minutes ± 5 seconds. (A 500 ml graduated cylinder to receive the output from WM2-W1, and a stopwatch are recommended).

After 90 minutes of operation and if the pressure and temperatures have remained unchanged over the previous 15 minutes, measure the water distillation rate over a 15-minute period. Mid-way during that test period measure room temperature and read cabinet temperature.

Plot the measured recovery rate and room temperature on the performance curve, page 2 of Mini-Spec 3098-MS-9100. If the following two conditions are met the recovery rate is acceptable and no tuning is necessary to adjust recovery rate:

A. The newly-measured performance point (recov. rate vs. room temp.) lies within 5 percent below and 15 percent above the curve shown for zero solids, and
B. The compressor head rise is less than 5 mm Hg.

There are five other interpretations of the test results; they are listed below:

A. Recov. Rate higher than 15 percent above the curve, delta P less than 5 mm Hg. Proceed to Section 5.1.1.
B. Recovery Rate lower than 5 percent below the curve, delta P less than 5 mm Hg. Proceed to Section 5.1.2.
C. Recovery Rate higher than 15 percent above the curve, delta P greater than 5 mm Hg, Proceed to Section 5.1.3.
D. Recovery rate with limits, delta P greater than 5 mm Hg. Proceed to Section 5.1.4.
E. Recovery Rate lower than 5 percent below the curve, delta P greater than 5 mm Hg. Proceed to Section 5.1.5.

<u>5.1.1 Rate High, Delta P<5mm Hg:</u> The most probable cause for a higher-than-predicted recovery rate is that the distillation process is occurring at a higher-than-predicted temperature. The condenser pressure should be no greater than the water vapor saturation pressure at a temperature 20°F higher than room temperature. If the condenser pressure is greater than that limit it is necessary to ventilate the distillation compartment. Consult with the project engineer for placement, size and location of ventilation openings in the cabinet.

If the condenser pressure falls below the limit set by a 20°F increase in saturation temperature above room temperature the high apparant recovery rate might be caused by a liquid leak from the evaporator to the condenser. To check whether a leak exists bypass the normal feed/recycle loop with an external loop containing NaCl in deionized water and with a nominal conductivity of 5 x 10^2 ohms-cm. The condensate generated from that must show an improvement in conductivity of greater than two orders of magnitude (greater than 5 x 10^4 ohms-cm) to verify that no leak exists. Should that improvement in conductivity not be measured a leak exists and must be corrected. The distillation unit must be disassembled. Check for leaky welds across the evaporator/condenser wall and within the main shaft.

Should the conductivity check prove that no leak exists and the condenser pressure falls below the limit set by a 20°F increase in saturation temperature (above room temperature) we have built a better still than we thought we could build. The improvement in performance is accountable to one or more of the following conditions:

1. A lower purge rate than experienced previously - with the laboratory pump. Less latent heat is being drawn from the condenser through the purge.

2. Better coverage of the evaporator surface by the feed liquid - probably caused by better concentricity of the evaporator surface to the center of rotation.

3. Lower pressure loss across the rotating demister than experienced with the stationary demister.

4. Higher compressor speed with the 400 Hz motor than experienced with the 60 Hz motor.

5. Higher heat transfer coefficient to the evaporating film caused by the higher centrifugal force generated by the higher evaporator speed.

5.1.2 Rate Low, Delta P<5mm Hg: The most probable cause for a lower-than-predicted recovery rate is excessive compressor clearance, but other conditions which are more readily corrected must be checked before a rectification as major as that is undertaken.

First, verify that the condenser pressure is greater than 35 mm Hg Abs (as read on the absolute manometer). If condenser pressure is lower than that level the distillation process is taking place at too low a temperature. It is necessary to improve upon the thermal insulation around the distillation cabinet. Consult the project engineer for methods to improve the thermal insulation.

