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DYNAMIC POSITIONING CONFERENCE
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POWER SESSION

Challenges of Protection and Control System Verification on DP3 Vessels with Focus on Ride through Fault and Blackout

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Drilling – DP Closed Ring

Challenges of Protection and Control System Verification on DP3 vessels with Focus on Ride through Fault and Blackout

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DP Closed tie operation
The Challenge

Background

DP3 power plants configured and operated with closed tie-breakers is more often included spec requirement from several clients.

IMO resolution 645

Bus-tie breakers should be open during equipment class 3 operations unless equivalent integrity of power operation can be accepted according to 3.1.3

Challenge

Build in sufficient protection and safety in the power plant to achieve the necessary integrity as required by IMO.

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DP Closed tie operation - Fundamentals

1) Avoid failures
   - High integrity switchboards
   - Insulated bus-bars and cable connections
   - Mechanical protection of cables
   - Interlocks for human errors
2) In depth understanding of the power system behavior
   - Dynamic studies and relay plan
3) Avoid transients – pre-mag transformers and capacitors
4) Fast and selective disconnection if failure should happen
   - Including Fuel and Excitation failures
5) Back-up for hidden failures
6) Extended test program including short circuit faults
7) Fast black-out recovery

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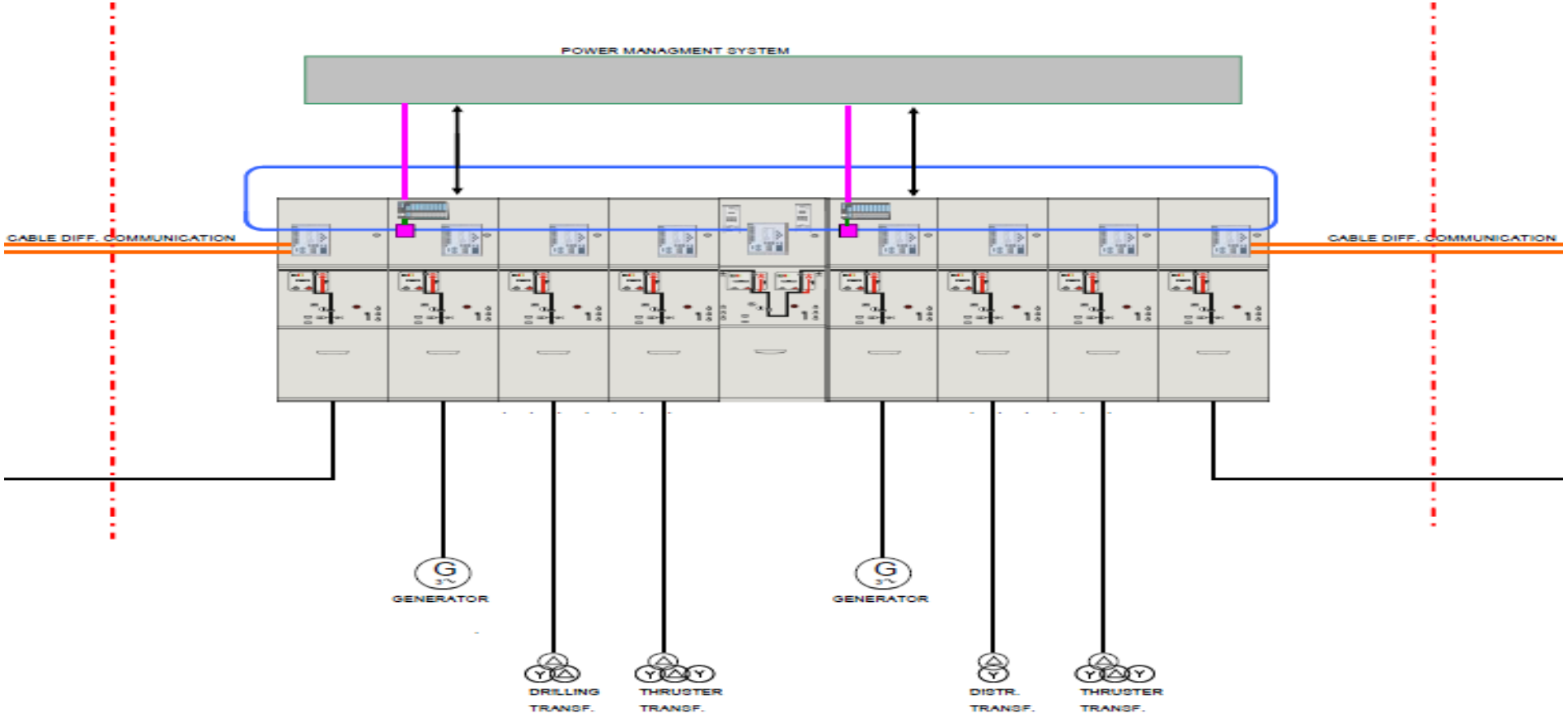
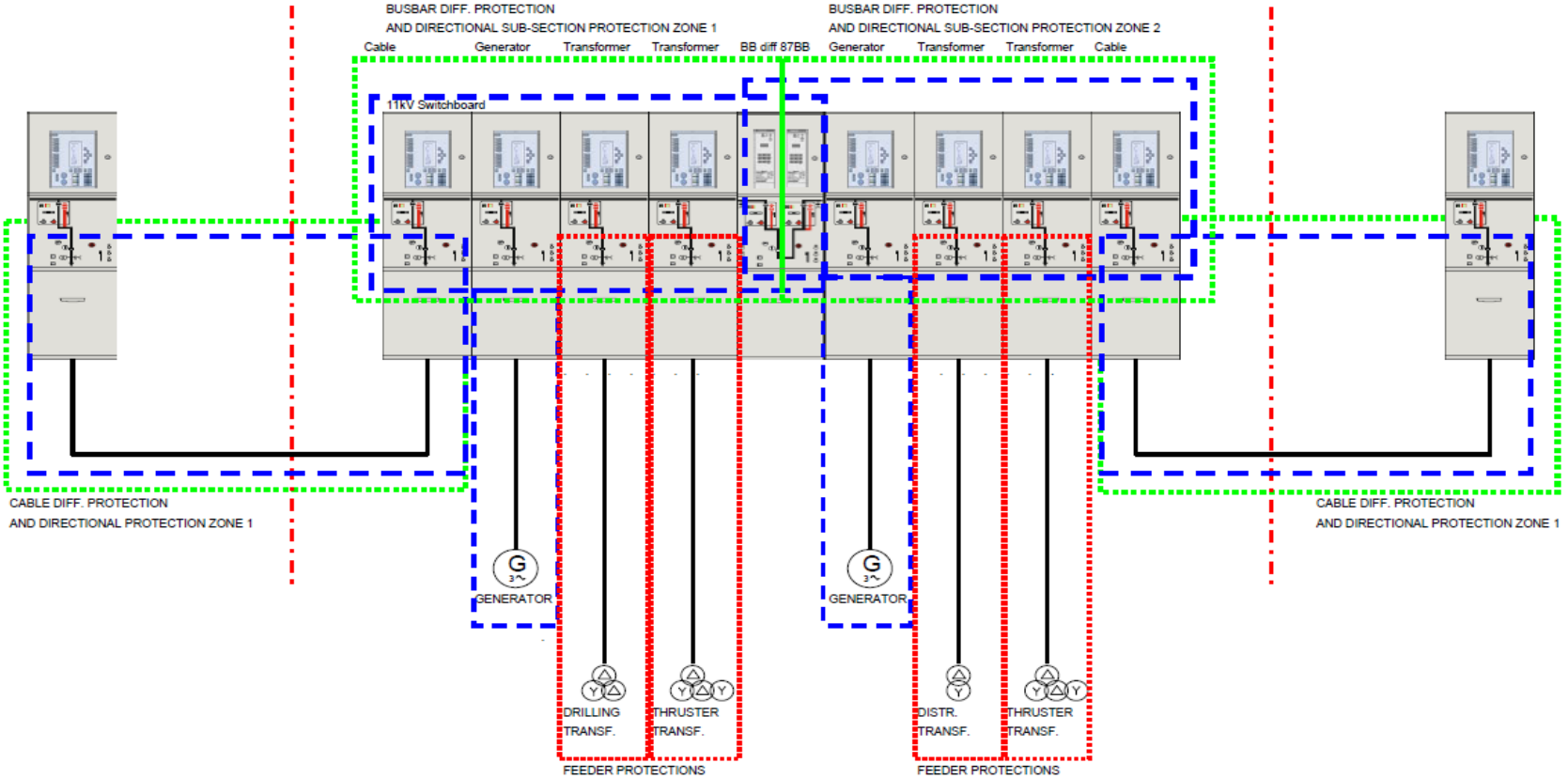
Fast and redundant Communication IEC61850/GOOSE



