This paper briefly describes the problems encountered with the drive shaft mechanical seal of a large centrifugal pump after the pump had been uprated. It then follows the development of a flexible throttle bush sealing system in case history format detailing the hydraulic and mechanical problems found during its development and the modifications made to improve its reliability and performance.

The paper concludes that the flexible throttle bush sealing system enabled the pump to be used for record periods of pumping, even though the system sustained some damage during pump start-ups, this did not have a major effect on leakage rates. It also recognises the need for more work to be carried out to obtain a better understanding of the adverse conditions generated on this pump and how these affect the operation of the flexible throttle bush system.

1. INTRODUCTION

The sealing of drive-shafts for large capacity and relatively high speed centrifugal pumps, such as those widely used for water transfer operations in the Hydro-Electric Power Industry, has traditionally been almost exclusively by use of complex and expensive mechanical face seals.

In addition to their high capital costs, such seals are difficult and time-consuming to install and maintain, and have been notoriously unreliable because of the severe mechanical conditions encountered. Furthermore, when such seals fail it is normally without warning and results in unacceptably high leakage rates which necessitate complete plant shutdown.

This paper describes the development of an alternative sealing system for such a pump with much reduced capital cost, ease of maintenance and higher reliability allowing continuing operation even when partial seal failure occurs.
The system development is described in case-history form over a period of several years for a water transfer pump operated by EDF at Mont-Cenis in the French Alps.

2. MONT-CENIS HYDRO-ELECTRIC SITE DESCRIPTION

The Mont-Cenis hydro-electric site comprises two main water reservoirs called Mont-Cenis and Plan D'Aval. Mont-Cenis is on the left bank of the river Arc, having a working volume of 320 Mm³ (264 Mm³ belonging to France) with a catchment area of 273 Km² and a water level between 1974 and 1892 metres above sea level. Plan D'Aval has a working volume of 33 Mm³ with a catchment area of 88 Km² and a water level between 1947.5 and 1921 metres above sea level.

The water from Mont-Cenis is used by the Villarodin hydro-electric power station which is equipped with two Pelton Wheels each generating 182 MW under a water head of 880 metres with a total flow rate of 5 m³/s.

The water from Plan D'Aval is used either by La Combe D'Avrieux, a single 120MW set under a head of 850 metres with a supply flow rate of 17.5 m³/s, or by Aussois hydro-electric power station which has three 30 MW sets with a supply flow rate of 12 m³/s or, on the same supply main as Aussois, by ONERA (Office National d'Etudes et de Recherches Aerospatiales) to whom E.D.F. supply water in order to operate their research facilities.

Plan D'Aval's capacity being relatively low, but having a vast supply of water feeding the reservoir from a large glacier during the thawing period, would make it necessary to produce electricity all summer when there is no demand for it. Therefore E.D.F. built a pipeline permitting the transfer of water between the two lakes by gravity. At the end of winter the water level in both lakes is very low, but as the thaw starts Plan D'Aval fills rapidly, so that its level soon exceeds that of Mont-Cenis. By opening the valves situated in Villarodin it is possible, simply by gravity, to transfer water from the higher lake (Plan D'Aval) into the lower lake (Mont-Cenis) until both levels are equal. Conversely when energy is needed in winter, the low capacity of Plan D'Aval is quickly exhausted, therefore it is possible to retransfer water from Mont-Cenis into Plan D'Aval during off-peak hours. The transfer flow varies from 16 m³/s for a 44 metre level difference to nil when levels are equal.

This gravity system is only operational when the water levels of each lake differ, therefore E.D.F. decided to install a centrifugal pump to enable the water transfer to continue against a negative differential head.

3. PUMP DESCRIPTION AND HISTORY

When the Bois D'Aussois pumping station was commissioned in 1975 its characteristics were as follows:-

- **PUMP**
  - Centrifugal with axial flow
  - Generated water head : 53 M
  - Flow rate : 9.5 m³/s
  - Nominal speed : 500 rpm
  - Make : NEYRPIC