Jaguar XK8 / XKR 1997 - 2005
Convertible Top
A System to Reduce Hydraulic Pressure

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This paper describes a method of reducing the pressure in XK8 / XKR convertible top hydraulic systems by reducing the voltage supplied to the hydraulic pump's DC motor. Cost is about $10 to $15.

The problem: leaking hydraulics

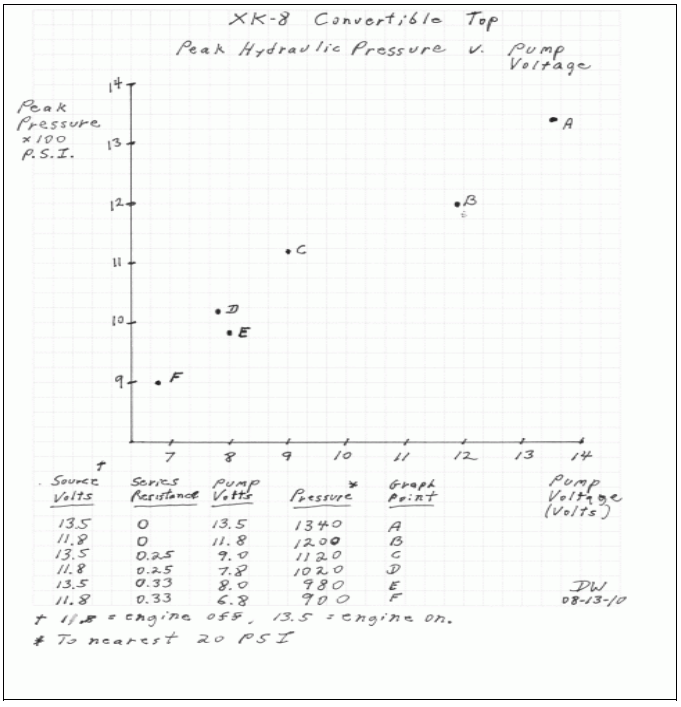
Raising, lowering, and latching the XK8 / XKR convertible top is accomplished through a system comprising a hydraulic pump (driven by a DC motor), a network of hydraulic hoses, and a system of rams located behind the rear seats and above the windshield. The hydraulic hoses have been known to rupture, especially near the points of connection to the rams above the windshield. The rate of such failures seems to be increasing as the cars age. When a failure occurs, leaking hydraulic fluid can create quite a mess in the car's interior, and an expensive or time-consuming job of hose replacement is needed. Not good.

Hydraulic hose failure has been linked to excessive pressure. Up to ~ **1650 PSI** of hydraulic pressure has been measured in the system, but it is known (by experiment) that less than **1000 PSI** is needed to operate the rams. The pump makes more pressure than is needed, and the excess pressure can rupture hydraulic hoses. Reducing pressure is no guarantee against hose failure, but it should improve the odds.

A hydraulic relief-valve system which reduces peak pressure to ~ 1000 PSI has been commercially available for some time. This paper describes another approach to reducing pressure: one based on reducing the voltage supply to the DC motor driving the hydraulic pump. A "voltage-reduction" system can be an attractive alternative to a relief-valve for some car owners, based on cost and other factors.

