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SUPPLEMENTARY REPORT OF PRELIMINARY TESTING
PRODUCTION TEST IP-234-AE, SUPPLEMENT 2;
PROJECT CG-775, PROTOTYPE TESTING OF THE
190-K PROCESS PUMPING UNITS

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SUPPLEMENTARY
REPORT OF PRELIMINARY TESTING
PRODUCTION TEST IP-234-AE, SUPPLEMENT 2:
PROJECT CG-775, PROTOTYPE TESTING OF THE 190-K PROCESS PUMPING UNITS

by

M. H. Schack
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April 6, 1961

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PROJECT CG-775, PROTOTYPE TESTING OF THE 190-K PROCESS PUMPING UNITS

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SUPPLEMENTARY REPORT OF PRELIMINARY TESTING
PRODUCTION TEST IP-234-AE SUPPLEMENT 2
PROJECT CG-775, PROTOTYPE TESTING OF THE 190-K PROCESS PUMPING UNITS

INTRODUCTION

As part of Project CG-775, Water Plant Expansion - 100-K Area, it is necessary that a development program be carried out to provide a basis for the design of modifications to the 190-K pumping units to achieve the increased process water flow rates.

The development program consists of the procurement of modified components and the installation of these components in one existing process water pumping unit and then testing for satisfactory operation under actual plant conditions. The prototype testing will be followed by the procurement and installation of the modified components in all the installed process pumping units as part of the project execution. Pumping Unit No. 1 at 190-KE was modified for use in the prototype test in accordance with Production Test IP-234-AE. The modification and preliminary performance testing were completed during the thermohm outage in April and May of 1959. The results of the preliminary testing were reported in document No. HW-60659.

The prototype pumping unit was inspected for cavitation damage on August 24, 1959 after a period of about three months operation in actual plant service. The low lift pump impeller showed no evidence of cavitation damage. The high lift pump impeller showed cavitation damage in excess of that permitted by the specification. A second high lift impeller redesigned by the manufacturer to correct the cavitation problem was installed during March 1960. The first inspection of this impeller was made on July 15, 1960 after about four months of operation and again cavitation damage was found to be excessive. A third impeller with further design improvements was supplied by the manufacturer and was installed in the high lift pump on January 14, 1961 for operational testing. Prior to placing the third impeller in operational service, a pump performance test was conducted to determine the head-capacity characteristics of this impeller. The results of the preliminary testing were reported in document HW-68196.

It was noted that the performance characteristics of the third impeller were nearly equal to that of the first impeller except for a lower maximum flow capability (cut-off flow) and a slightly greater power requirement. The purpose of this study is to discuss the process significance of this performance difference and to determine if an impeller of this design would meet the requirements of Project CGI-883 if its cavitation performance should prove satisfactory.

CONCLUSIONS

It is concluded that the lower maximum flow capacity or the slightly increased power requirements of the third prototype impeller should not preclude its use if the cavitation performance of this impeller proves to be satisfactory. The required combined five and six pump flow rates would be achieved with proper sizing of the impeller diameter. Adequate margin of safety would exist between

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design operating points (five and six pump operating points) and maximum capacity to allow for reasonable variation in reactor system characteristics. Under four pump operating conditions the third impeller would be operating at the knee of its head-capacity curve, near cut-off, and an estimated flow reduction of 1 percent below that of the first impeller design would occur. This performance departure from the first impeller could cause a one degree increase in the bulk outlet temperature surge following an instantaneous reduction to four pump operation. However, it is felt that the overall performance of the two impeller designs is sufficiently close so that, in making a choice between the two, consideration of the cavitation performance should dominate.

DISCUSSION

Head-Capacity Characteristics

A comparison of the hydraulic performance characteristics of the first and third prototype impellers is shown by Figure 1. The head-capacity characteristic of the third impeller has a steeper slope and a lower maximum flow capability. This change in performance is the result of a design change to correct the cavitation problem in the previous test impellers. In particular, the eye area of the impeller was made smaller and the vanes made thicker.

The relationship to the system characteristic of the combined output of four, five and six modified pump sets is given by Figure 2. The pump characteristics are shown for both the first and third prototype high lift impeller designs. It should be pointed out that the actual production impellers would be of larger diameter than the test impellers; 33 inches as compared to 31 7/8 inches for the first impeller design and 33 5/8 inches as compared to 32 1/2 inch diameter for the third impeller design. The larger diameter production impellers are required to achieve the process water flow rates of 188,000 and 200,000 gpm under five and six pump operation, respectively, as specified by the Project CGI-883 design criteria. It can be seen from Figure 2 that when trimmed to the proper diameter, both impellers are adequate to supply the required six-pump and five pump flow rates.

