DYNAMIC POSITIONING CONFERENCE
September 18-19, 2001

POWER PLANT SESSION

Insufficient Power

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INSUFFICIENT POWER

The title is a familiar alarm print out for most DPOs. It can be followed or proceeded by such alarms as:

- INSUFFICIENT THRUST
- HEADING OUT OF LIMITS
- POSITION OUT OF LIMITS

and if all power is lost, blackout. However if there is a power reduction then a blackout can be avoided but not a loss of position; a drift off.

The alarms that accompany a reduction or chop in power are typically, preferential trips, pitch or speed reduction of thrusters and phaseback if the DP vessel was drilling for example.

CAUSES OF 'INSUFFICIENT POWER' ALARMS

- DESIGN
- EQUIPMENT FAILURE
- CONTROL FAULT
- WEATHER
- OPERATOR ERROR

The causes can be broken down into the above and each covered in more detail on the following pages:

DESIGN

By design we mean that the size and number of power generators were initially insufficient or, have become insufficient as the vessel's work changed or the client expectations increased (or the vessel owners ideas became inflated by the Marketing Department).

- Incorrect Power Balance
- Incorrect Transformer Capacity
- Too Few Diesel Generators
- Uneven Number of DGs Per Switchboard
- Speed of Response of DGs Too Slow.

An **incorrect power balance** can be a basic error but it is more likely the result of growth of the operational requirements as the vessel is marketed after the long lead items like DGs and thrusters have been ordered. Another possibility is that the location(s) planned, were more benign in climate than the ones where the vessel is presently working. The other problem is how to measure the diversification of consumers and account for reliability/availability. Clearly there are different margins applicable to a vessel that is working 364 days per year and one that anticipates 200 days per year (as opposed to on passage and in port).

Transformers (usually the HV to 440V transformers), are best sized with ample capacity so the normal load is 50%. This allows for growth and some flexibility if the cooling system fails.

The **number of diesel generators** is usually a function of space and cost and this can result in four large machines. If the parameters had been reliability and uptime the results may have been six or eight diesel generators. While more machines will increase capex and maintenance time, it can reduce running hours and increase the average loading. Only even numbers are mentioned because an **uneven number of machines** is a problem if the basic concept is for two main switchboards. Of course one engine could be designed to power either, but this "soliton" is the start of other problems with the design.

The **type of engine** is also important because when there is insufficient power, the time for a machine to accelerate to take the new load is crucial to the avoidance of blackout and/or the speed of blackout recovery.

The larger and slower engine can be cheaper but a fast PMS does not keep a slow engine on line when power is suddenly lost from the switchboard.

EQUIPMENT FAILURE

By equipment failure, we mean that on experiencing a 'single point' failure the insufficient power alarm occurs because not enough power reserve was on time initially or the failure was not foreseen

- Generation Fault
- Large Consumer Fault
- Breaker Fault
- Bus Bar Fault
- Fuel Oil Pump Fault.

The **failure of one generator** should not cause an insufficient power alarm unless the margin on line was initially too low or it co-insides with a peak loading. If the generator fault is a control problem, the effect can be different and this is discussed later.

Similarly a fault on a large consumer should cause it to trip and no more problems arise. If, however the fault is large and the tripping slow, undervoltage trips can create an expanding problem and INSUFFICIENT POWER result. This leads to the next point, a **breaker fault**. The worst case is when it fails to trip when it should. This can be counted as two faults; one, the fault that should initiate the trip, and two, the fault in that the breaker fails to trip. This is a rare event but it has happened.

A **bus bar fault** is even more rare; they have happened but mainly as a result of a mistake after work has been carried out. If there is a fault (short circuit) on the main HV bus with the bus ties closed, a blackout is highly likely. If the bus ties are open, there is a chance that there is still a blackout; it depends on the set up of all consumers and the PMS.

The final **equipment failure** is illustrated in a fuel oil pump. In itself it is not a major item of equipment, but its effect can be that the diesel generator or generators it is supporting cannot deliver the required power and the power management system is unaware of this situation until the reserve power protection works.

CONTROL FAULT

A control fault could be hardware i.e. equipment, but this group is designed to cover more software issues associated with the vessel power management and DP Control Systems. An operator intervention can cause a sudden thrust demand and insufficient power alarm.

- Engine Governor
- Speed Control
- AVR
- Control (dc) Power
- PMS
- DP Control
- Thruster Control.

It is in the area of control that the insufficient power alarm is likely to cause the most concern. This is because several faults can have similar alarms and end results and on the modern DP Vessel there are so many alarms that those that start the sequence are difficult to separate quickly from those that are the consequence of the first.