Zone protection all over



DP Closed Ring Development - FMEA

Worked together with DNV on the closed ring concept since 2011

Continuous used the Failure Mode Effect Analysis during the complete design phase with third party involved

More than 180 failure scenarios analyzed

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DP Closed Ring – Extended FMEA
Test Scope

- Fuel Starvation .....
- Excessive Fuel .....
- Abnormal Fuel Actuator Current .....
- Too High Excitation .....
- Too Low Excitation.....
- Loss of Excitation .....
- Loss of voltage sensing to AVR .....

11kV Ground Fault Ride through .....

11kV Short Circuit Fault Ride Through .....

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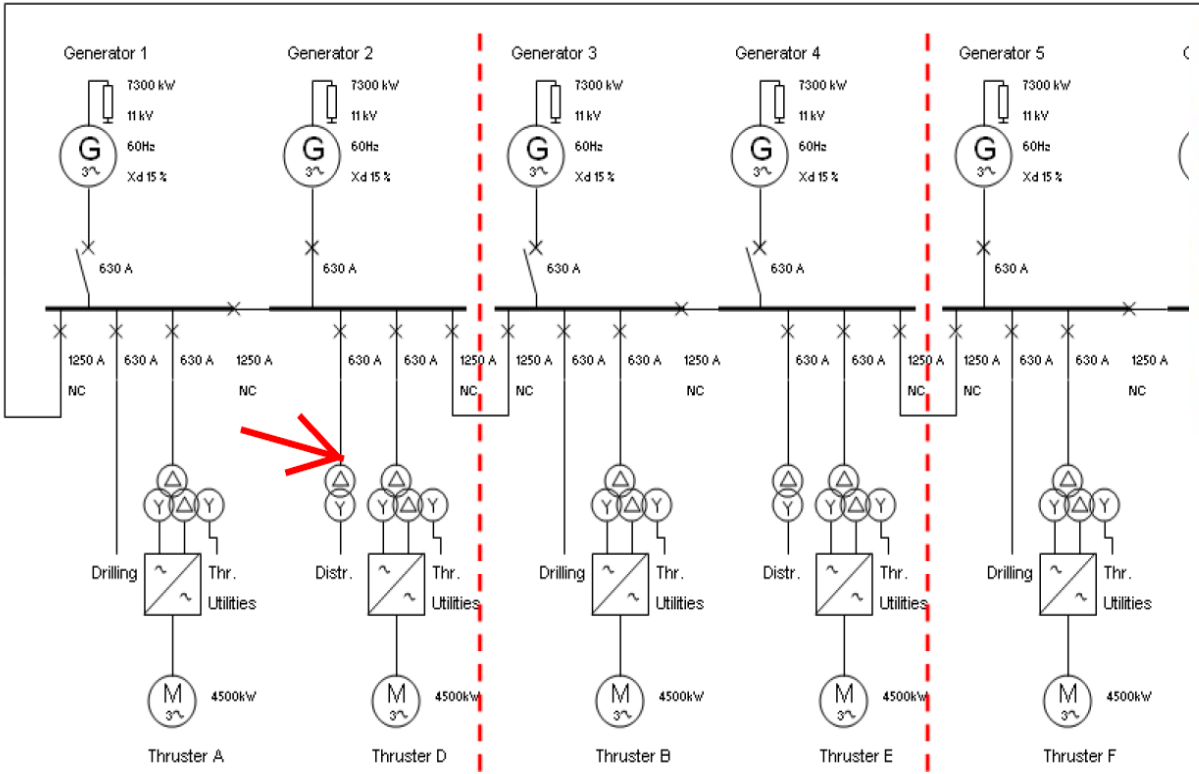