Second, an excessively high purge rate will draw too much latent heat (water in vapor form) from the condenser. Separate the electrical connector on the purge pump so that the pump does not run, and repeat the recovery rate test for as long a duration as it takes for the compressor pressure rise to exceed 5 mm Hg - or for 30 minutes which ever occurs first. Then reconnect the purge pump connector. Should that test increase recovery rate to the specified range it is necessary to add an orifice to the purge pump line. Consult the project engineer for sizing, location and construction details of that orifice.

Should no measurable improvement in recovery rate be detectable by operating the distillation unit without a purge flow and if the condenser pressure is within the specified limits it is necessary to dismantle the distillation unit and decrease the back flow through the compressor. Two possible locations where high back flow could occur are:

A. Around the compressor rotors - or between the rotors and the housing, and
B. through the compressor relief valve.

During disassembly take special care to observe whether the the relief valve has been jammed into an open position. Note also whether the valve moves freely by depressing the poppet with a finger inserted into the vapor outlet hole in the compressor housing. Should the poppet show any indication of sluggish or hesitant travel replace the valve guide bearing and apply a light coating of

Krytox lubricant to all bearing surfaces.

Should the valve operation prove satisfactory measure the axial clearance between the rotors and the stationary housing flat surfaces (verify that measurement with those made during compressor assembly in 3098-AS-9100). Divide that total axial clearance in half and machine that halved dimension from the compressor center housing. Center the rotors within the center section by machining the shoulders at the drive end of both rotors. Re-assemble the compressor per the Assembly Spec and repeat the calibration test.

If the recovery rate continues to be lower than the range specified above the cause is one or more of the following conditions.

A. A coating or insulating barrier exists on the evaporator surface which is restricting heat transfer. An attempt to roughen the surface and remove any coating should be made and the calibration repeated.
B. The compressor speed, driven by the 14-pole 400 Hz motor is lower than the speed was when driven by the 2-pole 60 Hz motor.
C. Though very unlikely, a low recovery rate with normal compressor pressure rise could be caused by a large vapor leak from the condenser to the evaporator. Inspect, again, the welds in the evaporator/condenser common bowl especially those which lie "above" the liquid level.

Should the low recovery rate not be corrected by any of the above attempts contact the project engineer for identification and correction of a condition more subtle.

<u>5.1.3 Recovery Rate High, Pressure Rise High:</u> The most probable cause for this condition is higher-than-predicted distillation temperature. Check the condenser pressure. It should be no greater than the water vapor saturation pressure at a temperature [illegible]°F higher than room temperature. If the condenser pressure is greater than that level more ventilation of the distillation cabinet is necessary. The project engineer will locate and quantify the additional openings necessary.

If the condenser pressure is within the above-defined limit the most probable cause is the presence of non-condensible gases in the condenser - which is the result of either an inadequate purge rate or a gas leak. Check for a gas leak by disconnecting the purge pump from the power supply while the distillation unit is evacuated. The manometer showing condenser pressure may show a small pressure rise (less than 5 mm Hg) during the first minute after the pump is stopped, but if it shows a pressure rise greater than 1 mm Hg during the next 10 minutes gas is leaking into the distillation loop. The leak must be found and corrected. If the above test proves that no leak is present operate the distillation unit with a laboratory vacuum pump connected directly to the purge port on the distillation unit. Should that test show a normal compressor head rise (less than 5 mm Hg) it is necessary to either locate and rectify a restriction in the purge line between the still and the purge pump or to replace the purge pump with one of greater capacity.

NOTE: Care must be taken to keep condensed water out of the manometer lines. Realizing that the manometers are located in an ambient cooler than the distillation unit - which contains saturated vapor, the operator must be certain that water does not condense and stand in the interconnecting lines. Should some condensation occur the application of heat to the lines will vaporize the water and send it back to the distillation unit. This note is included here to remind the operator that the high delta pressure might be simply an erroneous reading caused by a column of water standing in one (or both) of the manometer lines.