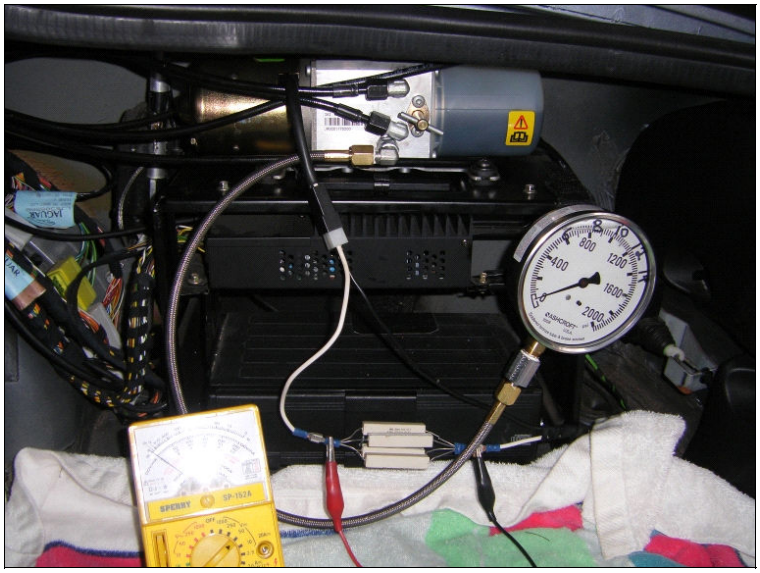
Lower voltage → lower pressure

The hydraulic pump is driven by a DC motor, and the peak pressure which the pump can create must in some way depend on the voltage supplied to the motor. Measurements were taken to determine the pressure-v.-voltage behavior of the system, and the voltage required to achieve the desired peak pressure of ~ 1000 PSI. The graph at right shows peak hydraulic pressure readings for various values of applied voltage. (Peak pressure occurs at the time of the "latch top" action which completes the "raise top" operation.)



The pump's motor is supplied with ~ 13.5 volts when the car's engine is running (i.e. alternator voltage) or ~ 12 volts when the engine is not running (battery voltage). Graph points "A" and "B" correspond to these two conditions respectively**. Points "A" and "B" demonstrate the principle that lower voltage creates lower peak pressure**.

Points “C” through “F” on the graph correspond to still lower voltages and pressures, achieved by **inserting electrical resistance** in series with the motor, reducing its voltage supply.



It should be noted that measurement accuracy is limited since data was taken using an analog pressure gauge and analog voltmeter (shown at right) to measure rapidly-changing quantities. The primary error introduced in this way is to **understate** the pressures at points “A” and “B”, since the gauge cannot track accurately a large, short-term rise in pressure. (As a consistency check, others have measured peak “engine on” pressure of 1650 PSI. The 1340 PSI measured here is somewhat lower, as expected.) This error is tolerable since we do not need high accuracy for the highest pressure readings. Instead, we are most interested in readings near the desired value of 1000 PSI, and measurement accuracy is better there. **Taking into account the limitations of analog measurement, the data still clearly demonstrate a pressure/voltage dependence. The measured change in peak pressure (probably understated) from 900 to 1340 PSI as voltage is varied from 7 to 14 volts is much larger than what could be attributed to measurement error.** (The resistors shown in the photo were used during testing but were replaced in the final design, see below).

Conclusions from the measurements:

- Contrary to the Jaguar driver’s handbook, it can be seen from graph points “A” and “B” that the convertible top of a car which has no pressure reduction system in place (either relief valve or voltage reduction) should **not** be operated with the car’s engine running. Doing so produces ~ 150 PSI more pressure than operating “engine off”, and this can only increase the chance of a hose failure.
- With pressure much lower than ~ 1000 PSI (e.g. graph point “F”) the convertible top mechanism is found not to operate smoothly. Such values are too low for reliable operation of the top.
- Inserting **0.25 ohm** resistance in series with the pump’s motor produces voltage of ~ 8 volts and peak pressures of ~ 1000 PSI when operating “engine off”, or ~ 9 volts and 1100 PSI when operating “engine on”. This is what we need (see “The problem”, pg. 1). **A resistance of ~ 0.25 ohm in series with the pump’s motor provides reliable convertible top operation with minimal excess pressure.**

Building a voltage-reduction system

Putting together a system involves selecting resistor(s) to achieve ~ 0.25 ohm resistance, and wiring it (them) in series with the pump’s motor. Resistors must be chosen considering both resistance value and power-handling (wattage) rating. The required wattage takes some math to work out, but a value of **100 watts** is more than adequate if **no heat sink** is used, as is a value of **50 watts** with the resistor(s) **attached to a heat sink**. Any higher wattage rating is also OK. In the following examples, note that for series-connected resistors of equal value both total resistance and total wattage rating are twice the value of one resistor. Suitable resistor choices:

- a single 0.20 to 0.25 ohm resistor, 100 watt rating w/o heat sink or 50-watt rating mounted on heat sink.
- two 0.10 ohm resistors in series with each other, 50-watt rating w/o heat sink or 25-watt with heat sink.

