Compatibility of Tubing Material with Hot Engine Oil

The Problem

The third generation Mazda RX-7 has over 33 feet of small control hoses (<1/4 inch id) under the hood. These hoses connect the solenoids and actuators that control the twin sequential turbo charging system, various emission control systems, and engine management systems. These hoses can carry vacuum (up to 24 inHg) or pressure (up to 12 psi) or both (not at the same time of course). On later cars, Mazda secured some of the more failure prone connections with small wide-band spring steel hose clamps. Many of these hoses are buried deep within the engine and are not easily accessible or visible. Failure of one of these hoses, in the form of a leak, usually at a connection, can be difficult and time consuming to diagnose.

Compounding this situation are two things. First, the under-hood temperatures on a third generation RX-7 are significantly higher than typically found in piston engine cars. This is due to the elevated exhaust temperatures of the rotary engine combined with the complex exhaust flow paths for the turbochargers and the presence of an exhaust pre-catalyst in the engine compartment. After driving on surface streets for 10 minutes, running at 70 mph on the freeway for 15 minutes, then driving on surface streets for 10 minutes (back to my house), shutting down and allowing a 10-minute heat soak, the following temperatures were measured with a thermocouple (Table 1).

Location	Temperature °F
Y Pipe (where many of the hoses connect to)	263 °F
Under intake plenum (where most of the solenoids are)	168 °F
Turbo Control Actuator (underneath the turbos)	248 °F

These temperatures were collected when the ambient air temperature was 65 °F. As you can imagine if the ambient temperature was 102 °F or I drove fast enough to bring the turbochargers fully online, the temperatures would be higher.

Another unique attribute of the third generation RX7 is the presents of significant amounts of oil in the intake system. This oil has two origins. The first is a design flaw, the crankcase ventilation system allows large amounts of oil into the intake system during hard cornering. It has been reported that cars under track conditions can loose a quart of oil into the intake system after several laps. The other source of oil in the intake system is leakage of the turbocharger bearing seals. As the turbocharger bearing seals age, they will allow the pressurized oil, which cools and lubricates the bearings, to leak into the intake system.

Oil in the control hoses was enough of a concern to Mazda that they equipped most of the factory check valves with build in pre-filters to limit the amount of oil passing through them.

All manufactures of silicone tubing and all material selection guides I looked at do not recommend using silicone tubing in the presence of motor oil. Unfortunately, most aftermarket automotive vendors are not aware of, or choose to ignore this recommendation. Most vendors I contacted who recommend using silicone tubing reply with something like this "We use it all the time and haven't had a failure yet" or "I soaked some in oil for a week and there was no effect".

Curious about this, I was wondering what effect motor oil has on silicone tubing. So, I devised a test that would more closely resemble the conditions tubing is exposed to under the hood of the third generation RX-7.

The Experiment

The experiment is rather simple. Figure 1 is a picture of the test setup. I placed three hoses made from silicone, Viton and Neoprene in oil maintained at 240 °F for 1,000 hours. This is not exactly the conditions a hose under the hood of a third generation RX-7 experiences, but since the Neoprene is similar to the OEM hose material I used it as a control. I checked the condition of the tubing every 200 hours. I stopped the experiment when the Neoprene tubing was in the same condition as many of the six-year-old OEM hoses on my RX-7.

Figure 1. The test setup consisted of the three tubes suspended vertically. Approximately two inches of the tubing was immersed in the 30W-engine oil. The oil temperature was maintained at 240 °F for 1,000 hours.

Neoprene

This is similar to the OEM tubing material. After the test, it was in similar condition that many of the original vacuum hoses are in after 60,000+ miles (Figure 2). The rubber has lost all of its elasticity and was very hard and stiff. Squeezing it firmly between my thumb and forefinger I could not completely pinch off the tubing. The OEM tubing typically fails because it hardens and no longer forms a seal with the fittings and begins to leak. The Neoprene tubing would most likely fail in a similar manner.

Figure 2. The Neoprene tubing on the left was not subjected to the hot oil. The tubing on the right was subjected to 240 °F for 1,000 hours. Although you can't tell from the picture, the tubing on the right has hardened to the point it can not be completely pinched off with your fingers. It is very stiff and non-rubber like.

Viton

Except for the oil film you could not tell the tested tubing from brand new tubing. There was no discoloration or swelling, the elasticity and strength was the same. This was a surprise to me, the specifications indicated that Viton was good, but I had expected some degradation in this test.

Figure 3. The Viton tubing on the left was not subjected to the hot oil. The tubing on the right was subjected to 240 °F for 1,000 hours. Other than a film of oil coating the surface there is no difference between the tubes. The elasticity, hardness and strength were not degraded.

Silicone

The silicone tubing had lost much of its structural integrity. It had swollen and split while immersed in the oil. When I squeezed it between my thumb and forefinger it crumbled into small chunks. It had not hardened like the Neoprene but it could be easily pulled apart with my fingers. Splitting from the ends, as seen in Figure 4, has been reported as the main failure mode of silicone tubing, heat and oil appear to rapidly accelerate this tendency.

Figure 4. The silicone tubing on the left was not subjected to the hot oil. The tubing on the right was subjected to 240 °F for 1,000 hours. The tubing on the right has lost its structural integrity. It has swollen and split. It will beak into small chunks if you try to pinch the tube end. The black substance inside the tube appears to be congealed oil possibly from a reaction of the oil with the silicone elastomer. This jelly like substance was not present inside the Viton or Neoprene tubing.

Conclusion

The best material for vacuum hoses on the third generation RX-7 is Viton tubing. Based on this test, silicone does not appear to offer much of an advantage in longevity over Neoprene tubing. The main difference is the failure mode. Silicone will remain pliable until its structural strength is compromised. This may be of some advantage. Hardened neoprene tubing, which has lost its elasticity, will not form a good seal where it is connected to a fitting. This failure mode is very hard to visually diagnose. The silicone tubing will probably loose its structural integrity and split. You can see from Figure 4 that this would be easier to visually diagnose.

So, the big question is, how long will any of these tubing materials last in your car? That's very hard to tell. Take for example the OEM tubing, some people reported leaking, hardened hoses, after three years use, others still have the OEM vacuum hoses in their car after seven years and over 100k miles without a leak. The best I can surmise, from this test, is that silicone will not harden with use like the OEM tubing, but will eventually fail. The useful life span of silicone tubing is not significantly longer than Neoprene tubing. In comparison, Viton will probably last the life of the car, maybe even longer.

For information on tubing suppliers, material costs, and other recommendations see the previous tubing article on this web page.