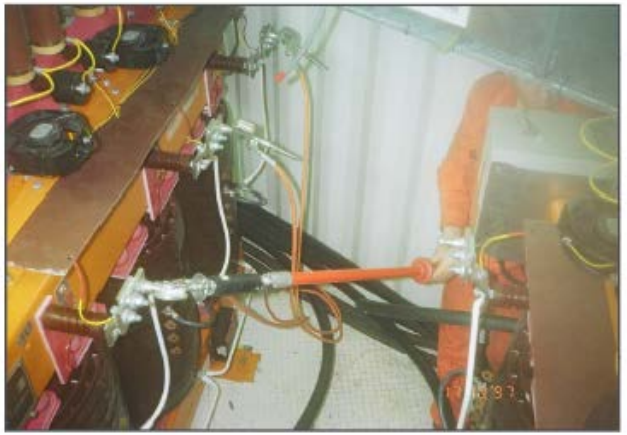
DP Closed Tie – Worst case failure





Safety procedures:

1. Disconnect completely
2. Secure against re-connection
3. Verify that the installation is dead (voltage testing)
4. Carry out earthing and short-circuiting
5. Provide protection against possible, adjacent live parts

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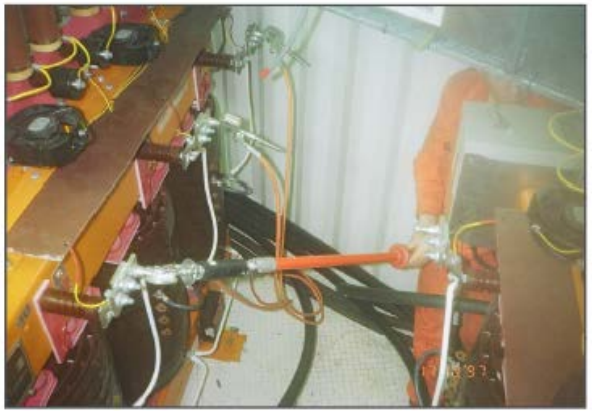
DP3 Closed Tie – Worst Case Failure

Bolted 3 phase short circuit to ground in high voltage distribution and at the same time:

DP operation

Hidden failure in breaker

Human error



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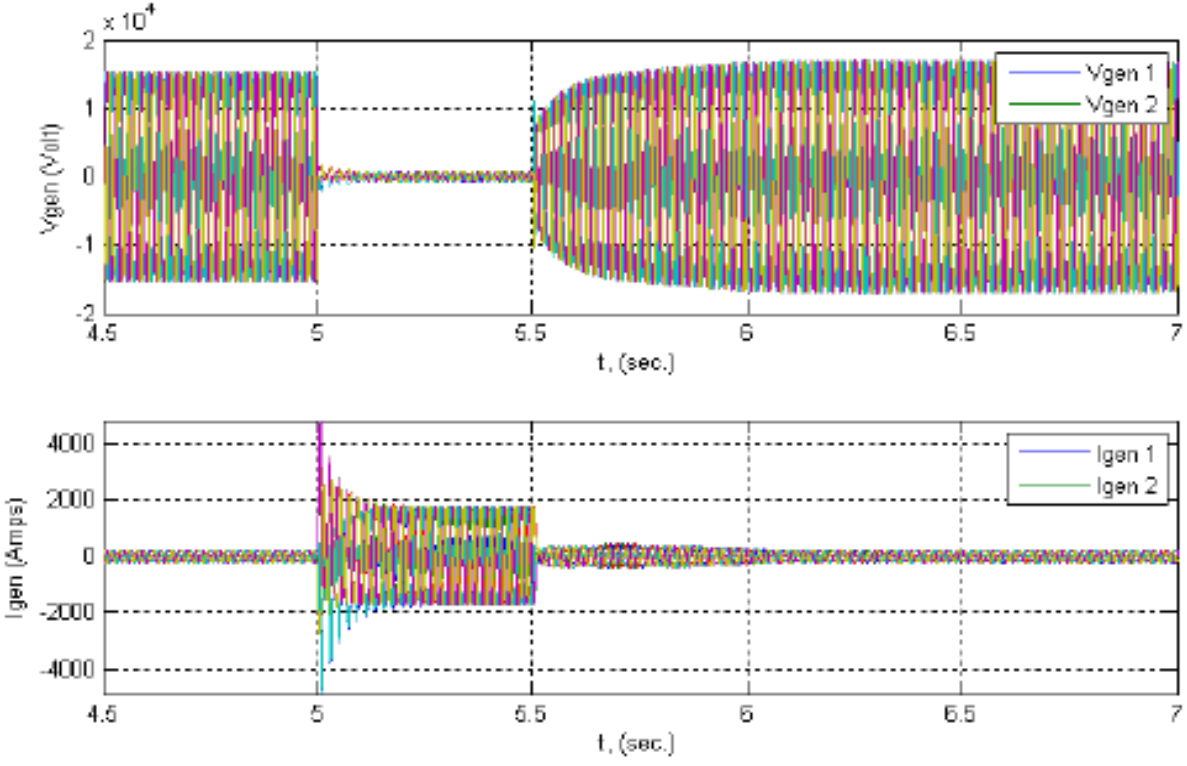
DP Closed Tie
Worst Case Failure



