Water Pressure and Flow Regulation for Water-cooled Lasers

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ABSTRACT
We experienced laser water valve failure resulting from poor water quality, frequent laser shutdowns from low water flow rates, and unnecessary service calls shortly after installing a new laser. The water valve failure resulted from deposits and corrosion. A dirt/rust water filter was installed, and no further water valve failure has occurred. A flow meter was added to the water system to adjust flow rates. It clearly shows when laser shutdowns are caused by low flow rates and indicates the need for water filter changes. Water pressure was monitored and is most affected by use of the laser. A convenient electric water control, activated by the laser key switch, has proved to be reliable. The water control is kept open by a timer ten minutes after the laser is shut off. We determined that our laser shutdowns were related to transient drops in water flow rates and possibly to draw off of water in other parts of the hospital.

From time to time adaptations must be made that affect safety or facilitate use of an instrument. Water-cooled lasers are protected from thermal damage by flow rate sensors that shut off the laser when interruption of water flow occurs. This may occur repeatedly and lead to costly and unnecessary service calls. We designed and developed a system to monitor water flow and stabilize pressure. Water quality was causing failure of water valves in the laser. Our system includes a dirt/rust water filter that has eliminated the valve failure caused by poor water quality.

MATERIALS AND METHODS
All electrical and plumbing components are standard parts available in hospital maintenance shops or electrical and plumbing supply houses. The electric water control valve (Alco Controls 231WB8P4) is energized by the laser key in the “on” position. This circuit requires 230 V AC, because the laser key switch carries that current (Figure 1). A ground fault circuit breaker is included in the circuit and is an essential safety precaution. The connection of the circuit to the key switch was made by the laser (Biophysic Ophthalmic Argon-Krypton) service representative. The remainder of the electrical and plumbing installation is accomplished easily by electricians and plumbers.

A plywood board was mounted flat against the wall. The system was attached to the board to stabilize plumbing and electrical joints and components. One half inch copper tubing was used to form the system, and was attached firmly to the plywood base.

Water enters the system through an on-off valve and is directed to a water pump, which maintains pressure in the system. Water then flows through a dirt/rust filter (AMF CUNO AP1610). An inline pressure graph (Dickson PR4) records pressures. Next, a loop is enclosed for an electric control valve and a bypass valve, which manually bypasses the electric control valve in case of failure. A non-recording pressure gauge allows easy visualization of transient pressure changes. Water then passes through a flow regulator and meter (Dwyer RMC 145 SSV). Water flow is mea-
RESULTS

We experienced problems with poor water quality, which caused failure of water valves in an argon-krypton laser. A new valve and a dirt/rust water filter were installed in the laser water regulation system. The filter must be changed frequently. Failure to do so causes a decrease in water flow, which appears on the water flow meter. We have experienced laser cutoff because of dirty filters and reduced flow rates below 2.5 gal/min. Our laser is very sensitive to flow rates dropping below 2.5 gal/min. We have had no failure of the water valve in the laser since the filter was installed. The life of the laser valve was increased ten-fold with the filter in place.

We were concerned about water pressure, so a water pump was placed in the system along with a graph recorder for pressure in pounds per square inch. The water pressure graph recorder gives a slightly delayed recording of pressure. A dial pressure gauge also was installed for immediate visualization of pressure changes. Pressure measurements are most affected by operation of the laser. When the laser is on, there is an open water system so that water can leave the laser.
Inadvertently, we recorded the times that the laser was in operation. The graph recorded one night when the laser was left on unattended (Figure 2). Pressure fluctuations other than those caused by use of the laser were uncommon.

The flow meter can be regulated to set the flow to specifications for any laser. It is most useful for determining the drop in flow rates that cause the laser to shut down. Our laser consistently shuts down if flow drops even momentarily below 2.5 gal/min. This has eliminated many service calls, because we could determine with certainty the cause of the shutdown. The drop in flow rates was caused by a sudden and momentary drawing off of water in other parts of the hospital, which may include the laundry and dishwashers.

The electric control valve is activated by the laser key switch. This was installed because of damage to a laser tube when water was not turned on before the laser. The system has worked flawlessly for 5 years on the Biophysic laser. This laser does not require water to be running after the laser is shut off. The Coherent 920 Dye laser will not start up with this electric control valve, but the valve has been used by us to time water flow after the laser is shut down. We constructed a timer that is connected to the laser key switch and the electric control valve (Figure 3). The Dye laser is started after the water flow is manually started. The electric control then maintains water flow and the manual valve is shut off. When the laser is cut off the timer shuts off the water after ten minutes. The electric water control could be placed on the outflow of the Dye laser and it would function to turn the water on and time it after the keyswitch is cut off. This would leave water pressure inside the laser at all times. We elected not to use the outflow side.

**DISCUSSION**

We were plagued by multiple laser shutdowns and were suspicious that water flow was a problem. There is no easy way to determine the cause unless a flow meter is placed in the incoming water line. We devised a system to incorporate this on a wall-mounted board. The flow meter is used successfully to specify flow rates and determine if laser shutdowns are being caused by low flow rates. We were able to determine that sudden and short duration drops of flow rates below 2.5 gal/min were responsible for laser shutdowns. The flow meter also indicates the need for water filter replacement and can be used to judge the frequency of filter changes.

Water quality was poor and caused failure of a water valve in our laser. A dirt/rust filter has greatly increased
the life of the valve.

Water pressure measurements are most affected by use of the laser. Operation of the laser opens the water line and a drop in pressure is apparent. A water pump was installed to ensure adequate pressure. We have not experienced pressure problems since the pump was installed. The pressure graph clearly shows the times that the laser is in use and recorded one instance when the laser was left running overnight.

Finally, an electric water control was installed to turn water on with the laser key. This is a great convenience when the water valve is remote from the laser, and we have experienced no problems with the system. It was originally installed for added protection of the laser, but it is most appreciated because of its convenience. A timer was designed to shut off the water ten minutes after the laser is turned off.

The manufacturer should be consulted before electrical connections are made because of variable specifications and possible problems with warranties and service contracts.

REFERENCES