5.1.4 Recovery Rate Normal, Pressure Rise High: The most probable cause for the existance of this condition is the presence of non-condensible gasses in the distillation unit, which is the result of either an inadequate purge rate or a gas leak. The check-procedure for rectifying that condition is explained in Section 5.1.3, above. Follow that procedure.

Should the tests in 5.1.3 show that non-condensible gasses in the condenser is not the cause for high pressure rise, and that the manometer lines are free of standing water columns, the next most probable cause is inadequate coverage of the evaporator surface by waste liquid. Disconnect the feed line between the liquid pump and the distillation unit and direct the pump delivery to a graduated cylinder. Operate the pump and measure the feed flow rate; it should be greater than 15 lb per hour (109 cc/min minimum) If the pump delivery rate is lower than the minimum in that test (delivery to sea-level pressure) connect the output to a 2-liter vacuum trap flask, evacuate the flask to saturation pressure at feed-water temperature and operate the pump for ten minutes. Determine its delivery rate to that lower pressure. If it is lower than 109 cc/min the Constant Flow Regulator Valve on the liquid pump (component 548) must be recalibrated. Follow the procedure in 3098-AS-4800. Should the feed delivery rate be greater than the minimum the cause of inadequate evaporator wetting is probably some mechanical eccentricity of the cylindrical evaporator surface with respect to its rotational center. Rectification of that condition requires a major rework of the distillation unit, and, realizing that the recovery rate is within the tolerance band, that rework might not be warranted. Consult with the project engineer for an evaluation of the penalty introduced by the high compressor pressure rise, and a decision on whether the extensive rework effort should be undertaken.

5.1.5 Recovery Rate Low, Pressure Rise High: There are several conditions or combinations of conditions which could produce these test results. The non-condensible-gas test described in section 5.1.3 should be run first to attempt and identification of the high-pressure-rise condition. Any leaks or purge pump deficiencies must be rectified before proceeding further.

The feed flow rate test explained in section 5.1.4 should be run to verify that the evaporator is being feed a sufficient quantity of liquid to maintain a continuous film all the way to the recycle trough. A feed rate below the minimum requires that the liquid pump be re-calibrated before proceeding further.

A check for water in the manometer interconnecting lines should be made to verify that the manometer reading is the actual compressor head rise. If after those tests are completed the parameters (recovery rate and compressor head rise) change to one of the above-described five conditions proceed under the appropriate paragraph. If however, the recovery rate remains low and the head rise remains high proceed as described below.

Disassembly of the distillation unit is necessary at this point. With only the outer shell and condenser cylinder removed place a dial indicator against the evaporator/condenser cylindrical shell, disconnect the three drive belts and rotate the shell by hand. Read the maximum run-out (eccentricity) at the compressor end, the trough end and mid-way between the two ends; a maximum run-out of .030 is acceptable at any location. If the eccentricity exceeds that dimension the evaporator bowl must be reworked to bring the eccentricity back to that limit--and the cause for the change identified and rectified.

Should the evaporator eccentricity lie within the tolerance check that the holes in the dam at the outlet end of the evaporator are located such that they drain the evaporator without producing a dry area on the evaporator surface. The minimum radial distance between a hole and the evaporator surface must be greater than the maximum eccentricity measured above. Note that the radial distance from hole to evaporator should be measured from the hole surface rather than the hole centerline. It is suggested that a tight-fitting drill be inserted into the hole being measured and a multi-leaf feeler gage be inserted between the drill and the evaporator surface to determine the radial distance.

Any hole found to be too close to the evaporator must be [illegible] closed and a new hole drilled into the dam closer to the evaporator centerline. If any corrections are made to evaporator eccentricity or dam drain hole locations reassemble the still and repeat the calibration test. Should the test parameters change to one of the other five conditions proceed under the appropriate paragraph. If however the recovery rate remains low and the head rise remains high or if no changes were made in either evaporator eccentricity or dam drain hole locations [illegible] below.

