Going Cold Iron in Alaska

R. Maddison[1], D.H. Smith[2].

The *Dawn Princess* arriving on the day of commissioning of the shore power system, 24 July 2001. This was the ceremonial inauguration of the provision of shore power, which was actually on-line for at least 10 hours on this first day of service. The shore steam system was not yet installed, note the empty hose hangers on the gantry and dock. The shore power cables can be seen about half way down the gantry. Normal access for operating the festoon system is by means of the catwalk at the deck level.

Princess Cruises operates several cruise ships in the popular Alaska voyages market. These ships typically make a port of call at Juneau, Alaska, which has a cool, damp climate. While berthed in Juneau, the state's smoke opacity laws combined with the climate place all cruise lines at risk for being cited for the emissions coming from auxiliary power and boilers. Princess Cruises opted to enable their cruise ships to "cold iron" while berthed in Juneau. This means that the ship would for a time shut down its power generation and receive all power from shore. Alaska Electric and Light Company has a surplus of clean hydroelectric power, which can be used to provide shore power to ships' as well as power to shore side electric steam boiler. This paper describes the development of several key elements of the project; the festooning arrangement, which handles the shore power hoses and cables between the dock and the ship (Juneau has a very large tidal range), the onboard structural and electrical modifications and the development of the power supply and automation system. The automation system is fundamental to the whole process allowing the ship's power requirement, supplied from its main diesel generators, to be switched to the shore supply and back again. These events have to be done transparently, allowing the two power sources to synchronize and the onboard machinery to respond without the slightest disruption to onboard services.

[1] Robert Maddison, Director/Superintendent Princess Cruises, Santa Clarita, CA.
[2] Daniel H. Smith, Section Head AMSEC LLC, M. Rosenblatt and Son Group, Oakland, CA.

INTRODUCTION

The Cruise Industry has been, and is still under pressure from State and Federal Governments, on a variety of environmental issues. These pressures have served notice to all cruise lines that they are to be responsible for finding remedies to these issues. This paper is about one such remedy to one issue, the issue of smoke emissions in an Alaskan port.

The Alaska cruises have become extremely popular, with several cruise lines and many cruise ships navigating these pristine waters. The cruise ships make several port calls during their voyages, of which Juneau, Alaska's Capital, is an important port visit. Over the past few years there has been growing concern by Juneau residents and State Legislators of the smoke emissions from cruise ships visiting Juneau, particularly with the increase in number and size of these ships.

Juneau is a land locked city of around 35,000 people situated at the base of several scenic valleys with a large waterfront and with Douglas Island opposite. The cruise ships dock along part of this waterfront where three large cruise ships can dock in line. About a quarter of a mile further south, and out of the built-up area of the city, is the South Franklyn Quay, a purpose built cruise ship concrete quay that is used primarily by Princess Cruises and four of its five ships that visit Juneau each week during the cruising season. These facilities together with an anchorage provide for as many as six large cruise ships to be visiting Juneau on one day.

The climate of southern Alaska is wet, the rainfall is measured in feet and the tidal range is large. Local residents will tell you that if it is not raining, it is going to rain. The topography of the landscape that surrounds Juneau provides a good deal of shelter from prevailing westerly winds and creates a situation where there is not very much air movement. This combined with the cool damp climate leads to a situation where emissions from the exhaust stacks of the Cruise ships tends to be contained within the area and accumulates as a visible bluish hue that hangs over the water between the mainland and Douglas Island.

The Alaska Department of Environmental Conservation dispatches Visible Emission Observers at specific times during the port visits in Juneau to record the opacity of the emissions from cruise ships. These observers judge the opacity through a defined view and should more than 20% of their view be obscured over a defined period of time then the company that is operating the ship that is emitting the smoke is liable to receive a citation. If a company receives more than two citations on the same vessel then the company is liable to be fined. The resulting pressure that has been placed on the cruise ship operators to avoid such citations has lead to a variety of solutions.

Two companies have opted to operate gas turbine powered ships in Alaska, whereas another has used ships equipped with so-called "Smokeless" engines. Princess Cruises opted to "Plug-in" to the local electrical power supply while docked at the South Franklyn Quay in Juneau and shutdown all auxiliary engines.

The source of the shore power was fundamental to this approach as there would have been little point in using shore power if this meant an increase in pollution from a local oil-fired power station. Juneau is supplied by hydroelectric power from the Snettisham hydroelectric power plant. The city consumes around 80 MW during the winter months but this drops to around 35MW during the summer, thus leaving ample supply for the 7MW that the Sun Class ships would consume.

The process of providing "shore power" to ships is not a new one. Dry docking of a ship usually involves the closing down of all combustion plant onboard and the "hard wiring" of suitable cables into the ship's main switchboard, with a period of several hours without power. In the military arena such a process is referred to as "Cold Ironing", inferring no steam from the boilers, which is the name that was adopted for this project.

The process of connecting a ship in the morning and disconnecting it in the early evening with no disruption to the onboard services and then repeating this four times per week for twenty continuous weeks has not been attempted before. The provision of this power had to account for a normal tidal range, within each 12 hour period, of around 18 feet with possible maximums of 25 feet.

Although this "Cold-Ironing" project became associated primarily with the provision of electrical power to the Princess ships, the aim had always been to have zero exhaust emissions, thus a secondary though just as important aspect of the "Cold-Ironing" project was the provision of shore side steam to the ships, via an electric boiler so that the ship's boilers could be turned off.