- High fault current
- Bus voltage reduced to approx 0V
- No power delivered to consumers
- Engine speed (HZ) increase
- Engine/Generator torque oscillations

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DP Closed Tie
Worst Case Failure Test

The short circuit test will verify the complete system:

- Fast acting CBs and selective protection relay setting
- 50BF (Breaker failure function)
- Load step response of diesel generator
- Thruster fault ride through (Kinetic buffering)
- CB and MCC fault ride through
- Fast load limitation system (ER/EHS notation)
- Auto start of stand-by generator
- No spurious trip on under/over voltage or frequency

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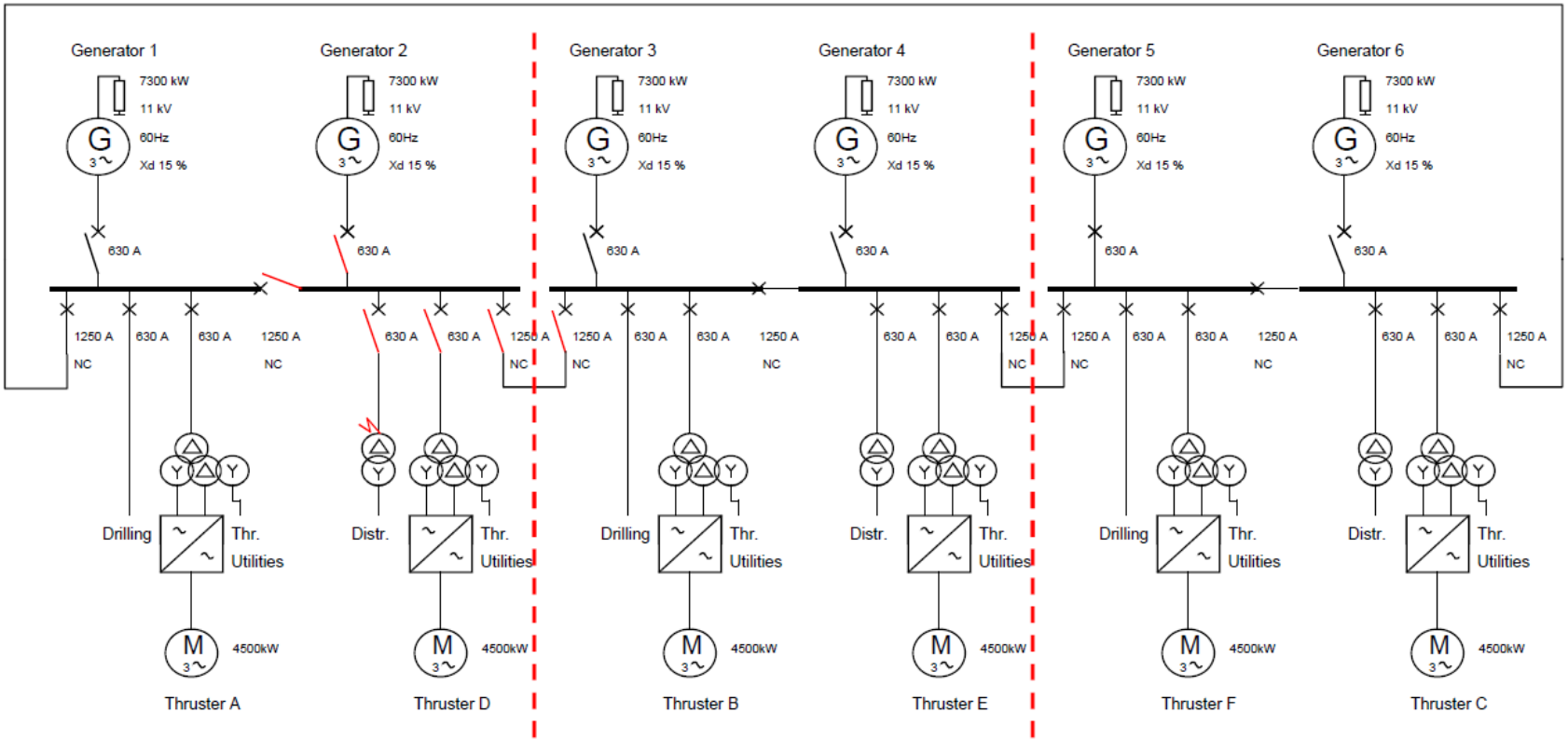
Condition after SC fault with hidden failure: One sub-section disconnected



Fast black-out recovery

Start condition:

Total blackout on the vessel

- Stand-by generators pre-heated and available
- UPS and control voltage available

Sequence on the next pages describes steps taken automatically to restore the power plant by:

- Soft voltage ramp-up of generators and transformers
- Thrusters VSD pre-charge automatically based on grid voltage

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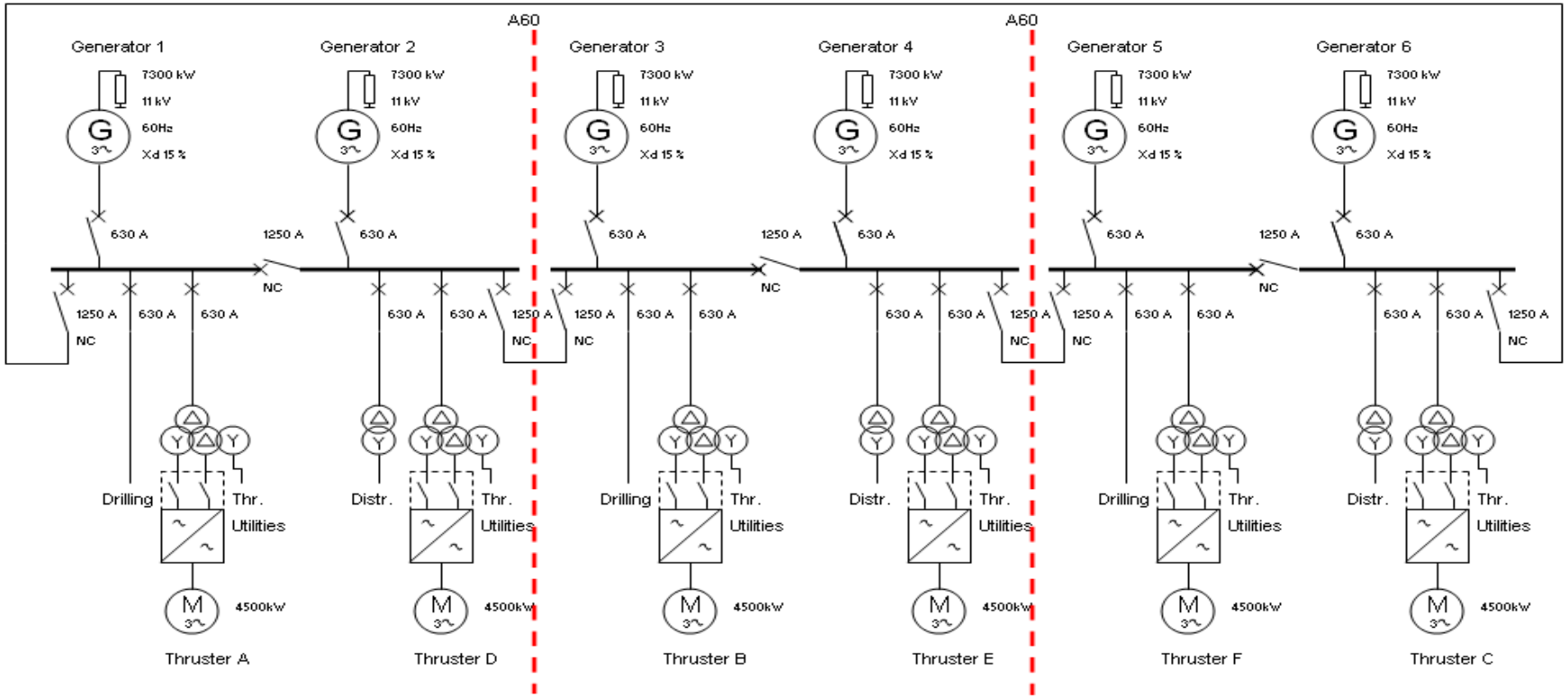
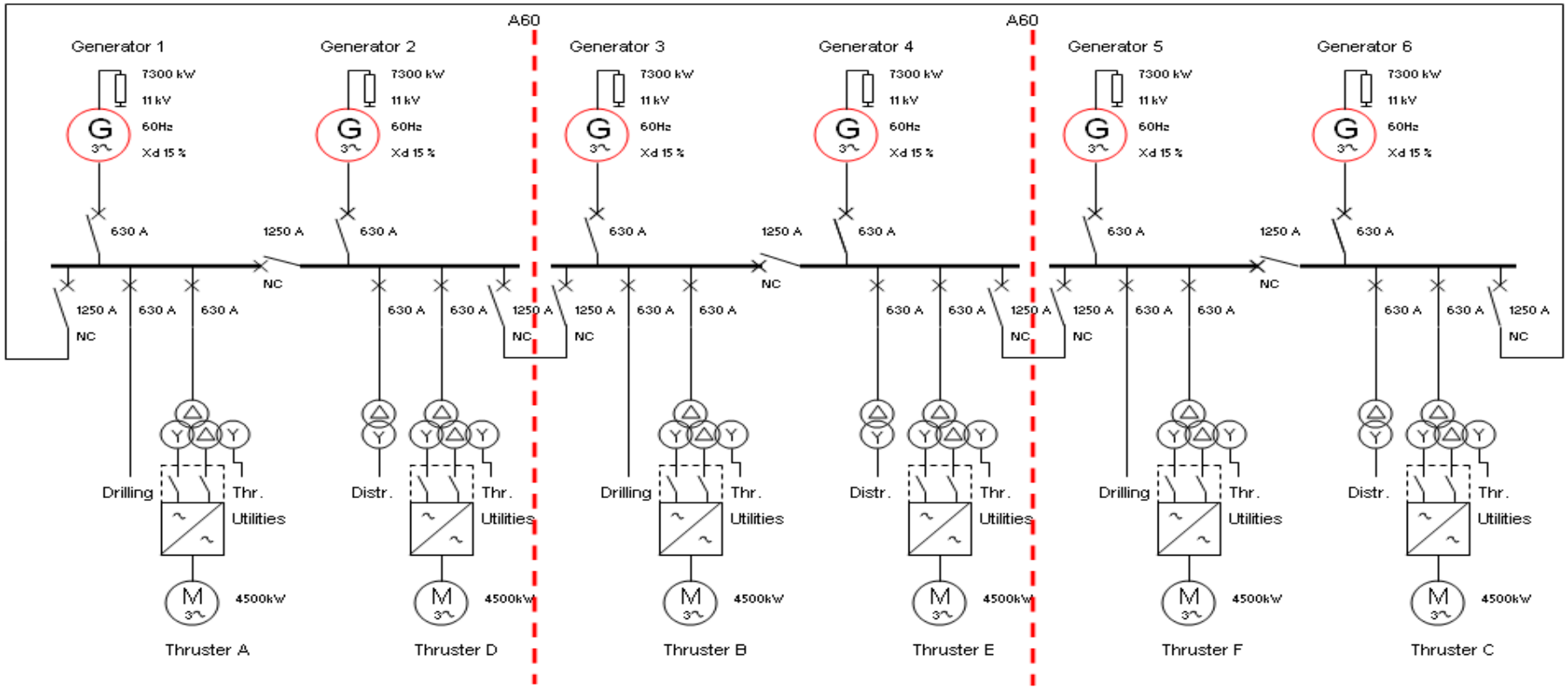
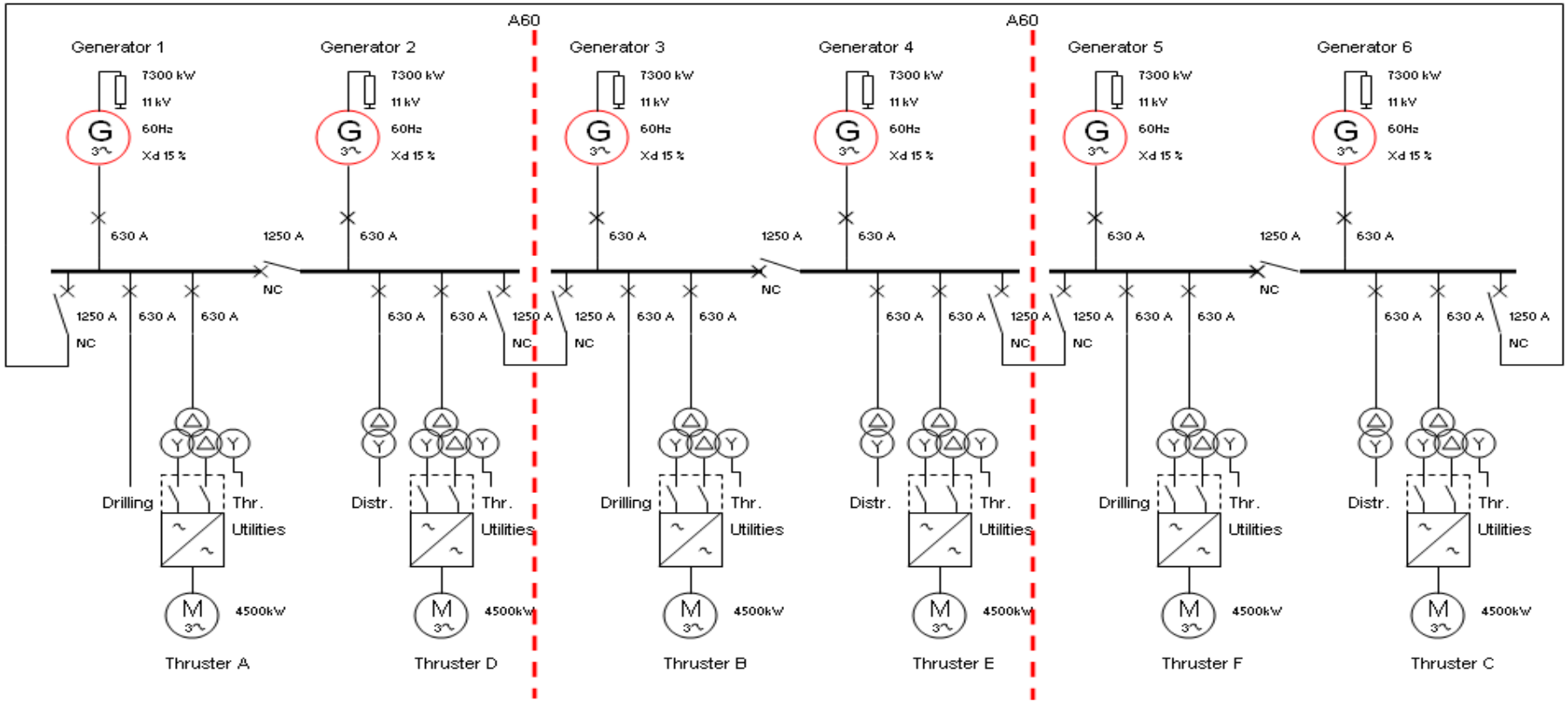
Starting Point – Blackout