The distillation unit must be disassembled to [illegible] the [illegible]ing demister (Excessive restriction to vapor flow might be the anomaly we are looking for.) Repeat the calibration test without the demister in place. If the recovery rate and head rise are within specified limits the demister must be modified as directed by the project engineer. Should operating the distillation unit not produce an improvement in those parameters consult the project engineer anyway; the problem is more subtle than any prevously encountered. Record any change made in section 5.1.X on the historical log.

5.2 Purge Rate Calibration: If no adjustments to purge rate, either to increase it or reduce it, in any previous testing it is necessary to minimize that rate at this point to maximize water yield from the VCD assembly.

Pass the output flow from the purge pump through a trap submerged in a bath of dry ice and acetone. Place a micrometer-controlled needle valve of known equivalent orifice calibration in the purge pump inlet line Operate the VCD assembly through several one-hour runs at decreasing needle valve openings. Measure the water collected in the trap after each run and observe compressor head rise during each run. Each successive run will show a decreased quantity of water collected in the trap and at some valve setting, an increased compressor head rise will be measured. Stop the one-hour runs after that during which the higher head rise is detected. Note the micrometer needle valve reading during the immediately preceeding run and convert that reading to an equivalent orifice diameter. Build a plug to fit the purge pump inlet CPV and drill an orifice hole into the plug which is 10 to 15 percent larger in area than the equivalent orifice established with the micrometer needle valve. Repeat the calibration test to (1) verify that the orifice installed in the pump inlet port is not too small and (2) to measure the purge water flow rate with the permanent orifice in place. Record the final orifice size and the final purge water flow rate on the test log.

5.3 Water Quality: No waste has been processed by the VCD thus far, but it is appropriate that some important measurements be made of the output water quality to establish that the post treatment cells will not in-fact introduce contaminents to the product water stream. Measurements to be made on water extracted from specific locations in the loop and the range of acceptable valves are identified below: Enter test results on the test log.

TR sect. (Ref.)	Water Sample Origin	Parameter	Acceptable Range
5.3.1	Downstream of ACF	pH	6 to 8
5.3.2	Downstream of ACF	Turbidity	less than 1.0 [illegible]
5.3.3	Downstream of ACF	COD	Less than 100 [illegible]
5.3.4	Downstream of ACF	Sterility	Zero live Organisms
5.3.5	From Valve 509-01	Electrical Conductivity	Less than 50 μMHOS/cm

5.3.6	Downstream of Ag+ Ster.	Ag+ Conc.	Greater than 1.0 ppm
5.3.7	Downstream of Ag+ Ster.	Turbidity	Less than 10 JTU

Should any measurement fall outside the range an un-anticipated failure has occured. Contact the project engineer for identification and resolution of the problem; one or more of the post-treatment cells might require renovation.

<u>5.4 Spares Modification:</u> Any design revisions or alterations made to either the distillation unit or the liquid pump must be made also to their spares. These alterations include many and all adjustments or re-calibrations made to adjust performance as detailed in preceding paragraphs and recorded on the historical log. Should any new or re-designed parts be necessary (i.e. demister screens, compressor clearance shims or constant flow valve) they must be procured and installed in the spare components as well as in the original assemblies.

<u>5.5 Clean-Up:</u> Remove the relief valve from WM2-W1 and replace with a sealable cap. Depressurize the distillation unit to ambient pressure by opening the CPV fitting on the purge pump inlet then firmly re-close that fitting. Remove the manometers, their interconnecting lines and tees, and restore the plumbing to that shown on the Assembly Drawing. Remove the thermocouple and other instrumentation. Place a sealable cap over the purge pump outlet interface connection WM2-G1. Drain the waste tank by opening interface connection WM3-W1 and cap that connection. Vent the waste tank gas side by disconnecting the source of compressed air at interface WM3-G1, and cap that port. Remove the electrical power connection at the controller.

Wash the entire assembly with soap and water, and wash the spare components.

Construct a suitable crate for the assembly and for the spares, attach shipping labels, and arrange for in-site inspection by the customer.

