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# Failures due to ingested bodies in hydraulic turbines

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ABSTRACT

The ingestion of large bodies in turbines can produce blockage in the runner that generates large, unbalanced forces. Blockage in the distributor can change the amplitude and uniformity of the pressure pulsations. Mechanical damage may also be generated.

In all cases, the efficiency of the turbine is reduced and the forces on the runner and the vibration levels in the machine are greatly amplified, which reduces the expected life of bearings and seals and even produces considerable damage.

In this paper, we present an overview of the damage caused by the ingestion of external bodies in hydraulic turbines. We describe some examples found during 20 years of monitoring. These types of failure have never been studied (except the typical sand erosion), as the grille of the trash rack should prevent the entrance of large bodies to the turbine. However, the trash rack is often partially broken and bodies may detach from the pipe lining.

Some cases of damage due to the ingestion of small bodies and particles are also discussed.



## 1. Introduction

Hydraulic turbines are currently of paramount importance for the generation of energy, due to their capacity to supply and regulate energy at peak hours when grid consumption is at a maximum. They must be reliable enough to start-up at any moment and to avoid unexpected stops.

Fig. 1 shows a sketch of a hydropower turbine. Water from the upper reservoir passes to the turbine through the penstock and leaves the turbine to the lower reservoir through the draft tube. A coarse grille with bars (trash rack) is located at the entrance of the hydraulic system. The trash rack prevents large bodies such as stones and logs from entering the conduit system to the turbine. The discharge (and power) given by the turbine to the electrical generator is regulated by the distributor. The distributor has fixed blades called stay vanes and variable pitch blades called guide vanes or wicket gates.

These are low rotating speed, rigid-shaft machines and, except in the case of high head turbines, vibration levels and failure rates are generally low.

Several studies have dealt with damage and its detection in hydraulic turbines [1–4]. However, in some cases, damage is generated by the ingestion of external bodies, rather than by failures in the machine itself. Hydraulic turbines suck in large amounts of water that can transport small particles, such as sand, and large bodies, such as large stones and logs. A body carried in the water will cause direct damage through impact or erosion and indirect damage through blockage.

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