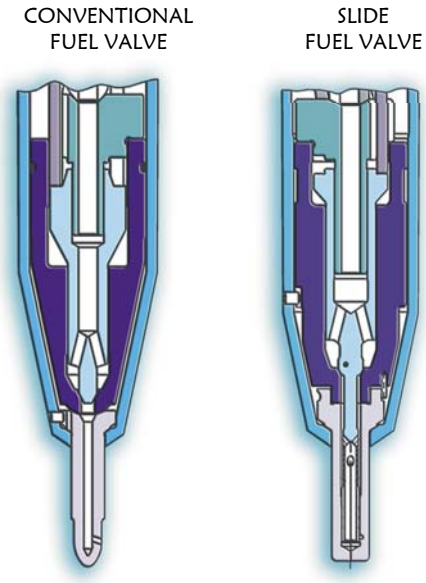
OGV Slide Valve Low-Load Emissions Evaluation

Technology Manufacturer
MAN Diesel & Turbo A/S

Co-Participants
MAN Diesel & Turbo A/S
Mitsui Engineering & Shipbuilding Co, LTD
Starcrest Consulting Group, LLC



Background

In 2008, the Port of Los Angeles and the Port of Long Beach participated in a demonstration of slide-type fuel valves to quantify their effectiveness as an emissions reduction retrofit technology for ocean-going vessels (OGVs) equipped with Tier 0 and Tier 1 two-stroke diesel main engines[1].

The demonstration was conducted aboard the APL *Singapore*. This new type of OGV main engine fuel valve is designed to improve combustion properties by eliminating sac volume (i.e., fuel drips) at the valve nozzle. The elimination of the sac volume results in lower fuel oil consumption. In addition, slide valve nozzles incorporate an optimized spray pattern designed to improve the combustion process - this is intended to reduce overall emissions, including hydrocarbon, NOx and particulate matter. The visible smoke level is also greatly reduced as a result of the improved combustion.

The manufacturer, MAN Diesel & Turbo A/S (MDT), had previously published data suggesting slide valves offered a potential for a 30% reduction in NOx emissions and 25% reduction in DPM emissions when the technology is optimized in new engines.

The results from the 2008 APL *Singapore* slide valve retrofit demonstration, although ultimately inconclusive, seemed to suggest that the use of slide valves as an OGV main engine retrofit technology might not provide the level of emission reductions originally anticipated. In addition to the APL data, new information provided by the manufacturer also indicated that potential benefits from slide valves could be eroded as engine load is reduced. Ships complying with the vessel speed reduction (VSR) program, which has upwards of 95% participation in San Pedro Bay, generally have main engine loads below 25%, which is the lowest load point at which slide valves had been previously tested. Discussions with MDT determined that there had been no low-load engine tests for slide valve emission reductions conducted specifically on large slow-speed, two-stroke propulsion engines below 25% load and, therefore, no data to determine whether the slide valve benefit is appropriate at these lower loads.

[1] New Tier 2 vessels already incorporate slide valves and therefore no additional reduction is applicable to their use.

The emission reduction benefits associated with slide valves is currently being applied in both port's emissions inventories for all vessel main engine loads. Due to the high participation levels of vessels complying with the VSR program, the Port of Los Angeles (POLA) and Port of Long Beach (POLB) sponsored additional emissions testing to determine what, if any, benefit results from MAN slide valves, especially at engine loads below 25 percent. Over 41% of all 2012 vessel arrivals to both ports are made by vessels with MAN slide valve equipped propulsion engines. This testing was conducted in support of the San Pedro Bay Ports Clean Air Action Plan OGV Measure Number 6 (OGV6) and is intended to improve the annual emissions inventories.

Project Objective

The ports, with support from their project partners, developed a comprehensive test plan to quantify emissions from OGV fuel valves as a function of fuel valve nozzle design and engine load. Three fuel valve nozzle designs underwent performance and emissions testing:

- Slide-valve (SV) nozzle C26 – this is standard equipment on new slow-speed marine diesel engines manufactured by MDT and its licensees;
- Conventional C3 nozzle – this is the fuel valve design used on Tier 0 and Tier 1 MDT marine diesel engines;
- Conventional C11 nozzle – this is a "low-NOx" conventional fuel valve, equipped with a nozzle that delivers a fuel spray pattern designed to minimize NOx emissions.

Technology Demonstration

The MAN 6S70MC-C7 marine diesel engine was selected as the test bed for the low-load emissions testing. This six-cylinder, slow-speed two-stroke marine engine was selected based on call activity data from both ports over the past several years and is the most representative propulsion engine available for testing in the fleet of vessels that has called at both ports.

Three test cycles consisting of the following load profiles were specified for each fuel valve configuration:

- Test Cycle #1: Engine load of E3 while temperature is stable;
- Test Cycle #2: Engine load of 15% while temperature is stable;
- Test Cycle #3: Engine load of 10% while temperature is stable.

Testing methods specified in the test plan were consistent with methods outlined in Chapter 5 of the IMO MARPOL Annex VI, NOx Technical Code 2008 (2009 Edition), and ISO8178. Tests were conducted for particulate matter, soot, and gaseous emissions. In the photos below, an MDT Technician Prepares Particulate Filters in Preparation for Sampling in Accordance with ISO 8178.

Results

Results from the Mitsui Engineering & Shipbuilding, Co., LTD., Gaseous Measurements and MDT Particulate Measurements of Fuel-Valve Tests on 6S70MC-C7 at Tamano Works, Japan are summarized as follows:

- Slide valves (SV C26) emit the same level or more NOx (g/kW-hr basis) at low loads compared to the two conventional fuel valve configurations;
- The conventional C11 fuel valve was found to emit ~15% less NOx (g/kW-hr basis) at low loads than the SV C26 and C11 fuel valves;
- Below loads of 75%, slide valves emitted more NOx (g/kW-hr basis) than the two conventional fuel valve configurations and the C11 emitted the least NOx of all three fuel valve configurations;
- SV C26 nozzles were confirmed to emit less diesel particulate matter (DPM) at low loads compared to the two conventional fuel valve configurations. At low loads, SV emits up to 50% less DPM than conventional C3 and C11 fuel valves and up to 65% less DPM for cylinder-lubrication-corrected particulate-emission results;
- SV C26 nozzles emit over 90% less total hydrocarbons compared to the two conventional fuel valve configurations.

The results of the MAN slide valve low-load testing were documented in a Final Report approved by both Ports in August 2013.

Project Costs

The Port of Long Beach and Port of Los Angeles contributed $216,000 ($108,000 each) in TAP funding for the OGV Low Load fuel valve test program.

Updated: April, 2014