

75-90% NO_x Reduction for Diesel & Natural Gas Engines

It's Now A Fact.

Up until now, high capital and operating costs kept the best NO_x control technology ever developed – Selective Catalytic Reduction (SCR) – from being widely used on diesel and natural gas engines. New thinking has changed all that.

Now, regardless of engine size, you can get 75-90% NO_x reduction on stationary, marine or locomotive engines ranging in size from 100 HP 75 kW) up to the largest engines that can be built. And, depending on your application, better fuel economy, too.

New Thinking At Its Best.

RJM ARIS™ Technology is an Advanced Reagent Injection System that incorporates urea-based SCR technology. New thinking has recreated this technology in a simple form -- one that is both cost effective and highly effective in reducing NO_x emissions for your diesel and natural gas engines.

RJM ARIS™ Technology meters precise amounts of a safe reagent into the exhaust stream of diesel or lean burn natural gas engines. Once in the exhaust, the reagent decomposes and forms ammonia that passes over a catalyst to turn NO_x into harmless water, nitrogen and CO₂.

The RJM ARIS™ Technology injection system uses a reagent of 32.5% (by weight) urea or aqueous NH₃ solution. Injector pulse width modulation with bypass flow is utilized for metering the reagent. The injection system consists of a pump, filter, electronic controller, injector and pressure regulator. The pump provides the proper recirculation flow rate from the tank to the injector and back to the tank. The reagent does not have to be heated; just maintained above freezing. It couldn't be simpler.

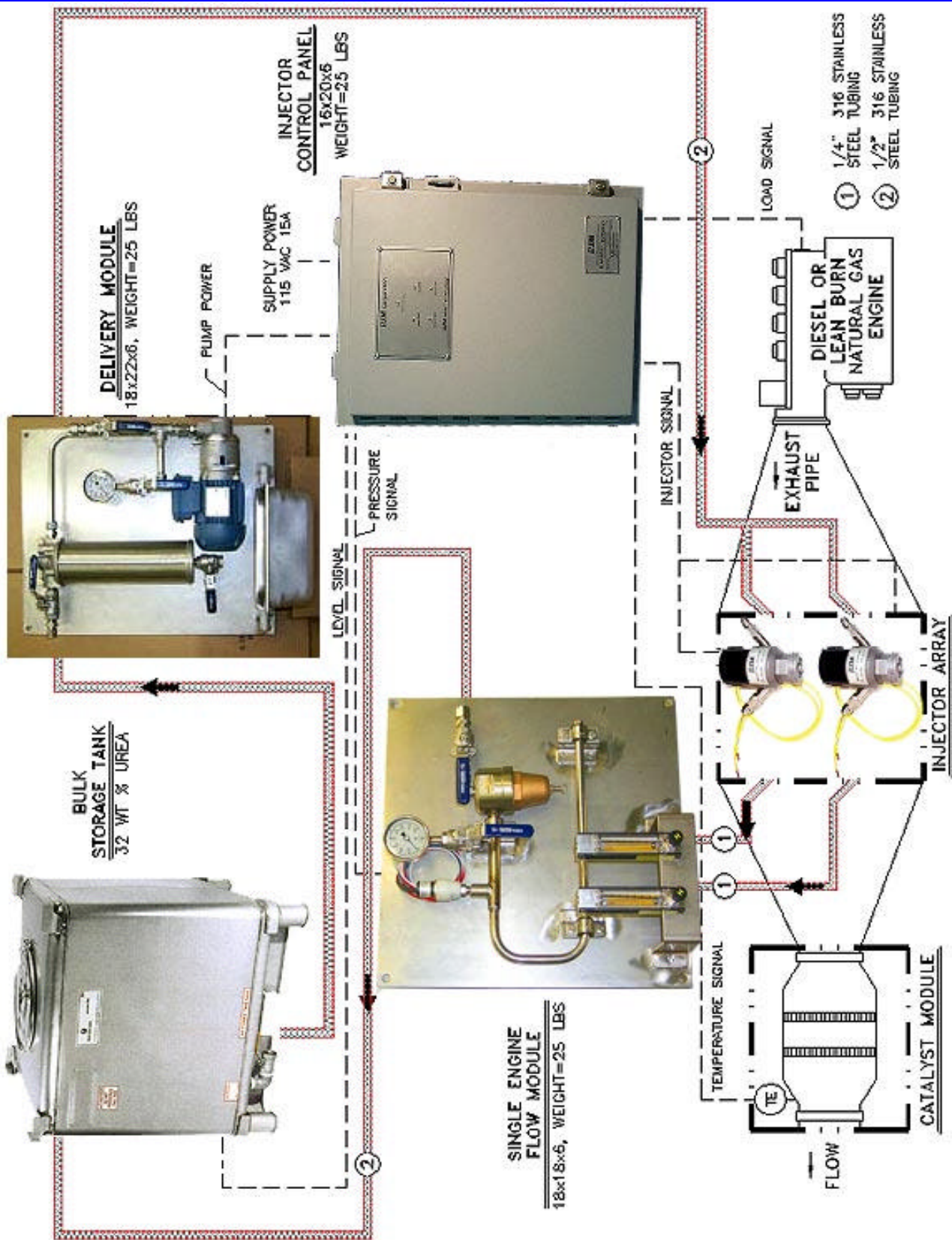
Nothing Is Too Big for RJM ARIS™ Technology.

