

PASS 2

PROTECTION OF AFTERTREATMENT SYSTEMS FROM SULFUR

For several years, Southwest Research Institute® (SwRI®) has been exploring the use of sulfur traps to protect sulfur-sensitive aftertreatment systems such as lean NO_x traps (LNT). In the latest advancement using SwRI's patented PASS technology, the PASS 2 system approach greatly simplifies the process of sulfur trapping and desulfurization.

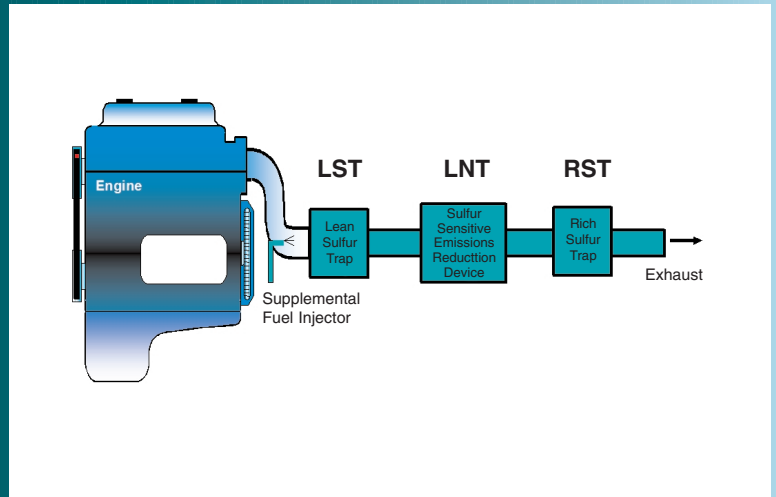
The PASS 2 Process

Sulfur dioxide (SO₂) enters the lean sulfur trap (LST) under lean exhaust conditions. The SO₂ is converted to sulfur trioxide (SO₃) as sulfite and sulfate species within the LST. The sulfur-free exhaust passes through the sulfur-sensitive LNT, which is able to convert NO_x to nitrogen at peak efficiency. As the LST reaches a predetermined sulfur storage threshold, a reducing agent (i.e., fuel) is introduced into the exhaust. The stored sulfur compounds are rapidly released from the LST in the form of SO₂, with some hydrogen sulfide (H₂S) possible.

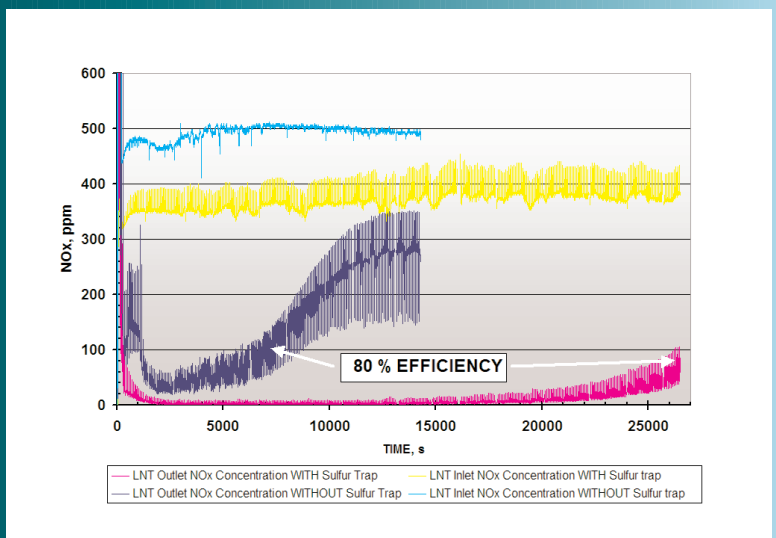
Under rich exhaust conditions, the SO₂ and H₂S pass through the LNT with no lasting detrimental effect on the LNT's performance. A rich sulfur trap (RST) can be included downstream of the LNT to temporarily store any H₂S and release it again as SO₂ under subsequent lean conditions.

Benefits

SwRI has successfully demonstrated that the PASS 2 system approach meets expectations. Based on the work performed, the LST tested could be effective for storing sulfur with high efficiency for at least 50,000 miles, and potentially longer when using ultra-low sulfur diesel fuel. A single desulfurization of the LST could release most of the stored sulfur within about five minutes, with only a minor impact on overall fuel economy. Moreover, the lack of high temperature usually required to desulfurize the LNT should result in significantly increased durability of the LNT. The PASS 2 system could be used to maintain emissions efficiency over 435,000 miles (an emissions warranty limit set by the Environmental Protection Agency) with an estimated nine desulfurizations of the LNT during that period.



