Onshore Power Supply for Ships

Environmental Protection IN THE AIR

Reducing ship engine emissions.

by Mr. Thane Gilman, P.E.
U.S. Coast Guard Systems Engineering Division

Onshore power supply (or OPS, sometimes referred to as "cold ironing") is a system of procedures and equipment that provides ships with a source of electrical power as an alternative to the ship's service electrical power system. The primary benefit is that, since the ship no longer has main or auxiliary engines operating, the engine emissions are virtually eliminated in the port area.

Many ports around the world are located near large populations, and engine emissions from ships unfortunately contribute to unwanted levels of nitrogen oxides, sulphur oxides, particulate matter, and even the "greenhouse gas" carbon dioxide. Onshore power supply achieves a better emissions reduction result than ship-installed emissions equipment. On the other hand, there are difficulties associated with high voltage, varying frequencies, and infrastructure costs that must be addressed in order to justify an onshore power supply installation.

Cold Iron

Receipt of shore power, along with other utilities such as potable water and steam, is part of the process of placing the engineering plant in a status known as "cold iron."

The term originates from the steamship era, when ship boilers and engines would go relatively cold after being secured. To bring a steam plant back online, supplying its own power after a "cold iron" period, would involve a substantial light-off, warm-up, and transition period compared to modern, fully automated plants.

System Requirements

A typical OPS system (Figure 1) requires many components. At the very least, significant infrastructure is required for the cable handling system, switchgear, protective boxes, transformers, and power cables. Additionally, this equipment must not interfere with vessel cargo operations, cranes, or passenger transit, so proper location of the ship/shore interface is critical.

The design of many modern vessels with high voltage electrical distribution systems, such as those of 6,600 volts or 11,000 volts, enables more power to be transferred with less cable area than traditional 450V electrical systems. However, most of the vessels comprising the world's fleets are 440V to 480V systems. The in-port power requirements for different types of vessels—and even vessels of similar type but carrying different cargo—can vary substantially.

Generally, passenger ships with immense air condi-

tioning, cooking, and lighting loads have significantly higher electrical loads than, for instance, a container vessel where a shore-based crane offloads the containers and the number of refrigerated containers is low.

Benefits

The most notable benefit is, of course, the elimination of engine emissions in the port area. Once the infrastructure is set up, ships that make relatively frequent calls to particular ports can transition to onshore power supply as a matter of routine. This is already being successfully implemented in the ports of Juneau, Alaska; Gothenburg, Sweden; and Los Angeles, Calif.

A secondary benefit of a secured plant is that maintenance and repairs can be facilitated on equipment that is not in operation. Also, the interval for receiving engine bunker fuel may be increased slightly as less ship fuel is used, and the relative cost of the energy provided by the shore facility may be favorable compared to the operating cost of ship engine/generator combinations.

Concerns

There are a number of issues that make the overall setup and operation of shore power complicated, including:

Cost. The cost of infrastructure, including electrical equipment such as transformers, switchgear, power cables, cable handling equipment, and associated support structures on the piers is significant. Obviously, as the distance from the shore utility to the ships on the piers increases, the cost multiplies. Similarly, the cost increases as the number of onshore power supply locations on a particular pier increases.

Compatibility. The ship and shore frequencies must match within limits for OPS to even be considered. See figure 2 for frequencies of electrical worldwide electrical systems. It generally requires a frequency converter for a 50-Hertz supply (shore) to work with 60-Hertz loads (ship), or vice versa. Frequency converters at the power levels required are an expensive addition to an already significant infrastructure.

Safety and quality of power. Standards must be agreed upon between ship operators and shore personnel as to safety procedures at a particular installation. Additionally, the minimum quality of electrical power required needs to be defined by the ship, such that safe disconnection of shore power can be initiated if the power quality deteriorates to a level where ship equipment may be damaged.

