

Performance of Hydraulic Systems

Overview

The performance of dam gates and associated operating systems (including operators, SCADA systems, mechanical and electrical equipment, operating procedures, etc.) has important implications regarding the safety of dams. Experience suggests the performance of hydraulic systems (exclusive of the spillway structure itself) is important during normal operations (e.g., misoperation and uncontrolled releases downstream) as well as during flood events.

Historic Experience

Since the 1995 failure of a gate at Folsom Dam, dam safety professionals have been increasingly aware of the vulnerability of gates and other hydraulic control systems at dams. While the event at Folsom Dam raised awareness of gate system reliability, this event was not unique. The events in Table 1 are a sample of dam gate incidents that occurred prior to 1995. The actual number of events that occurred prior to 1995, or since is not known.

Table 1
Gate Incidents at Dams Prior to 1995

Dam Name	State/Country	Year	Event Description
Bonneville	Oregon	1945	Vibration damage to spillway gates.
Wanapum	Washington	1964	Spillway gate hoist failed to stop.
Belden	California	1966	A gate frame collapsed. The gate controls were inadvertently interchanged, thus when throttled releases went through the unvented gate, the steel liner collapsed and the concrete around the gate frame was damaged.
Belden	California	1967	A steel liner collapsed, concrete failed and the gate seats were badly damaged.
Amistad	Texas	1976	During a gate operation, upstream roller intake gate rose, ultimately breaking a suspension cable.
Milks Camp	South Dakota	1976	A hydraulic gate jammed in the open position allowing water to drain continuously.
Coolidge	Arizona	1978	Drum gates failed to operate as a result of not being used in 45 years.
Jackson Lake	Colorado	1984	A spillway gate broke; ½ of a gate leaf missing.
Hatfield	Wisconsin	1993	Tainter gate hoist chain failure
Warm Springs	California	1995	Failure of a bulkhead gate hoist system during normal operations, resulting in dropping of the gate.

While the Folsom gate incident involved a structural failure, as did many of the events listed in Table 1, potential failure modes of gate systems is not limited to structural failure. A review of the NPDP database and the incident case files was conducted to identify the basic types or categories of failure modes of dam gate systems. A total of 65 events were identified which were grouped into 7 categories. The breakdown of these events is shown in Figure 1.

Of equal importance to the misoperation of dam gates is the role or impact these events had on the safety of the dam or on public health. Based on available information, the events categorized in Figure 1 were identified with respect to the consequences of the event. The consequences were identified into three distinct groups: dam failure, uncontrolled release (exclusive of dam failures), and no impact/unknown. The results are shown in Figure 2.

Note, these results are based on a limited dataset and information that is available at the NPDP and should be viewed as a sample of the experience at dams. As such, the relative proportions implied by the