Sign and date the test log, and arrange for delivery of the assembly and spares to the customer.

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TEST LOG

TEST REQUIREMENT No. 2098-TR-9800 | REV | SERIAL 001 | COMPONENT VCD Assembly

SEQ LINE	TR ¶	TEST DESCRIPTION	TEST RESULTS OR MEASUREMENTS		PERFORMED BY	DATE
1	4.1	Leak Test	[illegible]			
2	4.2	Proof Pressure	[illegible]		[illegible]	[illegible]
				TEST [illegible]		
3	4.3.2	Tank Quantity At Purge Pump Start	[illegible]	4250 ml	[illegible]	[illegible]
4	4.3.2.1	Pressure At which 503-11 opens	[illegible] mm Hg Abs	34 mm Hg Abs	[illegible]	[illegible]
5	4.3.2.2	" " " 509-01 is Indexed	"	34 "	[illegible]	[illegible]
6	4.3.2.3	" " " 559 is Energized	"	34 "	[illegible]	[illegible]
7	4.3.2.4	" " " 548 is Energized	"	34 "	[illegible]	[illegible]
8	4.3.3	Condenser Pressure, Cont. Press. Rise	t=0 [illegible]	[illegible] mm Hg	[illegible]	
		" "	t=15 min [illegible]	5		
		" "	t=30 min [illegible]	5		
		" "	t=45 min [illegible]	5		
		" "	t=60 min [illegible]	5		
9		Time elapsed for Condensate Start	[illegible]		[illegible]	"
10	4.3.[illegible]	[illegible] Shut-[illegible] Divert [illegible] t=[illegible]	[illegible]	[illegible]	[illegible]	
		" " t=[illegible] min	[illegible]	[illegible]	[illegible]	
		" " t=[illegible] min	[illegible]	[illegible]	[illegible]	
		" " t=[illegible] min	[illegible]			
		" " t=[illegible] min				
		" " t=[illegible] min				
		" " t=[illegible] min	[illegible]			
11		Time [illegible] to Motor ([illegible]) stop, min	[illegible]		[illegible]	[illegible]
12	4.3.[illegible]	[illegible] Valve Divert [illegible] t=0- [illegible] Tank	[illegible]		[illegible]	[illegible]
		t=[illegible] min	[illegible]			
		t=[illegible] min	[illegible]			
		t=[illegible] min	[illegible]			
		[illegible]	[illegible]			

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TEST COMPLETED BY: [illegible] DATE: [illegible] | APPROVED BY: [illegible] DATE: [illegible] | SHEET 14 OF 15

TEST LOG

3030 WILLIAM ... MONT, ... 40010

TEST REQUIREMENT No. 3098-TR-9800 | REV | SERIAL 001 | COMPONENT VCD Assembly

REF LINE	TR ¶	TEST DESCRIPTION	TEST RESULTS OR MEASUREMENTS	PERFORMED BY	DATE
14	4.3.3.3	Conductivity Recycling, Deionized Water	509 Valve Position; Normal (To 525)	[illegible]	10/18/73
15	4.3.3.3	" , Solution A (Aqueous)	509 Valve Position; Divert (To Reprocess)	[illegible]	"
16	4.3.3.3	" , Solution B (Aqueous)	509 Valve Position; Divert (To Reprocess)	[illegible]	"
17	4.3.3.3	" , Deionized Water	509 Valve Position; Normal (To 525)	[illegible]	"
18	4.3.3.3	Manual Reset of Valve 509	Yes, By Disconnecting 570 (Electrically) and Reconnecting	[illegible]	10/18/73
19	4.3.3.4	Manual Shut-Down Seq. Repeated?	Yes, Time to Shut-Down = ... minutes	[illegible]	10/11/73
20	5.1	Recov. Rate, .../~~sec~~ 30 min	590 ml/30 min = 2.6 lb/hr	[illegible]	10/13/73
		lb/day	62.5 lb/day At Pc = 27 mm Hg Abs	[illegible]	
		Room temp (and @ Pc = 27 mm Hg Abs	= 61°F		
		Compressor delta P	5 mm Hg d.		
21	5.1	Recov. Rate Within Spec?	Yes, Req'd = 56 lb/d @ Test Conditions ≈ 11% H	[illegible]	10/18/73
22	5.2	Orifice Size (diameter), inches	No Orifice Req'd	[illegible]	10/12/73
23	5.2	Purge Water Flow rate, cc/hr.	12 cc/hr (≈ 1% of Cond. Production Rate)	[illegible]	10/13/73
24	5.3.1	Water Quality, pH	7.1	[illegible]	11/11/73
25	5.3.2	" Turbidity	0.2 [illegible]	[illegible]	11/13/73
26	5.3.3	" [illegible]	< 15 ppm	[illegible]	11/11/73
27	5.3.4	" Sterility	Sterile	[illegible]	11/11/73
28	5.3.5	" Spec. Conductivity	29.5 μMHOS	[illegible]	11/11/73
29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TEST COMPLETED BY: [illegible] DATE: [illegible] APPROVED BY: [illegible] DATE: 10/.../... SHEET 15 OF 16

