

RESEARCH PROJECT TECHNICAL COMPLETION REPORT  
OWRR PROJECT A-047-OKLA

## DISPOSAL OF SOLUBLE INORGANIC SALTS

Submitted to

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Historically wastewater treatment has been an art rather than a science. Primary treatment (the mere removal of suspended solids) was satisfactory up to 1960, while secondary treatment (the removal of degradable organics in solution) was required in the 1960's. At the present while removal of nutrients such as N and P to prevent eutrophication is being heavily publicized, actual industrial reuse and recycle is limited by the progressive build-up of soluble inorganic solids (TDS). Removal of TDS is certainly the technological key to industrial water reuse in general and to the "zero-discharge" refinery in particular.

Any beneficial use of water raises the TDS, in particular as petroleum refinery operations become more sophisticated (e.g., to produce lead-free, high-octane gasoline) water consumption and degradation will increase accordingly (1). The predicted 4% per year growth in the U.S. energy consumption (2-4) demands that industry adopt greater reuse and recycle of water supplies. Unfortunately even tertiary treatment (e.g., carbon adsorption, etc.) does not remove soluble inorganic solids.

It must be remembered that a petroleum refinery receives brines in solution and/or emulsion with the incoming crude oil. Therefore even if complete recycle of all treatment chemicals could be retained there would still be a continual accumulation of TDS (5). Other petrochemical and industrial plants share this universal problem; for example the final treated effluents from canneries, plating operations, pulp and paper, steel mills, tanneries, and textile plants all contain soluble inorganic ions. The identities and concentrations of the specific ions present vary widely with the type of plant, but all final effluents consist mostly of TDS.

This crucial problem may be summarized concisely. Currently all industrial wastes can undergo primary, secondary, and tertiary treatments. These conventional biological and chemical processes remove suspended solids and lower the COD and BOD markedly. However these treatments do not affect the soluble inorganic solids, TDS. At present the TDS are almost invariably discharged into the river in dilute concentrations-usually less than 2000 ppm. As Federal, State and Municipal effluent and stream standards become more stringent the time-honored "elimination-by-dilution" practice will have to be discontinued. Unfortunately legislation against discharging TDS will not solve the problem of safe disposal of these soluble inorganic salts.

If economic considerations are ignored the dilute solutions of TDS can be concentrated to any desired level even to dryness by a suitable combination of reverse osmosis, dialysis, evaporation, crystallization, etc. However these processes merely reduce the waste volume and do not dispose of the TDS.

Several disposal alternatives may be suggested:

1. concentrate, treat, and inject into a deep well disposal
2. concentrate and discharge into the sea
3. concentrate and separate the TDS into reasonably pure inorganic compounds.

Conservationists will be justifiably suspicious of the first two alternatives. The third scheme is the only one which recycles the TDS provided the reasonably pure inorganic salts can be used industrially.

Dynamic hydrous oxide membranes, recently developed at Oak Ridge National Laboratory (6,7), offer the exciting possibility of removing TDS and of separating monovalent ions from polyvalent ones during concentration; thus creating new possibilities for later steps such as fractional crystallization.

The goal of this research project was the design and construction of a laboratory flow cell system for the evaluation of dynamic hydrous oxide membranes. The flow system has been designed, constructed, and evaluated on a preliminary basis. The flow cell which will contain the dynamic hydrous oxide membrane is shown in Figure 1. The liquid waste to be treated is fed into the annular region between the two tubes. The inner tube is made of porous stainless steel with an average pore size of 5 microns. The dynamic hydrous oxide membranes are deposited on the outside of this tube providing the necessary barrier for the removal of specific cations such as Mg, Cr and Cd from the feed water. As shown in the figure the waste solution leaves the system through the exit port and its flow rate is controlled by a back pressure valve. The purified product stream exits through the inner tube. A schematic diagram of the entire experimental flow system is shown in Figure 2. The high pressure gear pump is capable of operating to 1000 psi. Preliminary evaluation found the system to be in excellent working order.

In the advent of future finding, this equipment will be used to perform a detailed evaluation of the capabilities of the dynamic hydrous oxide membranes in the separation of such ions as Na, K, Mg, Cr, Cd, etc. In addition, the engineering characteristics such as permeation rate, concentration polarization, rejection efficiency, selectivity, and stability will also be studied.