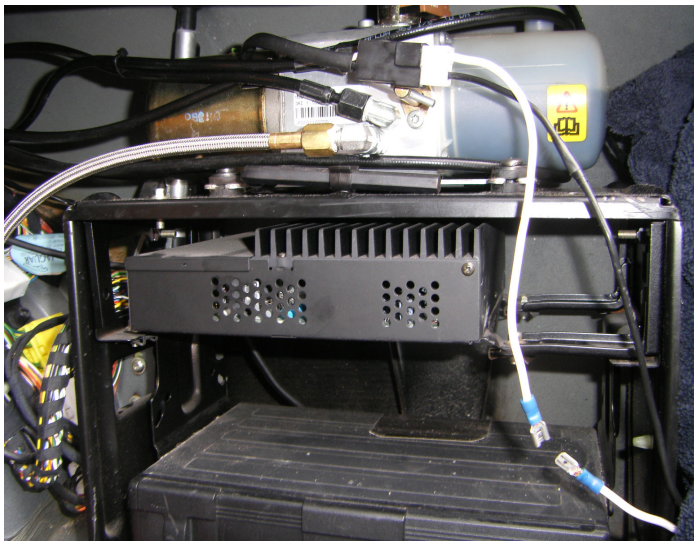
Parallel combinations of resistors (e.g. four 1-ohm resistors in parallel = 0.25 ohm) should not be used.

Installation and testing

A wire cutting/stripping/crimping tool and (possibly) some AWG 16-gauge or thicker wire, crimp-type connectors, and soldering equipment will be needed to connect the resistor(s) in series with the pump's motor. Some of the steps below are illustrative, and cover different implementations of the system as used by three different car owners:

- two 0.10 ohm resistors in series, spliced into one of the motor's voltage-supply wires,
- a single 0.22 ohm resistor, also spliced into the voltage-supply,
- a "no cut" installation method which eliminates the need to cut and splice a voltage-supply wire.

Installation:



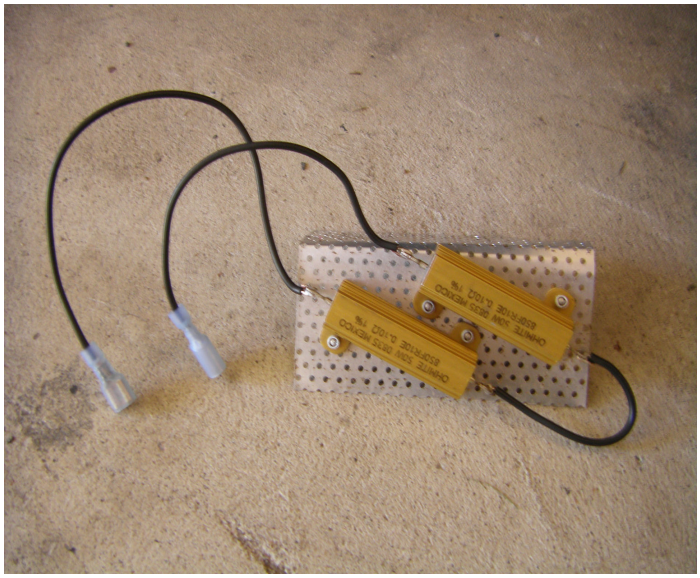
1) Be sure the **ignition is off**; remove the ignition key.

2) In the car's trunk, remove the panel covering the battery, and then the panel surrounding the CD-changer (i.e. the "right side wall" of the trunk enclosure).