Power Requirements

The power requirements of the third impeller were found to be slightly greater than for the first impeller as shown by Figure 1. The estimated motor horsepower requirements, at selected operating conditions, for the pump equipped with the third impeller as compared to that of the first impeller are given by Table I. The flow rates of 33,600 gpm and 38,000 gpm given in the table correspond to the six and five pump flow rates, respectively.

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TABLE I
ESTIMATED HIGH-LIFT PUMP HORSEPOWER REQUIREMENTS

Operating Condition	MOTOR OUTPUT HORSEPOWER			
	Impeller No. 1		Impeller No. 3	
	31 7/8" Dia.	33" Dia.	32 1/2" Dia.	33 5/8" Dia.
33,600 GPM	9,500	10,200	9,600	10,400
38,000 GPM	10,100	10,800	10,300	11,100
Maximum Horsepower	10,700	11,800	10,600	11,600

Of course, these conditions would not be obtainable with the smaller diameter impellers, assuming existence of the reactor system characteristic proposed by Project CGI-883. The maximum horsepower condition exists just prior to cut-off flow for the respective impellers and is not realized except under emergency conditions when operating with less than five pumps.

The power requirements of the third impeller exceed those of the first impeller except at maximum power conditions. The maximum power requirement of the third impeller is less because of its lower cut-off flow rate. The power requirements of either impeller are within the capabilities of the high lift pump drive which is rated for continuous duty at 11,500 hp. (10,000 hp. plus a 1.5 service factor). The design intent of Project CGI-883 was to not exceed 11,000 hp. motor output for the high lift pump drives under continuous duty conditions. As noted in Table I, the 11,000 hp. design limit may be slightly exceeded during five pump operation by the use of the third impeller.

EMERGENCY CONDITIONS

Under four-pump operation the third impeller will be operating in the knee of the head-capacity curve near cut-off capacity. The third impeller design would not be suitable for extended four pump operation because of the gross cavitation which would take place near cut-off. This is not a significant problem since it is not proposed to operate continuously with only four process water pump sets. The pumps would be capable of operating in the knee of the curve for short periods of time during emergencies without destructive damage as demonstrated by satisfactory operation of the prototype pump during tests at cut-off flow rates. These tests also indicated cut-off flow rates to be stable and constant with decreasing head. Thus, total reactor flow at cut-off may be determined by the intersection of the total cut-off flow rate and the reactor system characteristic. Under four pump operation, it is estimated that flow capacity with the third impeller design would be approximately 1 percent below that of the first impeller design (172,000 gpm down to 170,000 gpm). This flow decrease might be significant in the case of an instantaneous failure of one pump set during five pump operation. The instantaneous reduction to four pump flow could take place

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upon the unlikely failure of the shaft between the pump and flywheel. Flywheel energy would be lost and the failed pump would stop pumping immediately, resulting in an immediate flow reduction to that obtainable from four pumps. Although the panellits would trip, the total flow reduction would probably occur before the control rods could take effect. Consequently there would be a temperature surge which would increase bulk outlet temperatures as follows:

$$T_o = T_i \div \Delta T \left(\frac{\text{Five pump flow}}{\text{Four pump flow}} \right)$$

T_o = Bulk outlet temperature
 T_i = Inlet temperature = 2 C & 20 C
Equilibrium bulk outlet = 95 C

With first impeller design:

$$T_o = 2 \div (95-2) \frac{188,000}{172,000} = 103.5 \text{ C}$$

$$T_o = 20 \div (95-20) \frac{188,000}{172,000} = 102 \text{ C}$$

With third impeller design:

$$T_o = 2 \div (95-2) \frac{188,000}{170,000} = 104.5 \text{ C}$$

$$T_o = 20 \div (95-20) \frac{188,000}{170,000} = 103 \text{ C}$$

A temperature surge above boiling temperature could occur with the use of either design impeller upon the instantaneous loss of one pump and its flywheel energy. In the case of six pump equilibrium operation the temperature surge would be the same for either impeller. In the case of five pump equilibrium operation the temperature surge would be about one degree higher with the use of the third impeller. Whether the additional degree rise in outlet temperature would significantly add to the effects resulting from outlet temperatures above boiling is questionable. Therefore the one percent reduction in maximum flow capacity of the third impeller design is not considered a significant performance departure from that of the first impeller design.

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