Automated refrigerated container monitoring on ocean-going vessels

REEFER MANAGEMENT In order to control and monitor reefer containers on board vessels more efficiently with less effort from the crew, Austria-based Identec Solutions AG, a global provider of wireless technology, opts for a shift from smart reefer containers to smart infrastructure. In the following article, Dr Urban Siller, the company’s CEO describes the principles of the concept.

Ocean-going container vessels are going digital – cruising levels, speed profiles, fuel consumption of main and auxiliary engines, operating profiles, dynamic trim and real-time energy monitoring systems – everything is visible both in shore-based vessel coordination centres and on board.

When it comes to temperature-controlled container (reefer) management, onshore container terminal operators are investing in fully automated monitoring solutions. These systems allow the remote monitoring of temperature, air flow, humidity, power consumption and up to 40 more parameters, providing alarms and scope to archive data for reports, analyses and claims management directly linked to terminal operating systems.

On container vessels, it is still common practice to patrol all bays and decks every twelve hours to check each reefer and record its temperature using pen and paper, archiving these reports in filing folders for up to ten years. Deviations from cargo owner requirements are rarely included in daily noon reports and patrolling on board in heavy seas may cause safety issues for the crew.

So far, the approach by shipping lines has been to make the reefer container smart. Hamburg Süd, Maersk Line and other shipping companies retrofitted their reefer fleet with power line modems or systems for mobile phone communications in an expensive and time-consuming fleet conversion exercise.

The outcome has not proved successful considering the cost and effort of the fleet conversion process. More consolidation in international container shipping has meant that, the percentage of converted reefers compared with containers without a modem for automatic monitoring has steadily fallen. Today, this ratio is typically around 25%, requiring the crew to monitor up to 75% of the live reefers manually. With such a low automation ratio, the crew must continue to spend a lot of time in manual monitoring.

A second drawback comes from the choice of technology. Power line-based reefer monitoring systems communicate via a 400-V power supply network on board. These systems work up to a certain number of reefer containers but bandwidth problems may occur on large vessels with a high number of plugged-in units. Since container ships continue to increase in size and the reefer market is growing more rapidly than the dry container market, this technology is running into scaling problems.

GSM-based modems communicate with a vessel-based GSM receiver that must be switched off within the twelve-mile zone. This requires the crew to monitor all containers manually within the twelve-mile zone since a reliable GSM communication with land-based infrastructure is not possible through the steel structure of a ship. The cellular coverage of national network providers does not cover the boundaries of the twelve-mile zone, especially for containers stowed under deck.

Furthermore, not all these systems provide data both to the vessel coordination centre and also to the crew. Some systems are designed to keep the control centre fully informed but only provide data to the crew once in 24 hours. This requires the crew to continue the manual monitoring process.

A third aspect that limits the distribution of container-mounted reefer monitoring systems is the lack of operational ownership especially for maintenance and repair. Most – if not all – systems that were retrofitted in the past deteriorated over time in their monitoring capability because broken power lines or GSM modems were not properly maintained. This is an inevitable result of the separation between the party who owns the reefer and the party who is temporarily in charge of it during the global transportation process.

Automated reefer monitoring systems on ocean-going vessels should be designed to solve the operational problems faced by the crew during every single trip while also delivering data onshore simultaneously.

Ships need a minimum crew to sail safely. If this minimum crew gets charged with too many add-on tasks, service quality inevitably suffers. As an example, it is not feasible to prioritise between vessel maintenance and reefer monitoring tasks. Both require equal attention and must get carried out in parallel.

Today’s strategies are often based on handling both tasks by tight crew management or to sacrifice on vessel maintenance within the legal framework and engage so-called “riding crews” who sail with the vessel from time to time to undertake certain specific maintenance tasks. Alternatively, some shipping lines expand the crew above the minimum requirement, incurring additional manning costs to guarantee an outstanding reefer service quality without claims to their customers.

With a suitable automated reefer monitoring system on board, these operational issues vanish while providing additional benefits that contribute to the profitability and the environmental footprint of shipping lines.