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6.0 TEST LOG

TEST REQUIREMENT No.	REV	SERIAL	COMPONENT
[illegible]-9800		001	VCD Assembly

SEQ. NO.		TEST DESCRIPTION	TEST RESULTS OR MEASUREMENTS	PERFORMED BY	DATE
30	[illegible]	Water Quality, Turbidity	0.2 JTU's	[illegible]	[illegible]
31	[illegible]	Space Med[illegible] (if not) Liq Pump	FUTURE TASK. (TEST RUN w/ PERISTALTIC BOOSTER PUMP ON RECY & COND LINES ENTERING SSP LIQ PUMP)	[illegible]	10/18/73
32	[illegible]	Dist Unit	YES, MEAS MADE	[illegible]	10/18/73
		[illegible]	FUTURE TASK. (TEST RUN WITH WEIGHTS IN TANK	[illegible]	10/18/73
33	[illegible]	[illegible] in-place	YES	[illegible]	10/11/73
34	[illegible]	Clean-up Completed	YES	[illegible]	10/18/73

APPROVED BY: [signature] [illegible]/73

SHEET 16 OF 16

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WATER QUALITY ANALYSIS

This section is a report written for NASA by Northrop Services, Inc., to describe the results of chemical analysis. Both untreated and post-treated water samples generated during the ten-day parametric urine test were analyzed and a detailed analysis of untreated distillate generated on days 2, 5 and 10 is included.

PREPARED FOR

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

JOHNSON SPACECRAFT CENTER

CREW SYSTEMS LABORATORY

Chemical Analysis of Water Samples from the Vapor Compression Distillation System

(Chemtric, Inc. NAS 9-13714)

30-603

22 September 1974

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Chemical Analysis of Water Samples from the Vapor Compression Distillation System (Chemtric, Inc. NAS 9-13714)

The chemical analyses reported herein are in support of the Vapor Compression Distillation System test which was performed by Chemtric, Inc. Three samples were analyzed for pH, resistivity, total solids organic and inorganic carbon and 17 separate ions. Seventeen samples were analyzed for pH, resistivity, organic and inorganic carbon, silver, ammonia nitrogen, and chloride.

Sample identifications are listed in Tables 1 and 2. All analytical data collected in these analyses are reported in Tables 3 and 4 and the Water Analyses Report Form.