3) The hydraulic pump and its motor will be seen inside the right wheel well. Disconnect the 2-pin electrical connector (one black wire, one white) from the motor. (The photo at right shows the white wire cut and connectors installed, see below. The braided hose seen in the photo was installed for pressure measurements.)

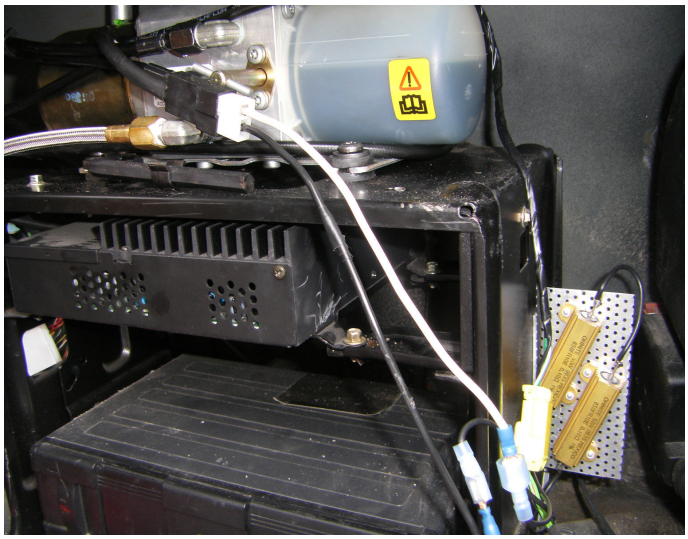
   Next, we will introduce resistor(s) into the motor's voltage supply, i.e. the black/white wire pair. Step 4) following describes three alternative methods for doing so. Whatever method is used, **AWG 16 gauge or lower** (lower gauge = thicker) wire must be used for any new wiring.

   *Note: in the black/white wire pair, neither wire can be thought of as "ground". The car's electronics will ground each of these wires during different portions of the raise/lower top cycle. For this reason, resistors and wiring we install must be "floating", not touching ground. The car's chassis is grounded, so exposed wire must not touch it. The metal casing of a typical power resistor is electrically isolated from the resistor inside; it **is** OK for this casing to touch ground.*

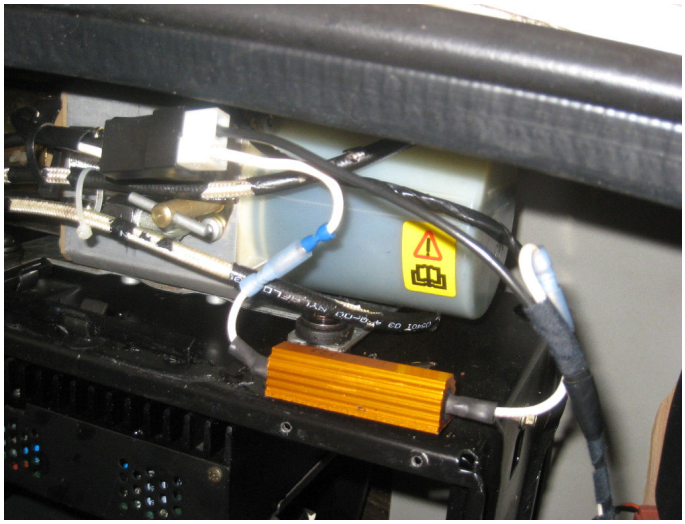


4) **"Two resistors" installation:** This is how the system was implemented in my car. Two 0.10 ohm, 50 watt resistors (www.mouser.com, part # 580-850FR10E, ~ $15.00 for two) are series-connected to each other and

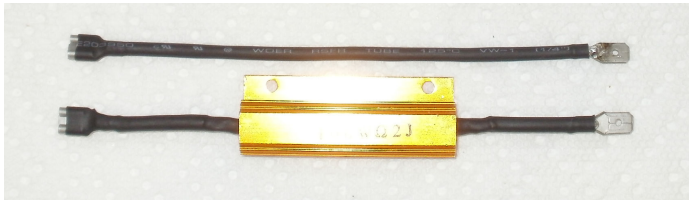
mounted on a piece of light metal lath, as used in sheetrock repair. Lead wires are soldered to the resistors, and connectors (one male, one female) attached. The white voltage-supply wire is cut midway along its length and connectors, one male, one female, are attached. (Either wire could be cut, but the white wire reminds us that we are not working with a "ground" wire.) The lath is attached using velcro to the tower in the wheel well which holds the hydraulic pump. The resistors are connected using the two male/female connector pairs. Installation is completed by re-connecting the 2-pin connector described in 3) above.