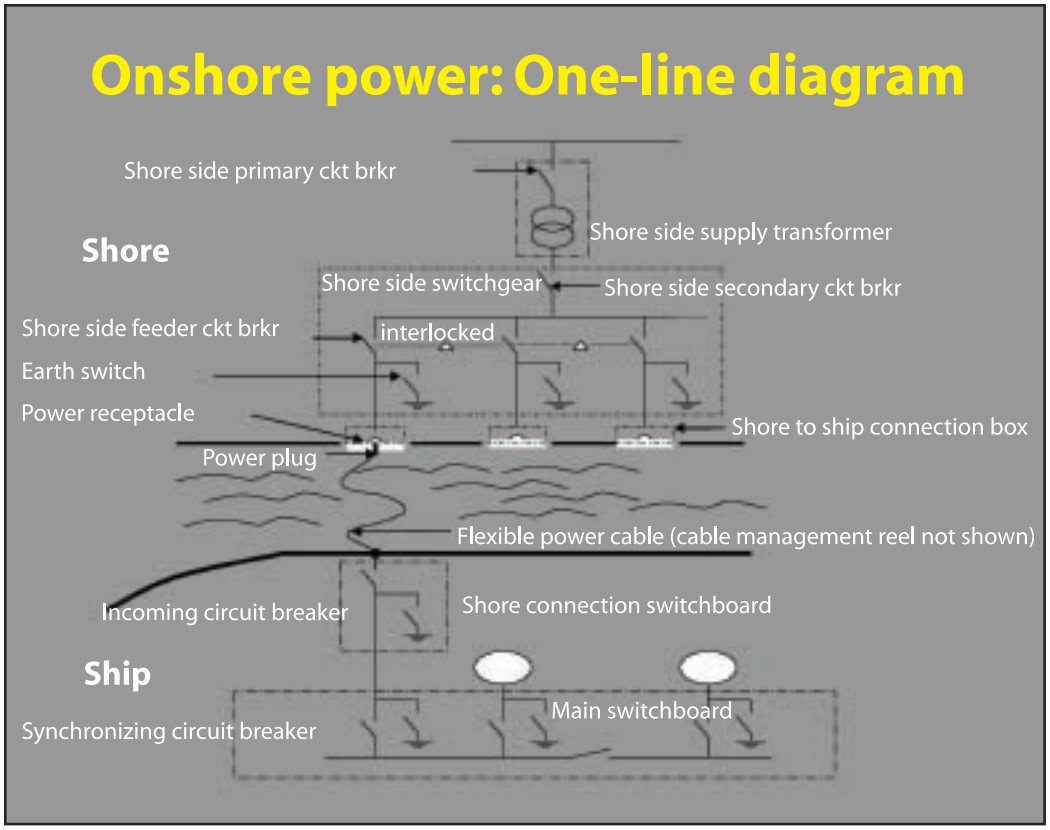

Figure 1: One-line electrical diagram of a typical onshore power supply system. USCG graphic.

Legalities. The number of stakeholders involved makes OPS incorporation into the law complicated. There are local, regional, state, national, and (potentially) international environmental and economic interests involved. Additionally, there are port authorities, vessel operators, and power companies with concerns. Many of the associated agencies have differing opinions with respect to the required strength of environmental laws. For instance, the laws of the state of California

