Performance and behavior of Dual-Fuel engines in LNG carriers - Classification

Class requirements

Dag Harald Williksen
2012-01-25
Agenda

- SOLAS requirements
- IACS UI (Unified Interpretation)
- IACS UR (Unified Requirements) vs DNV Rules

- DNV Rules for dual fuel engines
  - Design
  - Monitoring
  - Testing

- Application of a dual fuel engine
SOLAS Chapter II-1, Part D, Regulation 40-41

- **Regulation 40**
  - Secure power for all electrical auxiliary services necessary for maintaining the ship in normal operational and habitable conditions without the use of emergency source of power
  - Secure power to services essential for safety under various emergency condition
  - Secure people from electrical hazards

- **Regulation 41 – All vessels**
  - Main source of electrical power of **sufficient capacity** to supply all services on-board
  - Main source shall consist of **at least two generating sets**
  - Capacity of generator sets shall be such that if one set has stopped, it will still be possible to maintain normal propulsion and minimum comfortable condition of habitability.

- **Regulation 41.5 – When electric power is necessary for propulsion and steering**
  - Electrical system shall be arranged so that electrical supply to propulsion and steering is **maintained or immediately restored** in case of loss of one generator.
IACS SC157 – Main Source of Electrical Power

- IACS Unified Interpretation of “maintained or immediately restored”

- When electrical power is normally supplied by one genset:
  - Measures shall be taken to start and connect standby gensets within 45 seconds (preferably within 30 seconds to avoid emergency genset to start).

- When electrical power is normally supplied by more than one genset in parallel:
  - Measures shall be taken to keep the remaining genset /-s in operation after loss of one genset.
IACS UR M3 vs DNV Rules Pt4 Ch2 Sec4
Speed governor and overspeed protective device

IACS IACS Unified Requirement shall be followed by all Classes

IACS UR M3.2 – Speed governor, overspeed protective and governing characteristics of generator prime movers

- Steady state condition
  - Maximum speed variation of ± 5% at any load between no load and full load

- Transient response
  - ± 10% speed variations and recover to steady state within 5 seconds when maximum load step is switch on or off from any load
  - More than +10% speed increase may be accepted when engine load is switched off from full engine load to zero load (idle). Engine must not stop by overspeed protection.

Pt4 Ch2 Sec4 – Electric Power Generation

- Steady state condition
  - Written differently, but with the same content and requirements as IACS

- Transient response
  - Response requirements identical to IACS
  - Response requirements identical to IACS
IACS UR M3 vs DNV Rules Pt4 Ch2 Sec4, cont.…..

Load steps

- Prime movers are to be selected in such a way that they will meet the load demand from the ship’s mains

- **Two** load steps
  - 0% to 50% and 50% to 100%
  - Steady state condition after **5** seconds
  - Steady state is when new engine speed is within **1%** of declared engine speed at that power

- More than **two** load steps
  - E.g. 3, 4, 5 or more
  - Design to be **approved** by a **system specification**
  - Steady state condition after **5 seconds**
  - Steady state when new engine speed is within **1%** of declared engine speed at that power

- **Identical to IACS**

- **Three** load steps
  - 0% to 33%, 33% to 66% and 66% to 100%
  - Response requirements identical to IACS

- More than **three** load steps
  - 4, 5 or more
  - Approval identical to IACS
  - Response requirements identical to IACS
IACS UR M3 vs DNV Rules Pt4 Ch2 Sec4
Capability to keep on running

- M3.2.3. Last part of last section
- Priority of electrical power in case of one generator stopping
  - (..........In this case, due consideration is to be given to the power required for the electrical equipment to be automatically switched on after black-out and to the sequence in which it is connected. This applies analogously also for generators to be operated in parallel and where the power has to be transferred from one generator to another in the event of any one generator has to be switched off.)

- Pt4 Ch2 Sec4 A105
- Identical to IACS by stating:
  - When generator sets are running in parallel, it shall be ensured that, in case of loss of any of these generating sets, the remaining ones are kept in operation to permit propulsion and steering and to ensure safety.
DNV Rules for Ships – Testing of gensets

- Testing of genset capabilities is in our Rules required in Pt4 Ch2, not Pt4 Ch3, as this test has to be carried out **onboard and verified** by a surveyor.
  - Pt4 Ch2 Sec4 - Rotating Machinery, General – Electric power generation
  - Pt4 Ch3 Sec1 – Diesel engines

- In many cases are engine manufacturers not able to load engines/gensets in the same way as they will experience onboard a vessel.
  - Loaded by a waterbreak, not generator
  - Problems with switching on and off load suddenly

- Onboard test
  - Largest possible load step, based on configuration on board shall be applied
DNV Rules for Ships – Requirements for dual fuel engines

- **Design**
  - Air inlet manifold and exhaust manifold of sufficient strength, alternatively explosion relief venting, to withstand an explosion.
  - Avoid un-burnt gas fuel in exhaust system and outside vessel
    - Start and stop on fuel oil only
    - Switch over from fuel oil to gas:
      - Only possible at a power level where it can be carried out with acceptable reliability
      - Fuel gas supply shall be switched off no later than simultaneously with fuel oil.
      - Shall not be possible to switch off fuel oil before gas fuel

- **Monitoring**
  - Ignition failure each cylinder
    - Monitored by exhaust temperature monitoring or knocking sensors
      - Automatic stop of gas supply and alarm

- **Testing**
  - Same tests as for a diesel engine applies wrt load points
  - Same requirements as for a diesel driven genset wrt load response
  - Switch over from fuel oil to gas shall be tested at the maximum declared power for switching to gas
Dual-fuel engines as prime movers for generators

- A dual fuel engine should satisfy the same requirements as a diesel engine

- If the dual fuel engine is supposed to be used in normal operation in all modes, diesel, gas, or dual fuel mode, the requirements shall be meet in all these modes.

- A switch between modes, e.g. from diesel to gas will be considered as a transient event, hence capabilities of maximum ± 10% speed variations and recovery time to steady state within 5 seconds must be meet.
Cylinder balancing and variation in firing pressures

- We know that engines working according to otto-cycle will vary more than a diesel engine in firing pressure, cycle to cycle.
  - Diesel cycle, typically ±3 bar
  - Otto cycle, typically ± 20 bar

- The effect of variation in firing pressures is considered to be:
  - varying in level
  - fluctuating from cylinder to cylinder
  - high-frequency from cycle to cycle

- The torsional vibration calculation carried out with “1-cylinder in misfiring condition” is considered to be worse than the variation in firing pressures, hence we expect no problems in the shafting system due to the fluctuating firing pressure.
Safeguarding life, property and the environment

www.dnv.com