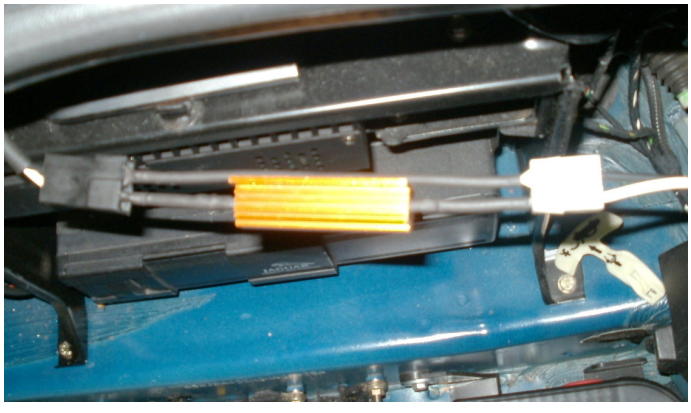


"One resistor" installation: This is how the system was implemented by Roadfly Jaguar forum member "RichXK8". It uses a single 0.22 ohm, 100 watt resistor obtained from http://stores.ebay.com/sunpec. Wiring and connectors are similar to my installation, described above. An existing sheet metal screw on the top of the hydraulic pump tower, and a flat piece of metal inserted under that screw, are used to secure the mounting flange of the resistor to the tower. This is an improvement over my installation; it is simpler, and fewer parts are needed.



"No cut" installation: This is how the system was implemented by "Test_point", a member of both JaguarForums and Roadfly. Instead of cutting one of the wires in the motor's voltage supply, he installed both a single 0.20 ohm, 100 watt resistor from http://stores.ebay.com/abillionstore and an insulated jumper wire between the two halves of the 2-pin connector described in 3) above. This method has the very attractive feature of being completely reversible, with nothing having been disturbed by the installation and removal. It represents yet another installation improvement.





Testing:

*Note: suitable resistor(s) may become warm, but will not become hot, in **normal** operation. It **is** possible to make the resistors hot by repeated raise/lower top operations in rapid succession. This will tend to make the pump's motor hot too (though not as hot as when operating without voltage reduction). Repeated raise/lower cycles in rapid succession should be avoided.*

1) Test the operation of the convertible top with the car's **engine off**. If the top does not raise and lower as it should, try a second test with **engine on**. Use engine-on for testing, and for day-to-day operation, **only** if engine-off does not work properly. Engine-on produces higher hydraulic pressure which is not needed if engine-off works properly.

2) If both of the tests in 1) fail, something is wrong; **remove the resistors** from the circuit. Feel free to send email with questions to the address below.

3) If either of the tests in 1) succeeds, the voltage-reduction system has been **successfully installed**. Peak hydraulic pressure in the system has been reduced from ~ 1650 PSI to ~ 1100 PSI.

   If desired (not necessary) the fuse in the pump motor circuit can be reduced from the "stock" value of 40 amps to 30 amps. This is so because the motor is now operating under reduced voltage, and is drawing less current. See the driver's handbook for fuse location. (The reduced load on the motor may extend its service life, though this is by no means proven.)

4) Replace the trunk side panel and battery cover. All done!

Thanks …

to all who provided help and encouragement, notably JaguarForums and Roadfly forum members Brookhart, Test_point, and RichXK8.

 Please send questions or comments to d.white11@verizon.net