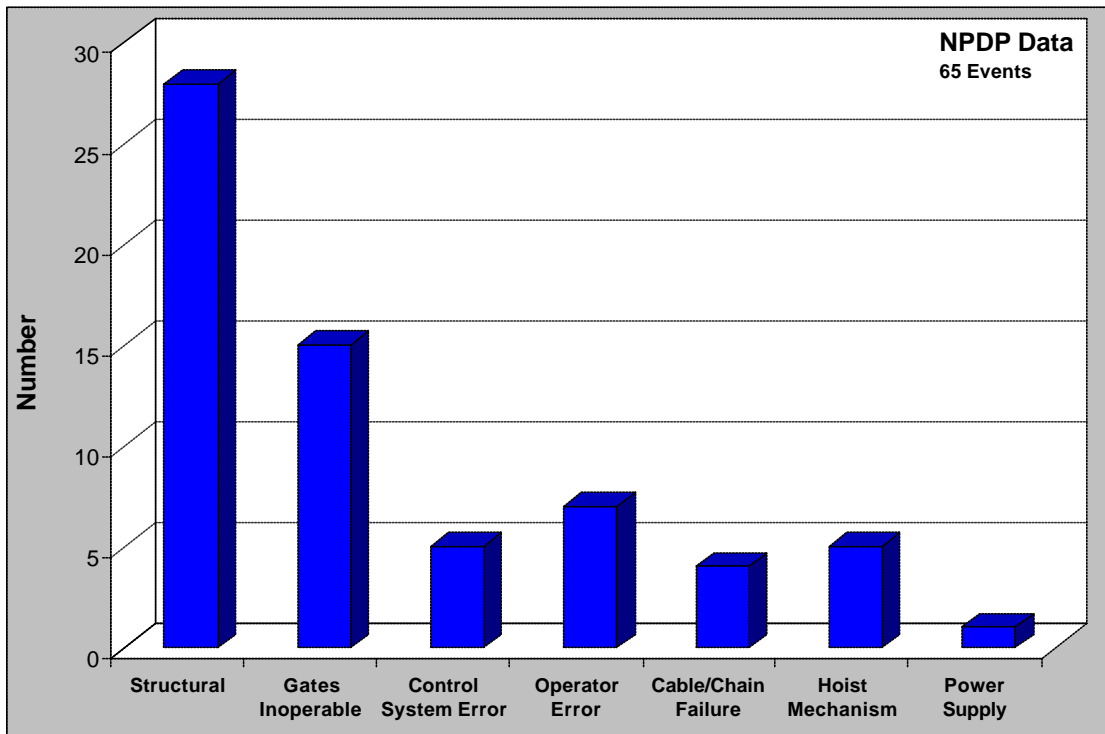


Figure 1 Breakdown of events involving the unsatisfactory performance of gates systems at dams.

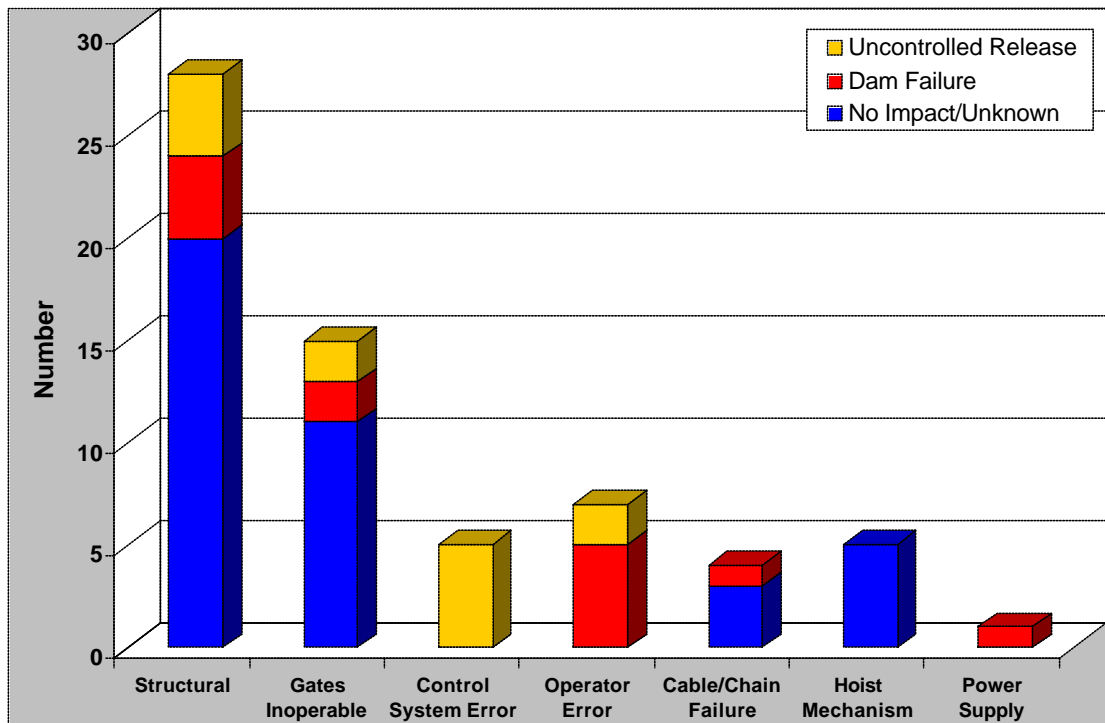


Figure 2 Dam gate system events and the consequences that resulted.

charts in Figures 1 and 2 are for information only and may not reflect the expected performance of dam gates of a particular type, size, design and maintenance history. Nonetheless, the information provided does highlight some of the experience with respect to dam gate systems and the unsatisfactory outcomes that have resulted.

Current Events

It is worth noting the reliability and performance of hydraulic control systems is an ongoing dam safety concern. Less than a year ago the failure of the Taum Sauk dam was attributed in part to operations of control systems at the pumped storage project. And earlier this month (October 10th), the Federal Energy Regulatory Commission reported to the NPDP operational problems of a wheel gate. As result of inspections and subsequent test operations, the owner concluded the rollers had seized or the gates have excessive drag and thus the gate must be removed and refurbished.