Table 1

Untreated Condensate

Sample Number	Sample Identification	
474 - 66	Day 1	4-10-74
474 - 67	Day 2	4-11-74
474 - 71	Day 3	4-12-74
474 - 79	Day 4	4-15-74
474 - 81	Day 5	4-16-74
474 - 84	Day 6	4-17-74
474 - 95	Day 7	4-18-74
474 - 97	Day 8	4-19-74
474 -105	Day 9	4-22-74
474 -107	Day 10	4-23-74

Table 2

Post Treated Water

Sample Number	Sample Identification	
474 - 68	Day 1	4-10-74
474 - 69	Day 2	4-11-74
474 - 70	Day 3	4-12-74
474 - 80	Day 4	4-15-74
474 - 82	Day 5	4-16-74
474 - 85	Day 6	4-17-74
474 - 96	Day 7	4-18-74
474 - 98	Day 8	4-19-74
474 -106	Day 9	4-22-74
474 -108	Day 10	4-23-74

Table 3

Analytical Results

Sample Number	pH	Resistivity, Megohm-cm	Carbon, ppm	
			Organic	Inorganic
474 - 66	5.2	0.15	12.5	< 1
474 - 68	7.1	0.045	4.5	2.5
474 - 69	7.0	0.070	3.5	1
474 - 70	6.7	0.057	4	1
474 - 71	4.2	0.030	20	< 1
474 - 79	4.1	0.030	21	< 1
474 - 80	4.8	0.038	5.5	< 1
474 - 82	6.9	0.055	6	1.5
474 - 84	4.8	0.050	23	< 1
474 - 85	6.8	0.070	7	1
474 - 95	4.6	0.040	43	< 1
474 - 96	6.8	0.067	7	1
474 - 97	4.5	0.043	32	< 1
474 - 98	6.8	0.067	27	1
474 -105	4.4	0.035	24	1
474 -106	6.9	0.045	14	1
474 -108	6.6	0.054	8	< 1

Table 4

Analytical Results

Sample Number	Silver, ppb	Chloride, ppb	Ammonia Nitrogen, ppb
474 - 66	50	--	--
474 - 68	300	--	36
474 - 69	500	--	150
474 - 70	800	--	258
474 - 71	< 50	--	192
474 - 79	< 50	210	450
474 - 80	1200	500	1428
474 - 82	1200	830	960
474 - 84	< 50	270	1250
474 - 85	1400	620	1150
474 - 95	< 50	30	1535
474 - 96	1300	600	1160
474 - 97	100	200	1625
474 - 98	1000	550	1350
474 -105	< 50	240	1485
474 -106	900	900	1510
474 -108	≈ 50	610	1450

WATER ANALYSIS REPORT

Source: Chemtric	Date: 7-18-74	Sample				
Determination	Specification Limits	474-67	474-81	474-107		
pH	6–8	4.8	4.8	4.5		
Resistivity (Megohm–cm at 25 deg C)	Reference only	0.067	0.05	0.03		
Total Solids, ppm	TBD but < 500	11.6	1.5	2.5		
Organic Carbon, ppm	TBD but < 500	16	24	24		
Inorganic Carbon, ppm	Reference only	< 1	< 1	< 1		
Cadmium as Cd, ppb	10	<10	<10	< 10		
Chromium as Cr^{+6}, ppb	50	1.2	2.7	8.5		
Copper as Cu, ppb	1000	< 50	<50	< 50		
Iron as Fe, ppb	300	2000	500	600		
Lead as Pb, ppb	50	<500	< 500	<500		
Magnesium as Mg, ppb	Reference only	20	< 10	< 10		
Manganese as Mn, ppb	50	< 50	< 50	< 50		
Mercury as Hg, ppb	5	42	< 5	IS		
Nickel as Ni, ppb	50	<100	1000	1000		
Potassium as K, ppb	Reference only	70	150	IS		
Silver as Ag, ppb	50	< 50	< 50	IS		
Sodium as Na, ppb	Reference only	100	250	80		
Zinc as Zn, ppb	5000	70	40	IS		
Ammonia as N, ppb	3000	120	1290	IS		
Fluoride as F^-, ppb	20,000	675	800	550		
Nitrate as N, ppb	TBD	3300	< 50	< 10		
Sulfate as SO_4^{-2}, ppb	250,000	400	500	500		
Chloride as Cl^-, ppb	450,000	170	160	255		
*IS Insufficient sample						