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UNION CARBIDE NUCLEAR COMPANY

Division of Union Carbide Corporation

Post Office Box X

Oak Ridge, Tennessee

R-9446

ORNL
CENTRAL FILES NUMBER

59-6-80

DATE:

COPY NO. 37

SUBJECT: CEC's PMC - 114 D Oil Diffusion Pump-
(Nominal 6" Prototype).

TO:

FROM: C.E. Normand

RELEASE APPROVED
BY PATENT BRANCH1-8-61
DATE

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CEC'S PMC - 144 D OIL DIFFUSION PUMP

(NOMINAL 6" PROTOTYPE)

C. E. Normand

This pump was made available to us for testing over a period of about a week. The results of our tests are summarized in this report.

1. Structural Features. This is designated as a 6" pump because it is built on a standard 6" pipe flange. The actual barrel diameter is 7-1/4": The barrel length is 18"; and overall space required is 11" x 15-1/2" x 21".

Both intake and discharge flanges are designed to use aluminum wire gaskets.

The cooling coil is of 1/4" copper tubing, taper wound from 1" spacing at the top to 3/4" at the bottom. The cooling coil extends down only to the level of the lowest jet.

The jet assembly is of a completely new "stub" design providing (4) stages of diffusion pumping.

The heating arrangement is novel. It consists of six (6) 3/8" x 5" finger type heaters, rated at 300 watts each. Each heater slips into a blind tube extending upward about 3" through the boiler base plate. Each heater tube has six (6) 9/16" radial fins extending along its whole length. The whole tube-fin assembly is surrounded by a close fitting metal sleeve 1-1/2" I.D. by 3" high, slotted for oil flow beneath its lower rim.

2. Operating Conditions. Standard operating conditions, as previously determined by C.E.C. in their tests, were maintained throughout our tests except as these were arbitrarily varied as part of the test. These conditions were: (a) Power - 1800 watts. (b) Cooling water flow 1 c/min. or to maintain discharge temperature at 35 - 40°C. (c) Pump fluid - Convoil-20.

3. Performance.

- (a) Speed: The un baffled pumping speed for air was measured over the 10^{-4} to 2×10^{-6} mm pressure range, and was found to decrease from about 1040 l/sec. to 860 l/sec. ($\bar{S} = 950$ l/sec.). This is significantly less than the speed found by C.E.C.

- about 1300 c/sec from 2×10^{-3} to 3×10^{-5} mm (See speed curves, Fig. 1).

In comparing these speeds it should be noted that different pump fluids and slightly different operating powers were used in the two tests. Also, our pressures were measured with a VG-1A ionization gage: C.E.C.'s measurements were based on pressures measured with a trapped McLeod gage. This difference in gages accounts for the different pressure ranges covered, and may have contributed to the differences in speed. The most important difference in the two sets of speed measurements is probably that of test domes. C.E.C.'s test dome had the diameter of the barrel, and a height of about 1-1/2 diameters. Our measurements were from a dome 20 in. in diameter and 20 in. high. It appears that speeds measure with these two arrangements should differ by the effective pump aperture conductance effect. This, indeed, proves to be the case.

The relative merits of ionization and McLeod gages for speed measurements, nor of large vs. small test domes need not be settled here. For comparing the speed performance of this pump with other pumps familiar to us, we consider the ion gage based speeds as more valid because the accepted speeds of existing pumps have been determined by this method. Also we prefer the large test dome as giving a more direct measure of what the pump will do in a practical installation.

Even on this basis the speed of the PMC-144D pump per unit area of pump aperture is a gratifying high 23 L/sec/in⁻².

- (b) Limiting Fore Pressure: The limiting static fore pressure, i.e. at zero input, is a remarkable 400 μ . Even more remarkable, this fore pressure limit is not appreciably depressed at the largest applied through puts-up to 1/2 atmosphere c.c. per sec. (370 μ /sec.) - high vacuum pressure almost μ .
- (c) Pressure Stability: Large pressure fluctuations were never observed. A low amplitude, high frequency fluctuation that appeared clearly on the recorder chart only when recording from the 10^{-7} mm range of the gage, proved to be due to leaks at the aluminum gasket.

Fig.1. Unbaffled Pumping Speed for Air.
CEC's PMC-144 D

- (d) Oil Back Streaming: The oil back streaming rate is extremely low. During the first 24 hours of operation, there was no detectable collection. During the next 48 hours, a total collection (in two burettes) of 1.25 cc was made - apparently at a constant rate. This indicates a back streaming rate of .026 cc/hr. Continued running for an additional 70 hours gave .0434 cc/hr. as the back streaming rate.
- (e) Ultimate Pressure: No particular effort was made to determine the true ultimate pressure of which the pump (unbaffled) is capable. The pressure quoted is merely the lowest stable pressure observed in the system to which this pump was connected. The low pressure obtained was 5×10^{-7} mm. This is less than the lowest pressure obtained in the same system with a 10 in., MCF-1400, modified to reduce back streaming.
- (f) Effect of Power Variation: The input power to the pump was varied in 6 stages from a maximum of 2150 watts to a minimum of 1060 watts. The only noticeable effect was a reduction of limiting fore pressure from about 450 μ to 225 μ . Base pressure and pressure fluctuations were essentially unchanged.
- (g) Effect of Water-flow Variation: Adjusting cooling water flow to outlet temperature of 21°C - 39°C - 61°C produced no clearly detectable changes in performance. Ultimate pressure may be slightly higher at both extremes - but this is not definite. Limiting fore pressure is probably slightly lower at the highest rate of flow (375 μ vs 400 μ).
4. Probable Causes of Improved Performance: It is quite impossible in a short test to evaluate individually such changes as new jet shapes, shorter vapor stacks, etc. There are, however, three novel features of this pump which probably contribute substantially to its performance.
- (a) The heater arrangement permits the application of higher power per unit area without causing "bumping" and "splashing". Thus the boiler runs at higher pressure than the conventional pumps, due both to higher density and higher temperature. Jets are, therefore, both "strong" and "dry". These conditions lead to low back streaming and low ultimate pressure.

- (b) The 4th pumping stage, employing a very short, high pressure jet, accounts for the high limiting fore pressure.
  - (c) The stopping of cooling coils even with the fourth stage, together with large power input, cause the lower pump barrel to run unusually hot. Thus considerable fractionation and deairation of returning oil occurs outside the boiler. This also contributes to low ultimate pressure.
5. Evaluation: As compared with conventional oil diffusion pumps; e.g. C.E.C.'s MCF series, this pump is superior in every major respect, except in power consumption. It
- (a) Requires less space,
  - (b) Gives higher pumping speed per unit area,
  - (c) Operates at higher fore pressure
  - (d) Obtains lower ultimate pressure,
  - (e) Is less subject to pressure fluctuations. Also it is relatively insensitive to variations in power, cooling, etc.

I consider it a distinct advance in oil diffusion pump design.

6. Availability: According to Mr. Stevenson, CEC is planning to produce a complete line of pumps of this type - 2 in. to 32 in. nominal size. Prototypes of the 2 in., 4 in, and 6 in. pumps have been built. The 6 in. pump will be first put into production. Expected release data, first quarter 1959. The 10 in. will probably be available during the second quarter. The larger sizes 20 in. and 32 in. are still in experimental design.