Carrying special cargoes such as avocados, blood plasma and pharmaceuticals, for example, becomes possible without additional cost or effort for the crew while complying with even the most rigid monitoring and documentation requirements of cargo owners. In other words, special cargo is no longer a burden but a revenue and profit generator and, where possible, should be actively targeted by the sales
team as a valid and cheaper alternative to shipment by air.

Systems that can report reefer data in intervals of 15 minutes or less, providing continuous real-time data about the reefer container, exceed even the most demanding monitoring requirements. Real-time based reefer monitoring systems allow the transportation of highly sensitive commodities with no additional operating costs for monitoring or documentation.

If the reefer monitoring system is capable of measuring the power consumption of every single container without additional hardware like add-on power meters, it is possible to detect where the onshore pre-cooling process was not completed properly. It is now the duty of the vessel to cool down the commodity to the setpoint temperature.

Live data from oranges and lemons indicate that this cooling procedure can easily take a day with an average power consumption of approximately 10 kW per container. This calls for 240 kWh of electricity to undertake the cooling of just one single reefer container. As a rule of thumb, 200 g of heavy fuel oil (HFO) are needed for each kWh of electricity generated by a two-stroke diesel engine which runs efficiently yet generates significant volumes of harmful emissions.

Cooling down cargo to the setpoint temperature has a significant cost impact for liners and increases the CO₂ footprint across a fleet of container ships. This is likely to become an important decision factor for or against a shipping line in a more environmentally conscious society and may even lead to an exclusion from certain ports. In addition, the world must focus on alternative energy sources or at least use land-based fossil power plants with filter systems to cool down cargo instead of marine HFO-operated engines.

In summary, knowing the energy consumption of every reefer container during a trip enables the vessel coordination centre to develop strategies that reduce electricity demand and make ship operations greener and more cost-effective.

Based on the above, it is a relatively simple exercise to specify the requirements that a reefer monitoring system must fulfil to become beneficial in container vessel operation:

- The system must be capable of monitoring all reefer control data, including power consumption for every reefer container on the market, independent of type, brand, age, ownership or shipping line;
- The system must be fully automated for monitoring, data storage and alarm management;
- The system must report in intervals of a maximum of 15 minutes to monitor effectively the current status of a reefer container in real-time or near-time, respectively;
- The system should work wirelessly to facilitate relatively easy retrofit installations. However, it must be certified to operate within the twelve-mile zone and capable of switching to country-specific regulations at the quayside;
- The system must deliver data in parallel both to the crew on board via the local network, and to the vessel coordination centre onshore via standard satellite communication link. For both channels the monitoring interval should be capable of adjustment;
- Ideally, the system should be able to provide the user with complete reefer controller log files to obtain all relevant information since the container started its journey;
- The system should have an open software and hardware architecture to interface with other reefer management systems (e.g., Maersk Remote Container Management);
- It should be easy to deploy and capable of operating effectively both on owned and chartered vessels, thereby avoiding the requirement for container fleet conversion;
- The system must provide low total cost of ownership through remote health checks and remote software and firmware updates. It should operate effectively without maintenance or a requirement to replace batteries during its operation;
- A stable system performance over years is expected with no deterioration over time;
- Furthermore, the system should offer additional functionality like pre-trip inspection (PTI) support, or support during reefer controller software updates;
- Finally, the system must deliver all reefer data required by the vessel coordination centre for big data analytics to increase continuously the efficiency of the reefer business.

The digitalisation trend in the shipping industry will drive the development of systems that deliver against the requirements listed above. One system is currently being introduced to the market that has demonstrated its capabilities on multiple trips across the Atlantic Ocean in a proof-of-concept application run by Hamburg Süd and Identec Solutions.

The likely trend in reefer container management is shifting from smart containers to smart infrastructure. Since the ocean passage represents the longest temporary time of ownership along the entire reefer supply chain, container ships should be the prime target for this novel approach.

Schematic of an automated reefer monitoring system suitable for ocean-going container vessels