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Project Summary

Solvent Recovery at Vandenberg Air Force Base

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The operation of Vandenberg Air Force Base (VAFB) as the western launch site for the space shuttle will increase the volume of solvent waste generated. This report gives results of a feasibility study of the addition of vapor recovery and solvent purification equipment for VAFB to reuse the large quantities of waste solvent generated in shuttle preparation operations. This project—sponsored by the US Air Force, with project direction provided jointly by the Aerospace Corporation and the US EPA—included four major tasks: development of (1) design criteria, (2) a conceptual design, (3) a site layout and solvent logistics plan, and (4) detailed system design specifications. It was determined that vapor recovery can be justified at only one location, and that Freon-113 is the only solvent that can be economically purified for reuse. The final system design calls for a carbon adsorption unit for recovery of solvent vapors from the component cleaning facility (CCF) and a solvent purification facility that includes a water-wash column, two fractional distillation columns, molecular sieve driers, and two-stage filtration. It has been recommended that both facilities be adjacent to the CCF, and that a bulk Freon system be installed for the CCF to reduce the handling of containerized solvents.

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

When Vandenberg Air Force Base (VAFB) is fully operational as a launch site for the space shuttle, the generation of solvent wastes will increase by an order of magnitude over current levels. This report gives results of a study to determine if it is economically feasible to recover some of that solvent waste on-site and, if so, the design of a system to recover the solvent.

Waste Solvent Inventory

Waste solvents will be produced by a variety of shuttle-related and -unrelated processes at VAFB. Some of these processes are strongly influenced by the shuttle launch rate; others are independent of it. All available data concerning the projected rates of waste solvent generation have been combined into a computational data base which is keyed to the launch rate. Preparation of this data base has been a significant part of this study, since both the economics and the design of a solvent recovery system depend on these data.

The latest figures indicate that waste solvent generation will exceed 70,000 gal./yr (265,000 liters/yr) by 1995, based on attaining a rate of nine launches per year by that time. (See Table 1.) The solvent Freon-113 is by far the largest component in the projected solvent waste, with an estimated concentration of 64 volume percent. The next most concentrated solvent species is methylene chloride, which is present at only 6.2 volume percent. It was determined that all other solvent species could not be economically recovered in the preliminary economic evaluations. Conceptual

Table 1. *Summary of the Liquid Solvent Waste Generation Rates (in Gallons)*[a]

Year Component/Launches	1986 1	1990 4	1995 9	Total 47[b]	Vol %
Freon	14346	32416	45793	327484	64.28
IC3OH	1929	1286	1384	17896	3.51
MEK	753	1539	2872	17285	3.39
ME CL	903	2734	5786	31614	6 21
PERC	627	2187	4786	25506	5 01
111TCEA	665	545	896	7263	1.43
TRICH	1364	171	154	6411	1.26
MIBK	170	260	411	2813	0.55
TOLUENE	267	355	502	3755	0.74
ACETONE	204	263	360	2764	0.54
ETH ACET	1	3	6	33	0.01
XYLENE	17	24	35	253	0.05
EGMBE	18	28	45	305	0.06
ETHANOL	107	416	931	4885	0.96
ME DIANIL	11	44	99	517	0 10
CRES ACID	37	146	329	1720	0 34
FORM ACID	5	19	43	226	0.04
AMMONIA	0	0	0	0	0.00
N-BUTANOL	2	6	14	75	0.01
CYHEXONE	2	6	14	75	0.01
NAPHTHA	21	29	42	311	0.06
PHENOLICS	5	20	45	235	0 05
HEXANE	2	9	20	106	0.02
PHOS ACID	30	30	30	300	0 06
MIN SPIRT	163	163	163	1625	0 32
RAM 225	0	0	0	1	0.00
FREON-11	20	20	20	198	0.04
ETH BENZ	19	19	19	192	0 04
CARB TET	20	20	20	200	0 04
METHANOL	815	143	143	5794	1 14
UNKNOWN	839	926	720	8088	1 59
DETERGENT	1	4	9	46	0.01
TURCO	3	10	23	118	0 02
AMINES	5	20	45	235	0 05
AROMATICS	10	40	90	470	0 09
KETONES	19	19	19	192	0 04
CHROMIUM	5	20	45	235	0 05
GLYCOL ET	5	20	45	235	0 05
ALCOHOLS	11	41	91	478	0 09
CELL ACET	5	20	45	235	0 05
WATER	187	397	748	4466	0 88
INK	0	0	0	3	0 00
SOLIDS	458	744	1220	8108	1 59
GREASE	2	2	3	22	0 00
DIRT	2	2	3	21	0 00
OIL	155	230	356	2478	0 49
STODDARD	2392	2392	2392	23920	4 70
PD-620	25	25	25	248	0 05
Grand Totals	26646	47815	70841	509437	100 00

[a] *1 gal. = 3 79 liters*
[b] *Maximum number of launches over 10-year period*

designs were developed for two purification facilities one to recover only Freon; and the other, both Freon and methylene chloride After evaluating the cost of these two systems and their respective savings in solvent costs, it was determined that there was no economic incentive to recover the methylene chloride at the low levels present in the composite solvent waste feed.