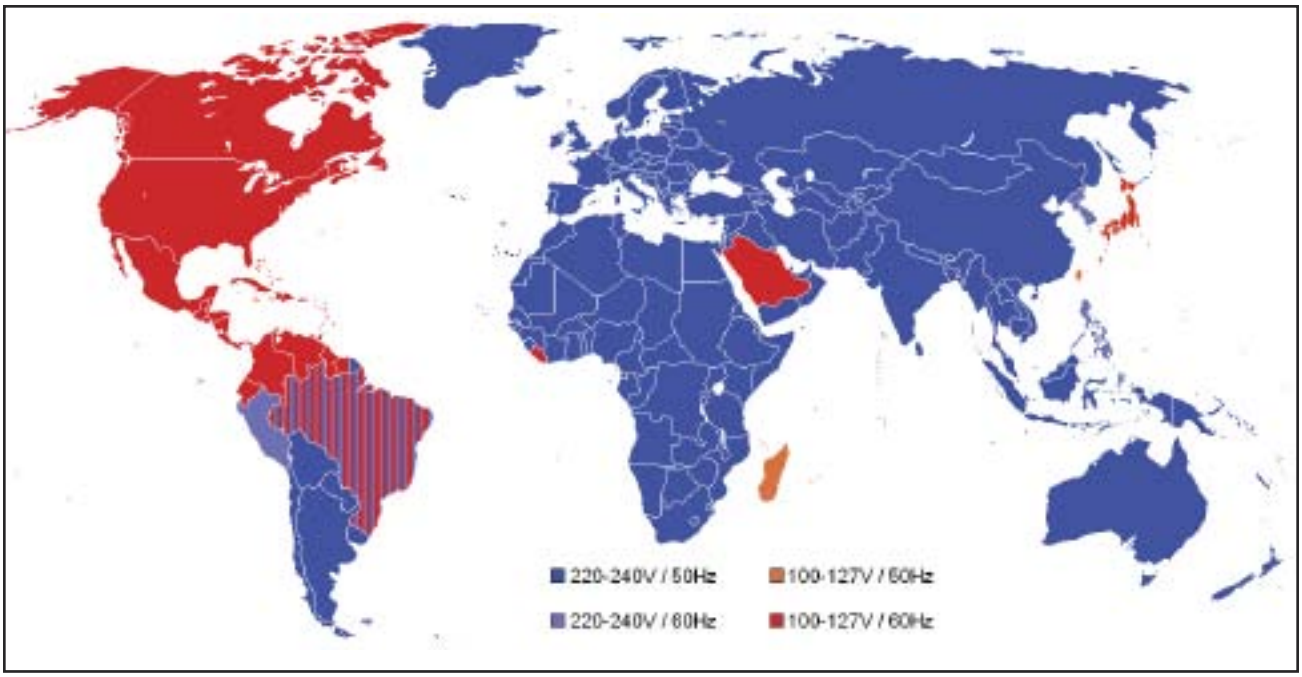

Figure 2: The frequencies of world electrical distribution systems.

may differ from those of the U.S. EPA, which may in turn not completely agree with the environmental standards set forth by the International Maritime Organization. What's encouraging regarding shore power is that, regardless of whether or not regulatory agencies agree on emissions levels, shore power provides a solution because it eliminates emissions.

Standardization. Efforts to formally develop an international standard for OPS installations have been underway within the International Organization for Standardization since 2006. The standardization work prioritizes onshore power supply issues such as:

- Safety requirements for the electrical system, including interlocks, grounding of faults, current-carrying capacity of components, and other protective features of switchgear and cable handling.
- Allowable variances in supplied electrical power when paralleling to ship's power and transferring loads.
- Documenting vessel-specific OPS issues. For example, the onshore power supply requirements for liquefied natural gas ships may be significantly different than for passenger vessels or container ships.
- Training and communications requirements during the OPS process. It is critical that personnel be trained in the operation of high-voltage power systems, and that both ship and shore areas designate persons in charge of onshore power supply procedures. Additionally, since there may be substantial distances between connections, equipment, and personnel, standards must be established for communications procedures and the sequence of steps in the OPS process.
- Definition of events that may trigger an emergency shutdown of onshore power supply, such as short-circuit faults or excessive movement of the ship relative to a pier.

About the author:
Mr. Gilman is an engineer for the U.S. Coast Guard at its headquarters in Washington, D.C. He serves as secretariat of the ISO TC 8/SC 3 Ships and Marine Technology/Piping and Machinery Subcommittee, overseeing 40 standards related to marine engineering and environmental protection. Mr. Gilman holds an M.S. degree, is a licensed professional mechanical engineer, and also maintains an active unlimited horsepower license as a marine engineer for both steam and motor vessels.