

# Environmental Pioneer Project in Macau

## Emissions Control Retrofit for 232 MW 2-stroke Diesel Engine Power Plant



### Macau Power Supply

The supply of electricity in Macau is provided by Companhia de Electricidade de Macau (CEM) from three power plants utilizing a mix of medium- and low speed heavy fuel diesel engine generators, heavy fuel steam generators, diesel fuel gas turbines and combined cycle gas turbines. The largest fraction of electricity is generated by the 2-stroke low speed diesel engines at the Coloane Power Station. These units have a combined power output of 232 MW. They were commissioned in the period from 1987 to 1996, making it the largest diesel engine power plant in the world at that time.

### Emission Control Challenge

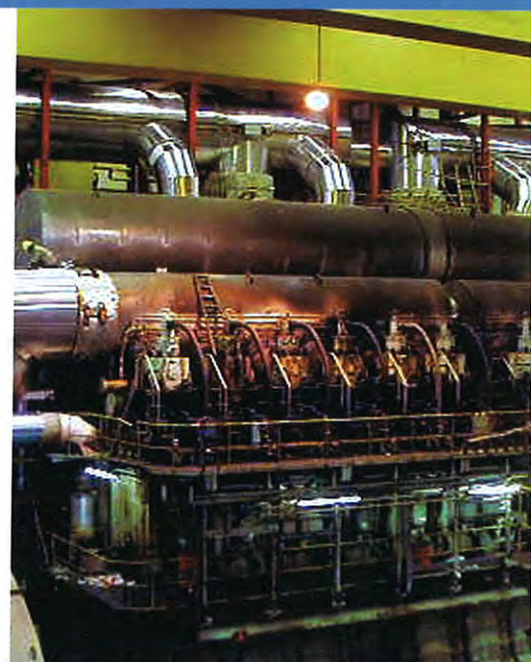
General development and rapidly growing tourism has moved Macau city and tourist facilities ever closer to the power plant. Air quality has consequently received growing public attention. In 2002 a decision was made in Macau to reduce emissions of the plumes from the base load diesel engines. The main element for emission abatement chosen was the installation of equipment for Selective Catalytic Reduction (SCR) for all of the six low speed engines for efficient reduction of nitrogen oxides (NOx). It was decided that the nitrogen oxides emissions should be reduced to less than 10% of the existing concentration.

### >>> The Consortium

Three world leading companies teamed up and formed a Consortium to implement this emissions control retrofit project:

Burmeister & Wain Scandinavian Contractor A/S (BWSC), a Danish company specialized in construction, erection, and commissioning of diesel engine based power plants, Mitsui Engineering and Shipbuilding Co., Ltd. from Japan, specialized in the manufacturing of low speed diesel engines, and Siemens AG/Argillon GmbH, a German company highly experienced in producing SINOx<sup>®</sup> catalyst and engineering of SINOx<sup>®</sup> emission control systems for coal fired power plants, marine- and stationary diesel engines and automotive applications. BWSC and MES had originally supplied the engines and built the power plants on a turnkey basis. For the implementa-

tion of this emissions control project BWSC has undertaken the structural design, designed and supplied the exhaust ductwork and carried out full erection of the installations – a most challenging and difficult task given the constraints of space in this retrofit application and the demanding time schedule. MES has provided state-of-the-art engine technology upgrades for fuel injection and cylinder lubrication of the engines, and the modifications to the turbochargers required to maintain engine performance with the emission reduction system integrated into the engine exhaust system. Siemens AG/Argillon GmbH has designed and supplied the emission control system with the proprietary SINOx<sup>®</sup> catalyst, that reduces the emissions of smog-forming Nitrous Oxides (NOx) to a minimum.

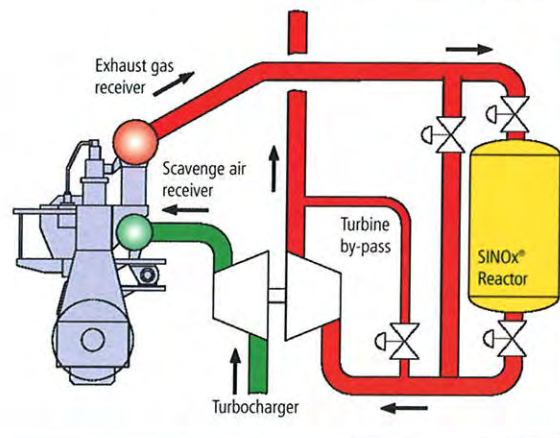
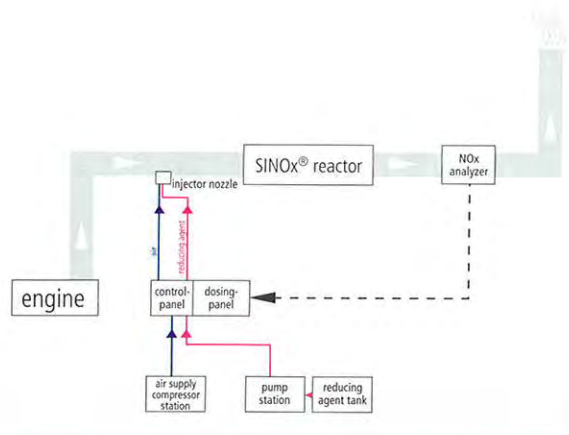




## >>>> The SINOx® SCR Process

The SINOx® System applies SCR (Selective Catalytic Reduction) technology, the most effective and proven process for Nitrous Oxides (NOx) reduction. The basis of the process is to transfer the NOx into harmless nitrogen (N<sub>2</sub>) and water vapor (H<sub>2</sub>O) by combining the NOx with a precisely measured, small amount of the reducing agent, ammonia (NH<sub>3</sub>), in the presence of a catalyst. By suppressing undesired side processes, the chemical reactions proceed

rapidly and selectively. The catalyst is integrated into the exhaust gas system. Due to the high efficiency of the 2-stroke engines, the exhaust gas temperature downstream the turbocharger (T/C) is low. Operation of such engines on heavy fuel oil (HFO), requires the SCR to be installed upstream of the T/C, with an operating pressure of 3.5 bara and an operating temperature up to 490°C



## >>>> Performance and Operating Results

Project implementation and installation had to be performed in a very challenging time schedule of less than 19 months between contract award and take-over of final sixth unit to commercial operation. Retrofitting the large equipment and extensive ductwork (up to 2.2 m outside dia.) into an existing power plant with very limited space available, posed a considerable challenge to the Consortium. The whole project was implemented by the Consortium within the contractual time frame and meeting commitments with a minimum down time and impact on operation and power generation for Macau.

The SCR-system has proven to be a reliable system, which has performed well since its initial operation. All contractual limits were achieved. The NOx reduction exceeds 90% conversion. Remaining NOx in the exhaust is well below current World Bank Requirements and the Macau SAR guidelines for the operation of the Combined Cycle Power Plant (Coloane B Power Station). The NO<sub>2</sub>-fraction has been eliminated almost completely. The overall result has shown that it is technically possible to retrofit 2-stroke-low-speed diesel engines operating on heavy fuel oil with a highly efficient NOx emission control system and to achieve very low emission levels, with significant reduction of the yellow-brownish plume appearance.

May, 2004

*The achievements of the Argillon/BWSC/MES Consortium in successfully implementing the emissions control retrofit project, has demonstrated that such technical solutions can be implemented within very challenging and demanding time schedules, high performance requirements and with minimal time and impact on operation and power generation for benefit of the people and businesses of Macau.*



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