Our technology provides effective NO_x control for even the largest diesel and natural gas engines. Standardized system designs are applied to engines ranging in output from 100 to 3,000 HP (75 to 2,250 kW). Engines over 3,000 HP (2,250 kW) may require additional engineering to optimize the number of injectors. In all cases, RJM ARIS™ Technology is sized for your specific needs. There's no wasted capacity or capital expense.

RJM ARIS™ Technology uses pre-engineered components to assure proven reliability, system dependability and reduce total system cost. So the technology easily satisfies most regulatory "Best Available Control Technologies" (BACT) requirements.

RJM ARIS™ Technology Offers Significant Benefits

- Get maximum NO_x reduction.
- The technology works regardless of engine load – from 30% up to 100% capacity.
- As a reagent, urea is not hazardous; it's easy to store and handle and there are no regulatory issues.
- No need for steam or compressed air systems to atomize the reagent.
- NO_x is removed for as little as \$1,000 per ton.
- Tune your engine for maximum fuel efficiency.
- Simple installation.

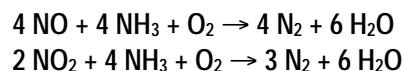


RJM ARIS™ Technology Offers Significant Benefits.

- It is capable of achieving NOx reductions up to 90%. Less NOx reduction is achievable by reducing the amount of catalyst installed in the duct and reducing the reagent consumed. A 75% NOx reduction is the most economical point with minimum slip.
- The technology can typically be utilized from 30% to 100% of engine load. (NOx emissions are minimal below 30% load, and exhaust temperatures are typically too low for the catalyst to be effective.)
- It eliminates the handling and regulatory issues associated with using ammonia. As a reagent, urea is easier to store and to handle. What's more, it's not hazardous. If you spill some, all you have is a fertilized spot on the ground. If you spill some of the other reagents on the market, you have a serious problem to contend with.
- The injector system provides the optimum droplet size and distribution without the use of steam or compressed air for atomization.
- Cost effectiveness of the technology is as low as \$1,000 per ton of NOx removed.
- Use of RJM ARIS™ Technology allows the engine to be tuned for maximum fuel economy and minimum particulate emissions. The fuel efficiency alone can save serious money, especially if your engine currently has retarded timing.
- Units are quick and easy to install. With a little guidance from RJM staff, you can even do it yourself.

Putting SCR Chemistry to Work for You.

When injected into the exhaust gas stream of a diesel engine, urea will decompose to ammonia (NH₃) and react with oxides of nitrogen (NOx) across a catalyst located downstream of the injection point to reduce NOx. This reaction is common to all SCR's and is represented by a simple chemical process described as:



RJM ARIS™ Technology utilizes a urea based reducing reagent to deliver ammonia to the catalyst. This reagent contains 32.5% urea in an aqueous solution.

RJM's reagents meet specific standards for water quality and urea quality and content and contains surfactants and stabilizers that prevent fouling of the urea injection system and contains no harmful chemicals that may impact the operation of the catalyst (e.g. phosphorus) or pose any danger with spills.

Optimum Distribution with a Single Fluid Atomizer.

The patented RJM ARIS™ Technology injection system comprises a single-fluid return flow urea reagent injector combined with a low pressure pump, pressure regulator and electronic controls to accurately meter the quantity of reagent injected as a function of engine load, speed, temperature and NOx emissions. The system is programmed to modulate the signal to the solenoid actuated injector valve which regulates the period of time the injector remains open during each cycle of the factory set injector cycle frequency.

