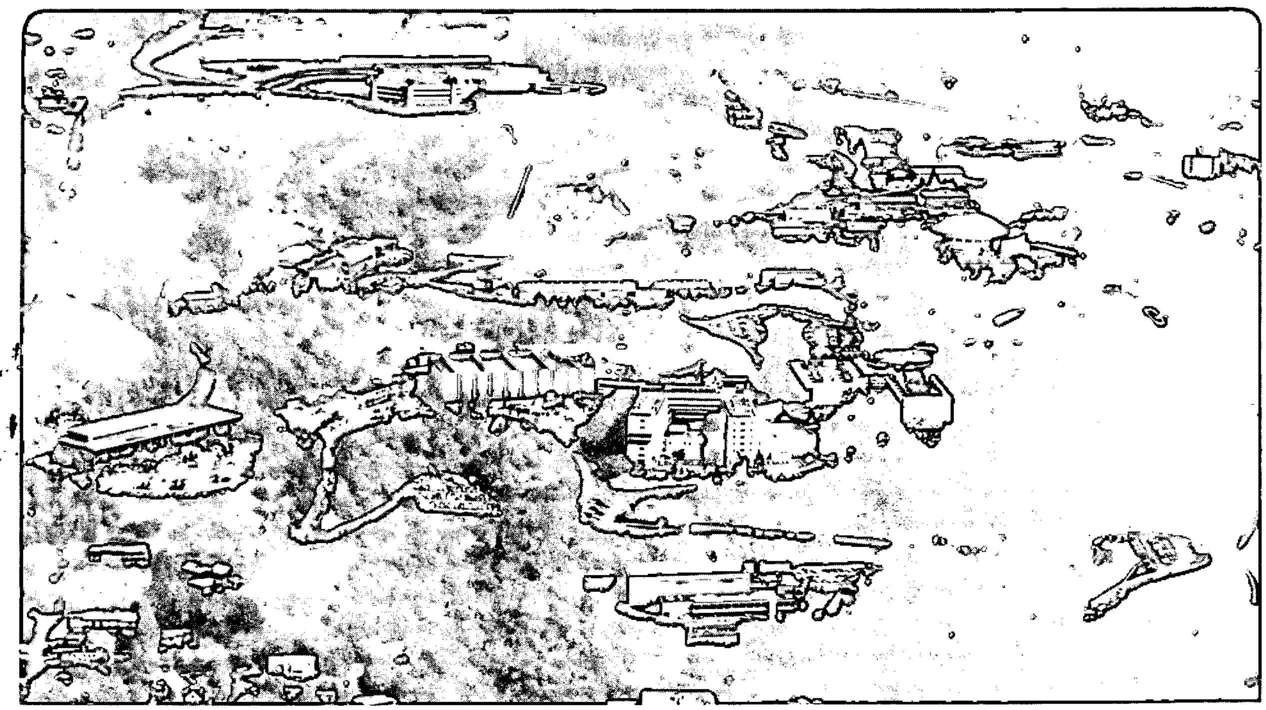
Lawrence Berkeley Laboratory

UNIVERSITY OF CALIFORNIA

Engineering & Technical Services Division



LAWRENCE BERKELEY LABORATORY - UNIVERSITY OF CALIFORNIA

ENGINEERING NOTE

CODE	SERIAL	PAGE
ES0510	M4995	1 of 3

AUTHOR: R. Byrns | DEPARTMENT: Mechanical | LOCATION: Berkeley | DATE: November 1, 1976

PROGRAM — PROJECT — JOB: ESCAR

REFRIGERATION

TITLE: ERDA REFER WORKSHOP - BNL - Nov. 3, 1976

Last year this first He Refer Workshop was held at ERDA-HQ Washington and about 28 people were present. A recently described law - part of the Murphy Law Tradition, states that "The usefulness of meetings is in inverse proportion to the number attending" - So I hope we can keep these workshops small and informal - mostly because a workshop can be more beneficial if we confess our mistakes rather than brag of our successes. (if any)

Now I hope to outline some of our problem areas briefly and then describe some of our work at Berkeley.

First and most important are <u>costs and funding</u>. A common mistake is to overlook the fact that Cryogenics requires and is a system. Many scientists look at only the device and it's end use and then expect the refrigeration to be brought up and plugged in at the last minute. (i.e. dewars of liquid helium)

I think we'd all agree that the Cryosystem consisting of say Magnets, Cryostats, Xsfer lines, Refer, Compressor and Gas management requires the fixing of all components <u>early</u> in the design, so that <u>all</u> funding costs are defined. The ERDA people don't like you to come back later for more money. In general the external system costs of Refer, Xsfr and Cryostats will exceed greatly the specific cost of the device such as a magnet COIL.

Its important to have sufficient refer capacity - carefully calculate the heat load and multiply by some factor like ε or π (just like cost estimates.) Special conditions like rapid cool down or transients may also affect the capacity needed.

Of course if the project cost is too high the probability of funding decreases rapidly.

An underfunded project can be a great burden - sorta like trying to cool a 10 watt heat load with and 8 watt refrigertor --, and if there isn't enough money to do the job then perhaps the scope should be reduced.