Solvent Recovery System

The use of solvent vapor recovery units was also considered for each existing, or planned, solvent use area at VAFB. The preliminary economic analysis eliminated all but two areas: the component cleaning facility and the SCAPE suit cleaning facility The preliminary analysis for the SCAPE suit cleaning facility was based on the use of a process similar to the existing unit at Kennedy Space Center, but it was later learned that the unit planned for VAFB would probably use different technology (either non-Freon cleaning or Freon-based cleaning in an enclosed unit with its own integral vapor-recovery/solvent-purification apparatus). As a result of this, vapor recovery facilities were found to be warranted only for the component cleaning facility.

The recommended system consists of a carbon adsorption unit (to recover Freon vapors from the component cleaning facility) and a purification unit (to upgrade the Freon in the liquid waste solvent stream to meet Type I military specifications) The purification unit includes a water-wash column, two fractional distillation columns, molecular sieve dehydrators, and a two-stage filter (plus an assortment of tanks, heat exchangers, and piping to integrate the major components). (See Figure 1.) A microprocessor-based control system improves quality control and minimizes the need for operator intervention/sophistication.

The vapor recovery and purification units should be adjacent to, or inside, the ultimate site of the component cleaning facility. This would allow installing a bulk Freon-113 handling system for the component cleaning facility, which is projected to be by far the largest user of the solvent. It would also allow flexibility in allocating manpower requirements between these compatible operations, as well as sharing of utility systems.

The use of a bulk system at the component cleaning facility will greatly reduce the need for handling drums of spent and reclaimed solvent. This is highly beneficial in limiting labor costs and in reducing worker exposure to the potentially hazardous solvent waste. The few spent solvent streams from other use areas that are suitable for Freon recovery will be handled as a special disposition under the existing Hazardous Waste Management Plan at VAFB

System Economics

The installed capital cost of the purification system is estimated to be $795,000, the cost of the vapor recovery unit is estimated to be $330,000. It has been assumed that the total investment of $1,125,000 in solvent recovery equipment would be financed with an interest rate similar to that currently paid on Treasury Bonds (about 11.75 percent). The gross saving in solvent costs over the 10-year project life—using a fresh Freon price of $9.74/gal. ($2.57/liter), and deducting $1 90/gal.($0.50/liter) for the