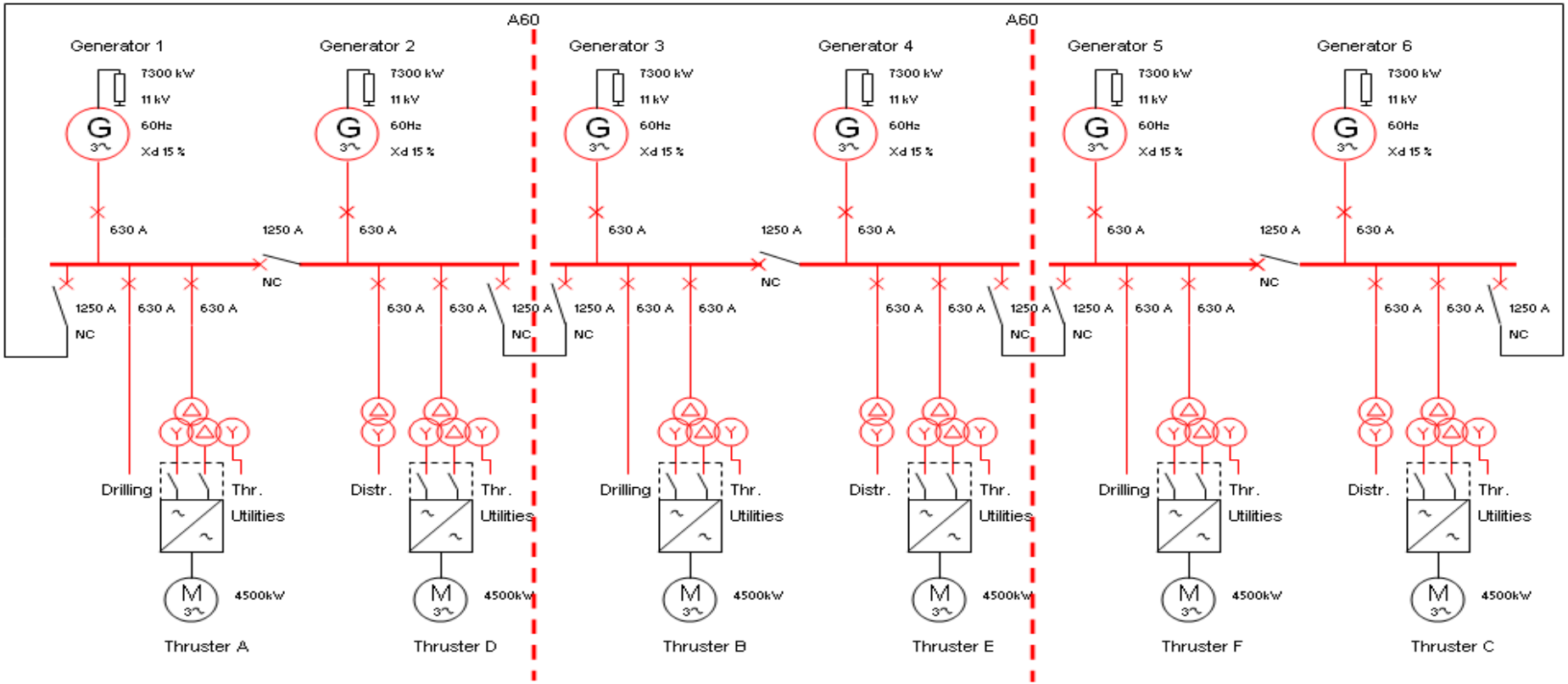
Generator Start, t = 0 sec



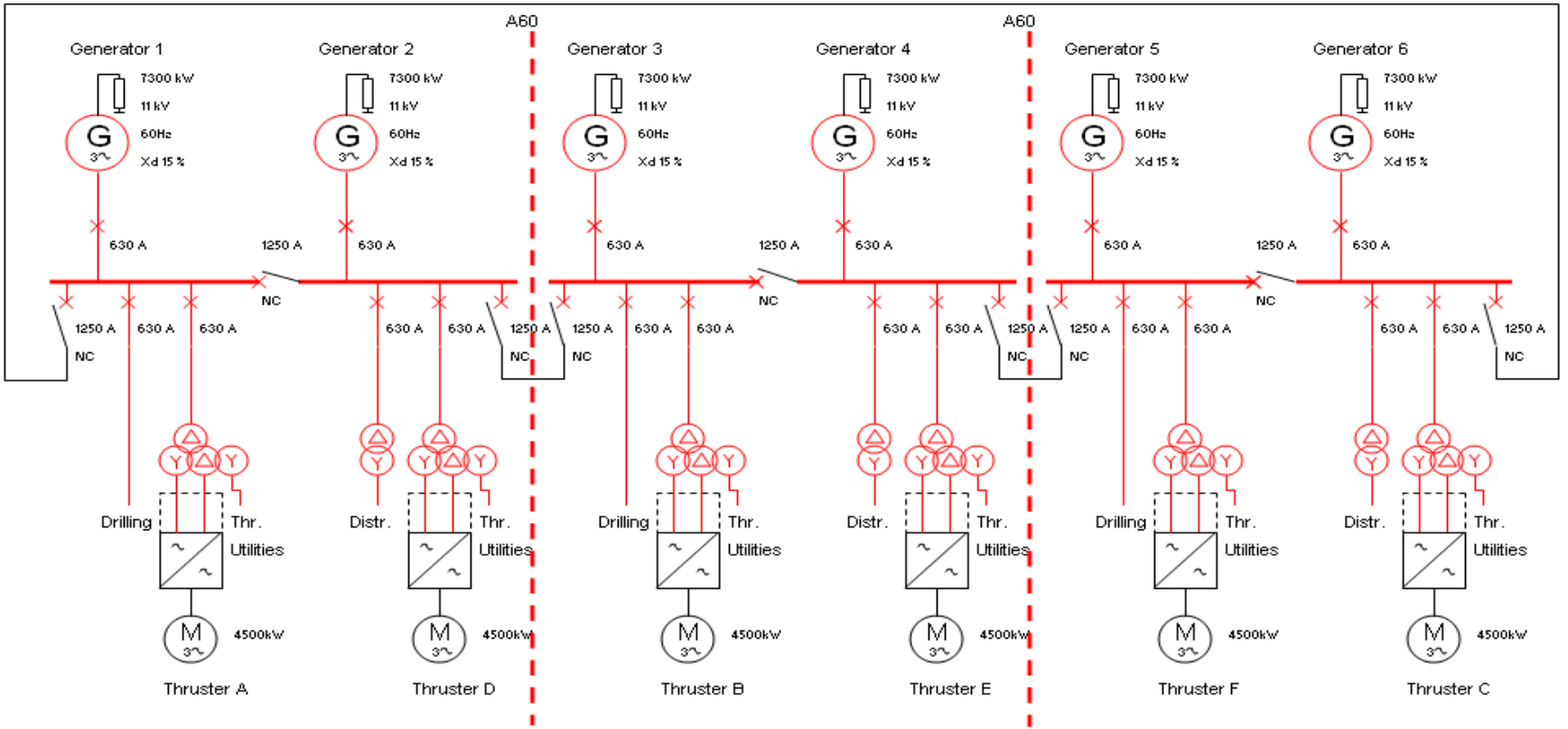
Closing Generator Breakers,t = 1 sec



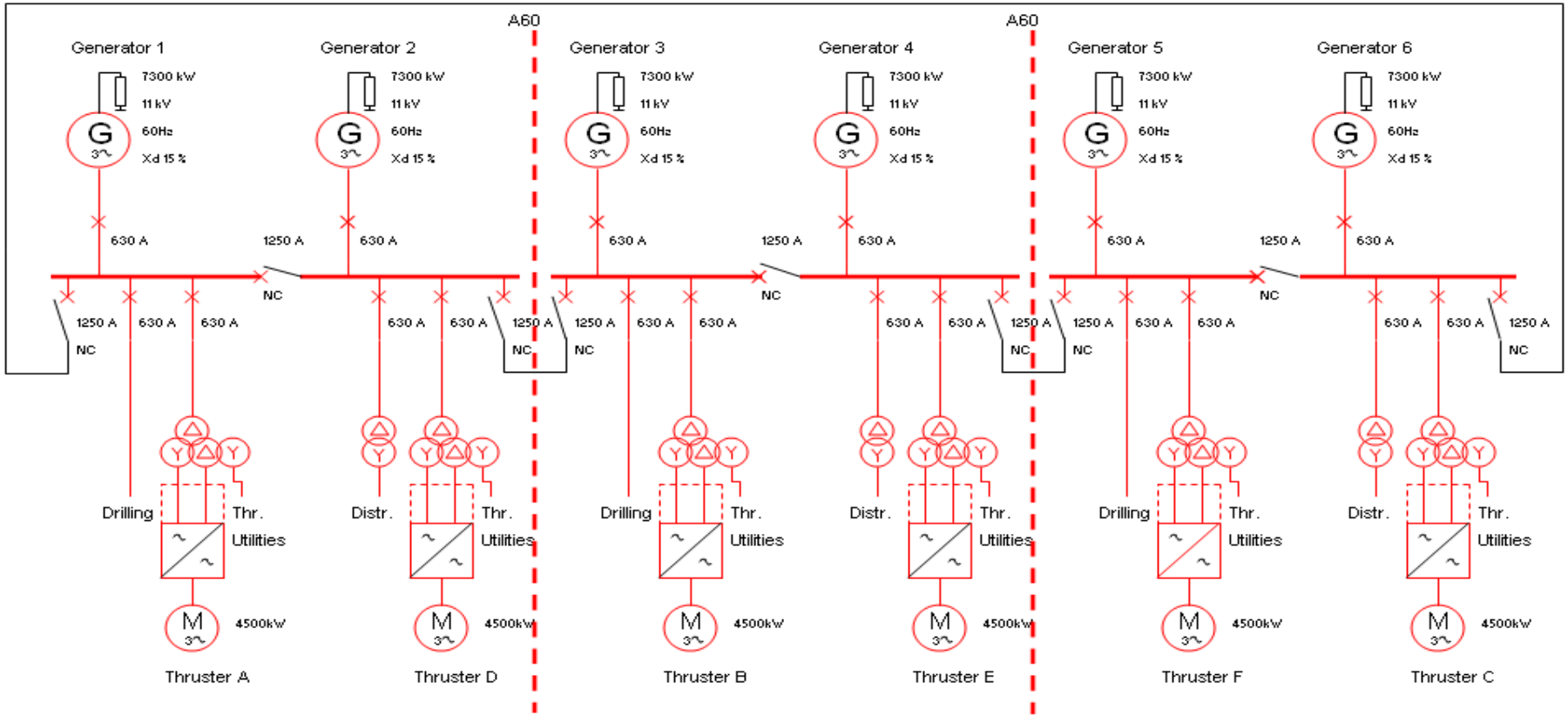
Soft starting generators and transformers by using AVR voltage ramp-up when generators is at 90% of nominal speed: t = 10-15 sec



Connecting Thruster Drives and pre-charging of thruster DC bus, t = 15-20 sec



Running Thrusters, t = 20 sec



DP Closed Ring operation Benefits verified by third party studies

- Up to 35% NOX reduction
- Up to 11% CO2 reduction
- Up to 9 % fuel reduction
- Up to 33% less operating hours on engines
- HSSE – Allow maintenance in engine rooms without running machinery
- Less carbonization - Engines operate on higher power
- Flexibility in operation
- Robust power supply to drilling consumers

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I am happy to answer your questions?

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