## REFERENCES

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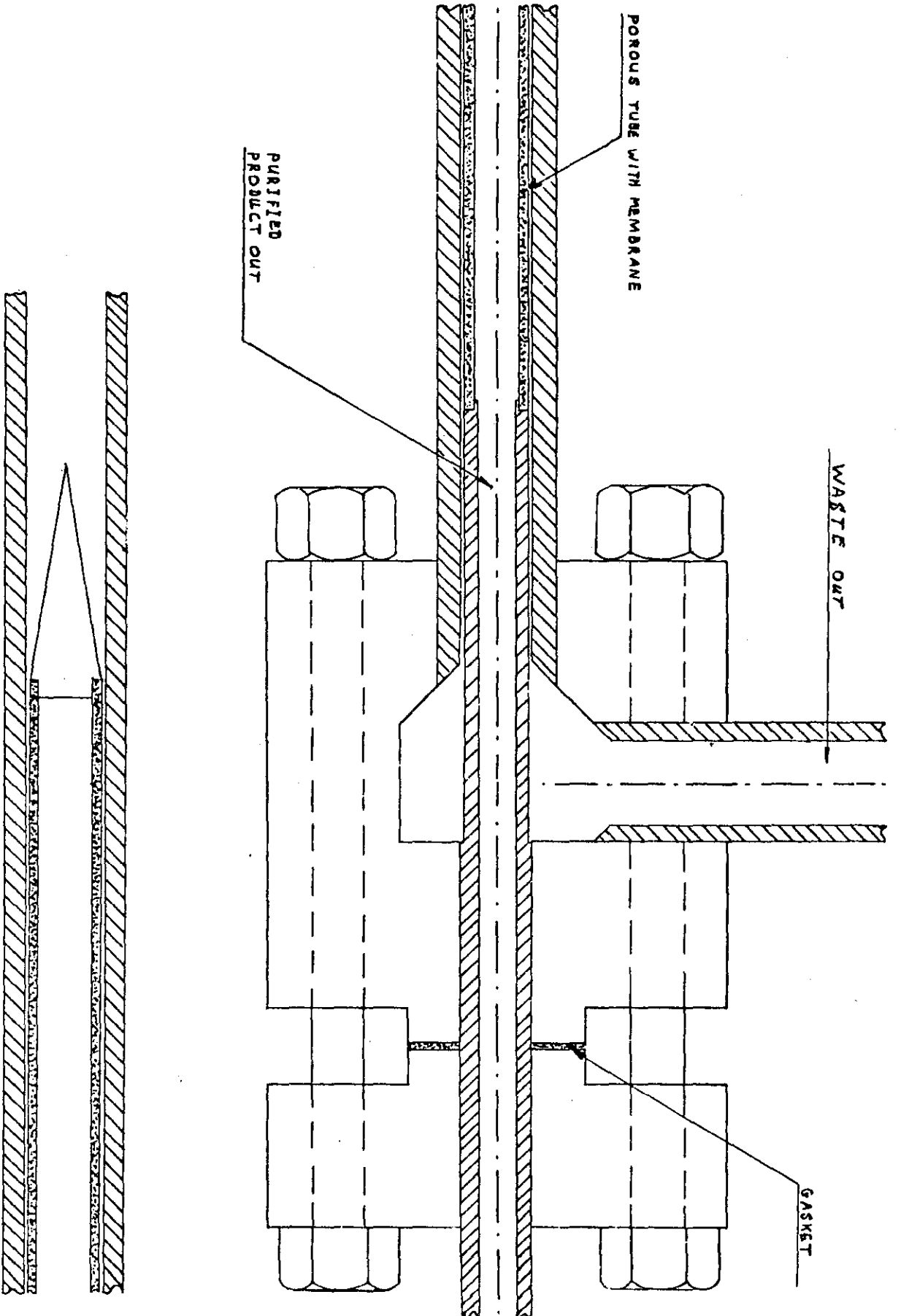
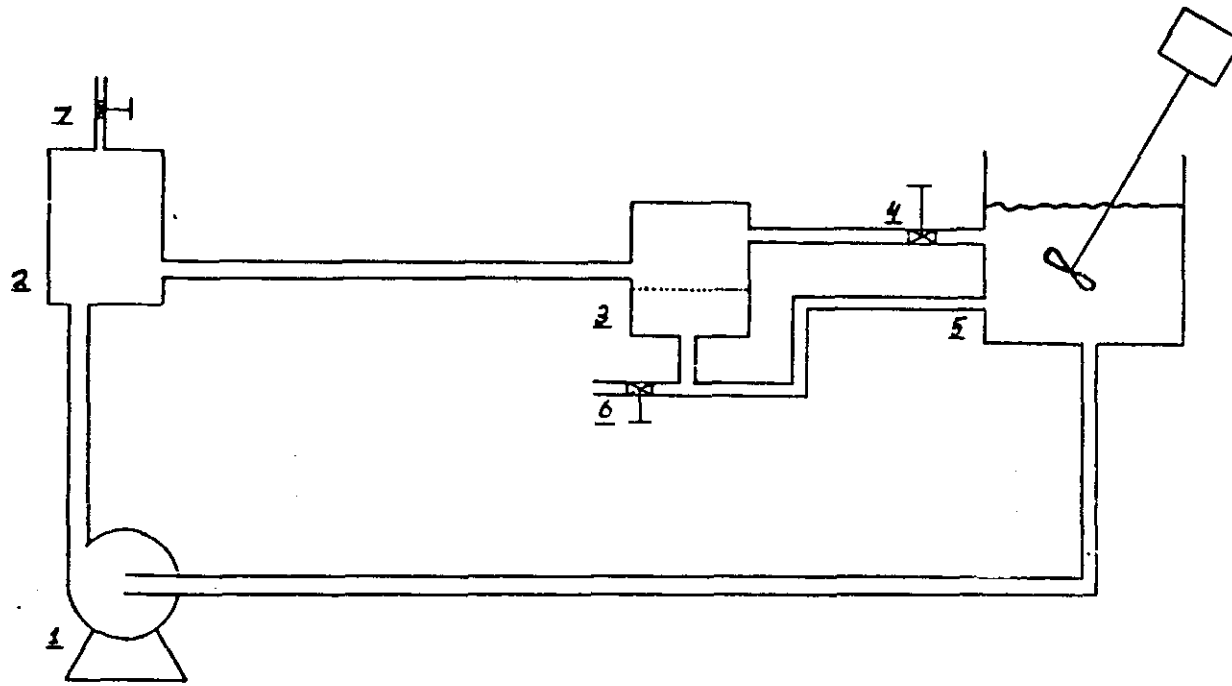


Figure 1 - SCHEMATIC OF CELL -



**LEGEND:**

- 1. HIGH PRESSURE GEAR PUMP;
- 2. LIQUID SURGE TANK;
- 3. CELL WITH HYDROUS OXIDE MEMBRANE;
- 4. BACK PRESSURE VALVE;
- 5. FEED TANK;
- 6. PRODUCT SAMPLING VALVE;
- 7. BLEED VALVE.

**FIGURE 2 :** SCHEMATIC OF REVERSE OSMOSIS SYSTEM