The best failure mode effect for a diesel generators governor depends on the system. Some **electronic governors** on some failures cause the engine to reduce speed and trip. Others are set up for the mechanical governors to take over in droop mode. Irrespective of the care and precautions taken, it is possible for one diesel engine to take all the load it can and risk all or part of the power plant. IMCA data shows that this is a failure mode that must be seriously considered. It is also this and similar failure modes like an **AVR** fault or a speed control fault (pick up or cable) that make a closed bus arrangement more robust than an open bus arrangement.

The **powering of the breakers**, sensors, relays and logic for the control of power and avoidance of insufficient power alarms is usually 24V and 110V DC. Their systems are generally very reliable but if they fail then the effects are fast and very difficult to recover from. With the DP control systems, it is now normal for each to have a dedicated UPS. This is the result of experience. Normally one would consider the loss of the charger supply and the loss of the battery back up as two failures. There have been two many of them to regard this as two failures. One must consider the failure of the output itself.

One may conclude that if the vessel has good procedures and a good **PMS (power management system)**, there should not be many occasions when there is an insufficient power alarm. This is reasonably true if the demand for power changes slowly, the system is set up correctly and the PMS has the data it needs.

The **DP control system** can provide an INSUFFICIENT POWER ALARM because it has simply lost data i.e. it has no generator information. It can also generate these alarms from a sudden thrust demand or unstable positioning caused by a multitude of possibilities. On some occasions the fact that there is insufficient power on line can limit the drive off or excursion but mostly the effects are bad and a serious problem can develop if the generators cannot actually deliver their rated power.

Thruster control is another area where insufficient power alarms can be generated. The most likely is when one thruster provides high (unwanted) thrust and others have to compensate. The other occasion when insufficient power frequently appears on the DP alarm print out is when the DPO gives up with the DP control system and moves to joystick control.

WEATHER

A similar sequence of events can occur if the weather suddenly changes in speed or, for a monohulled vessel, direction.

- Slowly Deteriorating
- Current
- Solitons
- Squalls
- Rapid Wind Increase

Deteriorating weather should never cause an insufficient power alarm by itself, because additional power should have been on line in advance of the requirement. However some PMSs are set so that an alarm for insufficient power may come at the same time that a generator starts. The risk from this approach is that the incoming machine does not solve the problem, but makes it critical. It is uncommon for this to happen but there are enough occasions to change the procedures on some vessels.

Currents do not change rapidly, unless they are tidal and then one would expect more power to be on line before an alarm. The classic exception is when the tide is changing and the vessel was head to the current and during the change a 1 knot current comes on the bean of the vessel. The DP control system would not respond until perhaps a 4 or 5m excursion had been reached (deadband) and then apply substantial thrust and cause insufficient thrust and insufficient power alarms. The quick current or fast integral features of DP control system helps if the operator selects them in good time.

If the sudden current change is an internal wave or **soliton**, then the position loss can be much more than a few metres and cause some considerable duration of an insufficient power alarm.

The most common weather cause of a DP incident (loss of position) with or without a power alarm is a **wind squall**. However, given the frequency of such events the number of times they cause a serious DP problem are few.

For an accommodation unit that is gangway connected a squall can cause auto lift of the gangway, but this type of excursion is relatively small for most vessels working in open or deep water.

The most dramatic weather associated DP problem is **rapid wind increase** when the wind suddenly hits a monohulled vessel on the beam and increases from practically calm to 40 knots in a minute or two. A monohulled vessel may not have time to change heading before the position loss is too great. These circumstances occur offshore Brazil, West Africa and in the Middle East.

OPERATOR ERROR

And finally operator error, which really covers direct mistakes rather than the mistakes associated with all the above. It is not difficult to make every incident human failure. Even being struck by lightning in a thunderstorm can be blamed on human error, for not installing an adequate lightning conductor.

- DG Trip
- F.O Valve Closed
- Stopped Wrong DG
- Opened Bus Tie
- Closed Breaker
- Maintenance

The list above illustrates some of the many mistakes made by operators that have directly and immediately caused insufficient power alarms. There are other categories of operator error that could be included like software bugs, poor procedures, no, or no adequate check lists etc, etc.

Several recent incident reports show all the above causes very clearly and these have analysed by Global Maritime and published by IMCA. They will be shown at the MTS Dynamic Positioning Conference.

CONCLUSIONS

- **INSUFFICIENT POWER ALARMS**

  WILL HAPPEN but they ARE NOT NECESSARILY CRITICAL

- **BLACKOUTS OF ALL MAIN POWER**

  CAN HAPPEN but they ARE NOT NECESSARILY CRITICAL

- **FAILURE TO RECOVER AFTER BLACKOUT**

  IS CRITICAL and SHOULD NOT HAPPEN