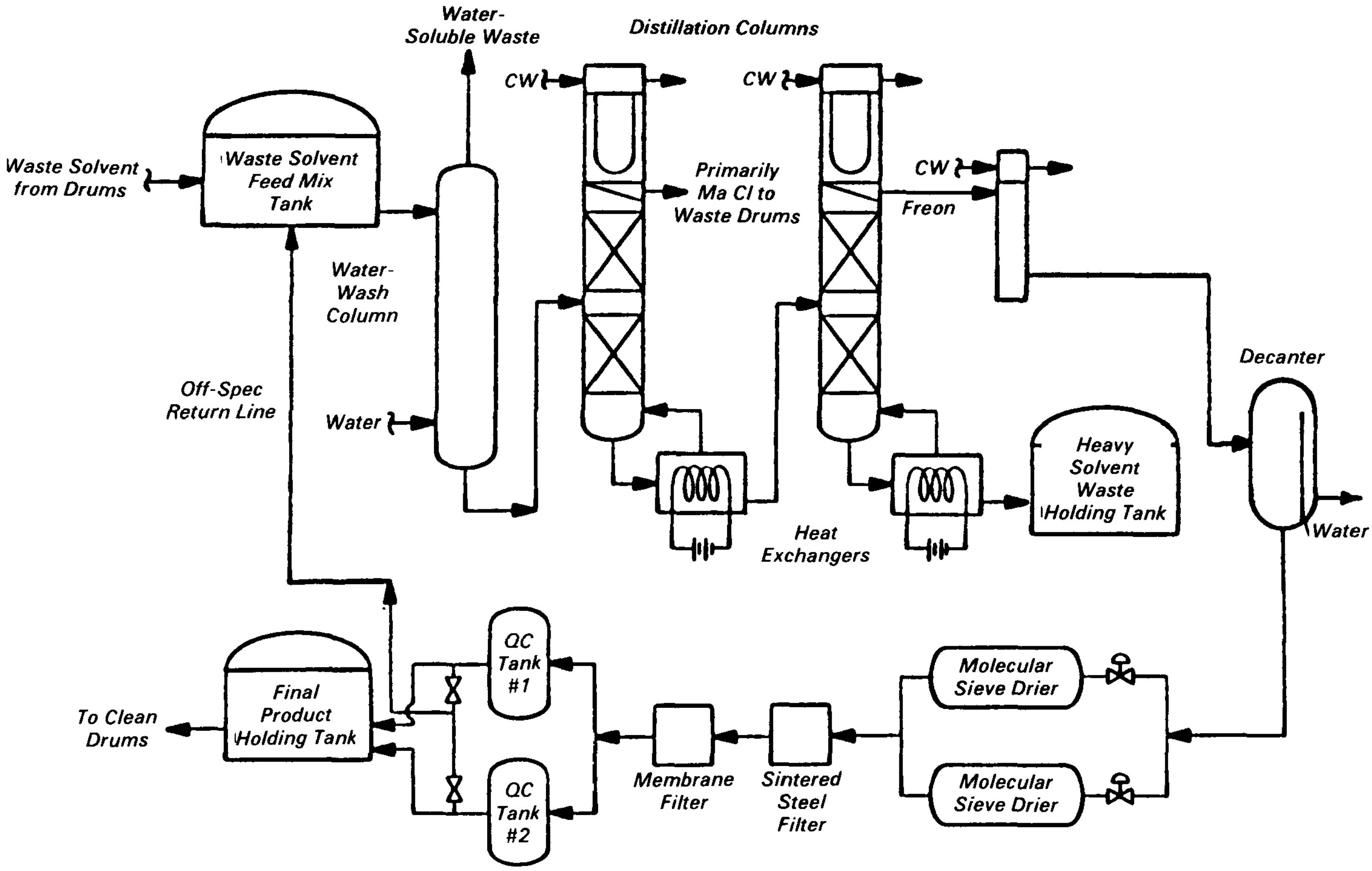

Figure 1. *The base case purification facility.*

loss of offsite recovery potential—is in excess of $3,720,000. Assuming a 10-year economic life cycle and using the Treasury Bond interest rate as the discount factor, the net present value of the investment in solvent recovery equipment is $118,550 (expressed in constant-value 1983 dollars). (See Table 2.) If a 5-percent general inflation rate is added to the calculation, the net present value of the investment increases to about $530,000. That is equivalent to an internal rate of return or 19.45 percent, or a simple payback period of about 5.3 years.

More recent information indicates that the launch rate may peak at about four launches per year and that the full activation of ground support facilities may be delayed until 1989. Although this information arrived too late to be incorporated in the main design and economic calculations for this study, some estimates were made of the probable impact of these changes on the economic viability of the solvent recovery project. The

Table 2. *Net Present Value (NPV) Calculations (Inflation Excluded Basis) for Combined Purification and Vapor Recovery Units*

Year (A)	Value of Solvent Recovered $/Year (B)	Annual Operating Expenses $/Year (C)	Annual Cash Flow $/Year (D)=B-C	Discount Factor, % 11.75[a] (E)	Net Annual Discounted Cash Flow $/Year (F)=D*E	Capital Expendit. $/Year (G)	Cumulative Net Present Value $ Sum of (G-F)
1985	0	0	0	1.00	0	1125000	-1125000
1986	157290	70865	86425	0 89	77338	0	-1047662
1987	260707	104012	156695	0.80	125476	0	-922186
1988	260707	99464	161243	0.72	115541	0	-806645
1989	325133	119417	205716	0.64	131910	0	-674735
1990	368794	131845	236949	0.57	135962	0	-538773
1991	408509	131933	276576	0.51	142014	0	-396760
1992	441967	140430	301537	0.46	138550	0	-258209
1993	472337	148086	324251	0.41	133322	0	-124887
1994	499913	154988	344925	0.37	126910	0	2023
1995	525360	171444	353916	0 33	116526	0	118549
Totals	3720716	1272484	2448232		1243549	1125000	118549

[a]*The discount factor was set at the interest rate for long term Treasury Bonds, which was 11 75% according to the Wall Street Journal of December 13, 1983*

reduction in launch rate, and the corresponding reduction in waste solvent generation rates, decreases the potential gross savings That effect is more than offset, however, by the delay in system construction, since the marginal years of operation (with only one or two launches) are eliminated The preliminary calculations indicate that the net present value of the project would be $637,850, which corresponds to a 21.6 percent return on investment These figures are based on a 10-year project life (1989 to 1998), a total of 39 launches (3 in 1989 and 4 in each of the remaining years), a 5-percent general inflation rate, and an 11.75 percent discount rate

Conclusions

The construction of onsite solvent recovery facilities will create several benefits in addition to the economic incentives. Although no existing environmental regulations would force VAFB to control the atmospheric emissions of Freon-113, the compound is under study in EPA's National Emission Standards for Hazardous Air Pollutants (NESHAP's) program, and could require control as a hazardous air pollutant in the future. Note that aerosol propellant uses of the halocarbons have already been prohibited. Onsite recycling/reuse of this large component of the liquid solvent waste is also very much in line with the policies expressed in California's recent Executive Order to strictly limit any land disposal of organic wastes. Investment in the solvent recovery project will result in a hedge against future price increases for Freon and improved reliability of the supply for this vital solvent.

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The complete report, entitled "Solvent Recovery at Vandenberg Air Force Base," (Order No. PB 84-222 405; Cost: $13.00, subject to change) will be available only from:
National Technical Information Service
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Springfield, VA 22161
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