Operating costs should also be considered. In the past it's been "keep the capital cost down and let the operating costs fly!" but now in our energy short era-- we should specify <u>limits</u> on electrical load, LN consumption, He gas loss and maintenance. Low operating costs in general require high capital costs. Interestingly, ERDA now has a division for conservation.

Another problem is plant turn-down, still undefined to me - how to do it economically i.e. going from 2Kw @ 5^{O}K pulse load to say static load of 1Kw - with say 1.5MW power input-to 0.7MW. input, and have all the expanders, compressors and heat exchangers to along easily.

Contractual Problems are the next big hurdle. Specifications, RFP's and Q's must be very clear and well defined - the simpler the package the better. A contract implies a certain trust between buyer and seller - and in general its better to stay away from lawyers and litigation. It's also well to stay away from the GAO and ERDA. HQ. - Wash. contracts office if you can. The last few large refrigerator purchases have profited greatly from experience early in 1975.

Too low a bid can lead to many costly problems downstream of the contract, like trying to get delivery and performance. It is also important to have developed sources of supply so that there is some competition. For example, four sources of screw compressor will assure fair pricing.

After the bureaucratic problems come the Technical problems which are nicer and more fun. (Can Technology survive bureaucracy?) Most agree that the reciprocating compressor has room for improvements. You can get good performance from a recip - it has good efficiency and can have fair reliability - say 8-16000 hrs. MTBF for oil lubricated; to 2000 hrs. for dry ring with mini-lube somewhere in between.

The recip has high installation COSTS. Plumbers, electricians, millwrights, riggers, carpenters. Big massive foundations are needed for high shaking loads - Expensive castings require up to 2 years foundry lead time. It also has parts that wear - valves and rings-and performance can deteriorate gradually or suddenly.

The present trend is to rotary compressors for improved COSTS and reliability. We expect screw compressors to be about half the cost of recip, installed - have 3 to 6 months delivery and give MTBF's of up to 50,000 hrs. say 6 to 8 years. We'll say more later on Screw Compressors.

There is also some work at present on centrifugal machine-Union Carbide, Linde with Helium/Freon Binary mix and Sexsmith at Oxford on a small high speed centrifugal.

Heat Exchangers shouldn't be a problem, but with the brazed aluminum, which are cheaper than the Giaugue-Hampson or Fintube, many are experiencing corrosion unless all the brazing salts are washed out well or all moisture is removed on warm-up - we once lost a 20 ft. Trane unit after 2 years of service and replaced with copper Joy tube. Stanford, Fermilab, Brookhaven and Livermore have had troubles in this area.

Gas Purity - Leakage, make-up and reliable inexpensive on-line monitoring are real problems.

Expanders. The reciprocating expanders are efficient over a wide range, giving good turn-down capability - altho the reliability leaves something to be desired Our major problems have been exhaust valve icing. Some have had large enough impurity build-up in the cylinder to have the cylinder head driven-off or bend the crankshaft. Recips are good up to about 1500 watt of plant.

Rotary equipment tends to be more reliable, but has a sharper efficiency peak. Turbine expanders are available in oil bearings (costly because of the oil Sub-system) and gas bearings - Hydrostatic and Hydrodynamic. It bothers me that after all the money our government has spent on gas bearing, foil bearing, oil and magnetic bearing research, we still must pay high preminum prices for small helium Turbo expanders to Britian, Switzerland, France, Germany of Japan.

Heatloads and Distribution are the last major problem area in the Cryosystem, and there are still many unknowns and things yet to be proven for a large system. Poolboiling is the oldest and most simple system based on laboratory type dewar feed. When flow rates and loads get high then we need circulation systems and one can choose:

Pumped liquid as at Fermilab
Supercritical flow as at BNL
Two-phase flow - LBL

Berkeley Cryosystems and Programs. We have six CTi 1400's on three of our larger accelerators cryopumping the vacuum systems. On the Heavy Ion Linear Accelerator the cryopumps are the only vacuum pumps (except for Titanium Sublimators for H_2) The tanks are ∿ 150 ft. long. and 10 ft. dia. For the Bevatron the vacuum system is ∿ 10,000 $ft.^3$ (750 lbs./air.) and the Cryo-system has made feasible the whole heavy ion H.E. program. Next F.Y. - 78 we plan to increase the system another 3000 watts @ 20^{0} K and reach 10^{-9} vacuum

Mike Green and others are working on large volume magnets say 1-2 m dia. x 1-2m long for colliding beam work at SLAC. Cooling mode is with 2 ø Helium.

Then we have ESCAR (Experimental Super Cond. Acc. Ring) a small proton synchrotron/storage ring to check out superconducting magnets in a complete accelerator system. Escar hopes to contribute by furnishing experinece with a total system, and provide information pertinent to large systems. Risks are smaller with a smaller pilot model machine.

In FY 77 we hope to have 2 quadrants of magnets installed as well as an operational refrigerator. Two screw compressors are being installed and we expect power in December. CTi has scheduled cold box delivery in April 77.

Slides:

1. Escar FY - 77
2. Cooling Circuit & Refrig. Distrib.
3. CTi/Sulzer Cycle
4. Screw Compressor

TECHNICAL INFORMATION DEPARTMENT
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720