One of the unique advantages of the RJM ARIS™ Technology injector system is that it provides the droplet size distribution required without the capital expense and operating cost of an additional atomizing medium, such as steam or compressed air.

Depending on the reagent flow required, one or multiple injectors are fitted to the exhaust gas duct upstream of the catalyst. A standard RJM ARIS™ Technology prefabricated pumping and control module will feed up to two injectors and is generally suitable for engines rated up to 3000 HP (2,250 kW). For larger applications requiring multiple injectors or for multiple engine sites, RJM offers custom engineered systems. These systems may use a common reagent circulation loop feeding a number of engines with multiple injectors on the exhaust duct of each engine.

In general, reagent injection is not started until exhaust gas temperature reaches 250°C which enables the thermal decomposition of urea to ammonia upstream of the catalyst. The RJM ARIS™ Technology injector uses the return flow of urea from the injector to keep it cool and prevent urea deposits from forming in the injector valve. Electronics are designed to cease urea injection should there be a low level of urea reagent indicated by the tank level sensor.

Choosing the Best Catalyst.

Several different types of SCR catalyst are available for application to diesel engines including noble metal based catalysts, vanadium/titanium washcoated or extruded catalysts and zeolite based catalysts. The selection of a catalyst is principally determined by its NOx conversion performance over the range of exhaust gas temperatures encountered on a particular application. RJM ARIS™ Technology is best suited for use with catalysts designed for operation in exhaust gas temperatures of 250°C - 650°C, which covers the bulk of the range encountered in stationary engine exhaust ducts as well as those of marine and locomotive engines.

Performance of a catalyst is generally a feature of its specific catalytic activity which, in turn, determines the volume of catalyst required. This is defined in terms of space velocity (S.V.) which is the exhaust gas volume per hour corrected to standard temperature and pressure divided by the catalyst volume. Typically space velocities are 20,000 - 60,000 for diesel SCR and vary with the baseline emissions, percent NOx reduction required, and specific catalyst activity.

Success Is Guaranteed.

The fundamental requirement for successful application of urea SCR is that the exhaust gas temperature be adequate for urea decomposition and that the SCR catalyst be selected to match exhaust gas temperature and exhaust gas flow rate. Actual NOx reduction then becomes a function of matching reagent injection and catalyst sizing to the baseline NOx and percent NOx reduction required. Generally the reagent feed rate is defined in terms of NSR which is the molecular ratio of NH3 species to the inlet NOx. The reaction of reagent across a catalyst is typically 100% so that a 0.7 NSR gives 70% reduction and a 0.9 NSR gives a 90% reduction.

For stationary engines exhaust gas temperature should be between 300 - 600°C for best performance. Below these levels reagent injection should be minimized, and above, the catalyst may be thermally damaged or exhibit decreased NOx reduction performance.

In-Use Audit and Verification.

Each RJM ARIS™ Technology urea SCR application requires programming of the injector Electronic Control Unit (ECU) to control the injection rate to one or more engine parameters such as rpm, load or NOx output signal. An engine map is then generated which identifies NOx emissions as a function of engine power output as well

as exhaust gas flow rate and temperature. Data for the engine/NOx map may be generated by the engine manufacturer or packager through factory engine tests or from field data generated by RJM.

The data from this engine map forms the basis of RJM's Process Design Specification which defines operating conditions, hardware selection and reagent flow rates upon which any performance guarantees are based. As such, the first step in an audit program is a review of the RJM Process Design Specification which will confirm that injection hardware, reagent flow rate and catalyst selection are adequate for the certified performance level.

Nobody Does It Better.

There are a number of technologies that reduce NOx emissions in diesel and natural gas engines... injection timing retard (ITR), water injection, emulsions, turbocharging, intake air cooling, air fuel mixing, high injection pressure and rate shaping, exhaust gas recirculation systems (EGR), turbocompounding, and more.

SCR technology is, by far, the most effective. None of the other technologies, even in combination, can surpass the 75-90% NOx reduction only an SCR system can give you. And, only RJM ARIS™ Technology gives you the reliable NOx reduction capacities of an SCR at the lowest possible price.

Just In Time.

More stringent NOx regulations are pending for new stationary diesel engine installations in various regions of the world. In the near future, retrofit NOx control legislation is expected for existing diesel installations. So RJM ARIS™ Technology is here when you need it most.

Contact RJM today.

RJM CORPORATION
501 Merritt Seven
Norwalk, CT 06851-7003
Phone: 203-847-7000
Fax: 203-847-5000
E-Mail: aris@rjmcop.com

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