PASS 2 Advanced System Design. SO₂ is stored in the LST under lean exhaust conditions. Addition of a reducing agent releases the stored sulfur compounds, which can then pass through the LNT with no lasting detrimental effects.



Sulfur Poisoning of LNT With and Without LST. Use of the LST increased the time for deactivation of the LNT by a factor of four.

Experiments and Results

When comparing deactivation of an LNT by 1,500 ppm sulfur fuel with and without the LST, use of the LST increased the time for deactivation of the LNT by a factor of four. When the LST was regenerated by injection of diesel fuel into the exhaust, there was a momentary reduction in LNT NO_x conversion efficiency, but the LNT was back to full efficiency within seven short cycles. SwRI believes that sulfide species form on the active metals in the LNT during the LST regeneration. During subsequent lean exhaust periods, the sulfide converts to SO₂ and is released during the next rich excursion. Within just a few cycles, all of the sulfur was removed and the LNT operated at normal efficiency.

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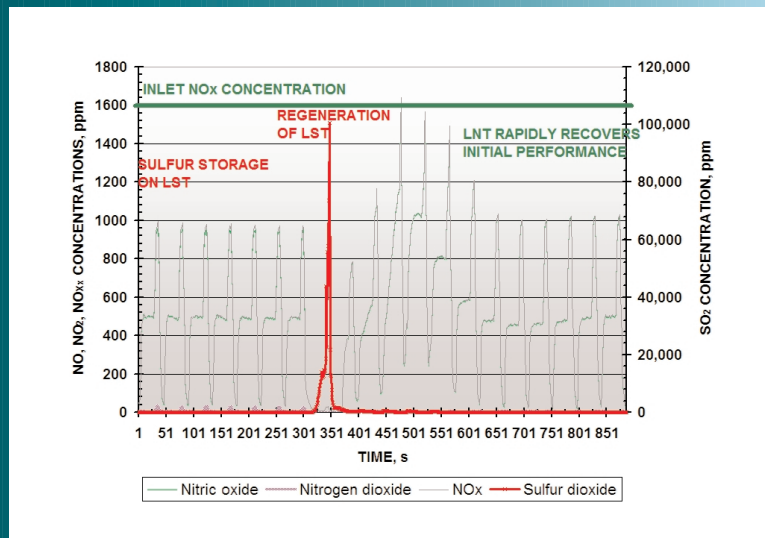
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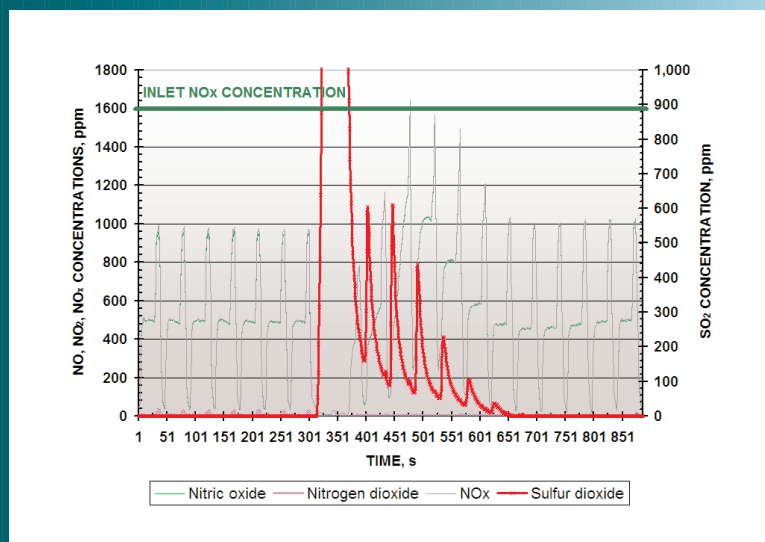
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Effect of Rich Regeneration on RST Emissions. Following injection of diesel fuel into the exhaust, the LNT was back to full efficiency within seven cycles.



SO₂ Under Lean Exhaust Conditions Post-RST. The expanded scale shows several SO₂ releases after the primary release under rich conditions.