This paper describes the progress of this project from the initial developmental stages, the installation of all the necessary equipment to the implementation of procedures that enables the four Sun Class ships of Princess Cruises to be connecting to shore electrical power on a routine daily basis from mid July 2001 until the end of September, the end of the Alaska Cruise season. It also describes the parallel development and installation of equipment necessary for the supply of shore steam, which will be operating from the beginning of the Alaska Cruise season of the year 2002. It should be remembered that this was achieved in one of the remotest inhabited areas on earth and in a community that is land locked, such that all materials required from outside the Juneau area had to be brought in by air or by sea.

DEVELOPMENT

Project Requirements

From the onset this project was going to involve many different contractors from many countries; and eventually involved 25 contracting companies from eight countries. The primary companies involved were Alaska Electric Light and Power (AELP) the public utility for power in South East Alaska; M. Rosenblatt & Son (MR&S), an Oakland, CA, based Naval Architecture and Marine Engineering consultancy; Callenberg Engineering, a Swedish based Marine Electrical/Electronic company; and ABB Automation of Italy who specialize in Marine Control Software. The civil engineering firm of Peratrovich, Nottingham and Drage served as the onsite overseer for most of what was done in Juneau, in addition to their role with the development of the Gantry.

The time span of this project was a period of approximately 5 months. Some of the long lead items such as the transformer for a new substation were ordered right at the end of 2000 (Virginia Transformers) and the electric boiler (Precision Boilers) at the start of 2001. Due to the weather conditions in Juneau during the winter months, work could not start on the substation until March 2001. It was about this time that work also commenced in the Caribbean on the four Sun Class ships that were to receive shore power. While AELP worked exclusively on the installation of the three-stage transformer into a suitable substation, MR&S together with Callenberg Engineering began work on the means of delivering the power to the ships.

The Sun Class ships require about 7 MW of power at 6,600 volt and about 7,000 kg/hr of 9 bar steam. This is much more power than is typically provided by a ship's shore connection during a refit, as there is much "life" on these ships even though most passengers are ashore.

Provision of Power to the Quay

The AELP involvement was to deliver the required power to a "Dock Switch" situated at the end of the South Franklyn concrete quay. The power was to be obtained from the main 69KV transmission lines that supply Juneau from the Snettisham hydroelectric power plant via the Thane Substation. A new substation was constructed adjacent to these power lines at a distance of about 800 yards from the Quay in which was installed the transformer. The primary winding is therefore supplied with 69KV and rated at 25 MVA. The main secondary winding is able to supply either 6.6KV or 11 KV via a changeover switch. The Sun Class ships main switchboard takes 6.6KV but the Grand Class, of which one, the Star Princess, will be operating in Alaska in the summer of 2002, require 11KV. This secondary winding has a maximum rating of 13 MW. A smaller tertiary winding was installed to supply the electric boiler at 12.5 KV at a rating of 7 MW. This third winding also provides a means to supply the City of Juneau with power should there be a break in supply between this new substation and the City.

The power is transmitted the 800 yards from this substation to the Dock Switch via three 5 inch diameter Cables installed underground. The cables were laid in open trenches except where they had to pass beneath a road, for which a tunnel was made. At the quay the cables were laid in steel conduits traveling the length of the quay to the dock switch. Due to the disruption to the parking areas adjacent to the dock and access to the dock this work had to be completed by mid May when the first Cruise ship would be visiting.

One section of the trench was made large enough to take an 8 inch diameter steam pipe and the 2 ½ inch condensate return pipe. These were laid at the same time to take advantage of the window before the Cruise ships started arriving. In order to avoid disruption to passenger movements on the quay the cabling and steam pipes had to be installed along the concrete quay before the mid May deadline.

This installation work involved several other local contractors and was overseen by a civil engineering consultancy based in Anchorage with an office in Juneau, Peratrovich, Nottingham and Drage.

Handling of Cables and Hoses

The task of coming up with a suitable method of delivering the power from the Quay onto the ship was given to MR&S. This task was to develop the means for easily and quickly getting the cables and steam hoses from the dock to the ship. Juneau has a tidal range of up to 25 feet. The ships moor to a dock and dolphins parallel to the shore and in water that drops off quickly. Wintertime storms meant that a laid up cold ironing system would have to endure storms with possible 100 knot wind and icing conditions. Also, Juneau is in a seismic zone.

Additionally, there were restrictions placed by the owner of the dock; primarily to minimize impact upon the working area of the dock. This problem was overcome by making arrangements to only occupy space at the end of the dock, beyond normal passenger access.

AELP working somewhat in advance of everyone else at this stage had defined early on the equipment to be installed. They had identified the need to plan and install switchyard facilities in support of the power to be provided, the Dock Switch. Callenberg Engineering was quick to identify and procure samples of candidate power cables that would safely transmit the required voltage and amperage and could be handled. These team members defined the cabling requirements early, allowing development of cable handling to proceed with a clear vision.

Princess Cruises also polled the Chief Technical Officers (Chief Engineers) on the candidate ships to receive shore power as to their steam requirements. This would require an electrically powered steam generator, an electric boiler. The handling requirements assumed a closed system and keyed upon a set of hoses for the steam supply and condensate return.

A mechanical method of delivering both the power cables and hoses had been considered for some time. Several concepts were considered starting with a barge mounted crane or a pier-mounted crane. The concept that won out was a festooning arrangement, wherein the hoses and cables hang from trolleys in bights, supported by a rather sizable fabricated steel gantry. Separate festoon systems were provided for the purpose of handling shore power cables and shore steam hoses. Both festoon systems were installed on a common galvanized S8x18.4 trolley rail beam, the span for each festoon being about half of the length of the beam. The trolley beam is straight, about 133'-3" long, and mounted with its bottom flange about 45'-0" above mean low water. The trolley beam is aligned parallel with the ships it will be serving. Cables and hoses festooned from this gantry are not to be allowed to hang lower than 25'-0" above mean low water, a loop depth of 20'-0" maximum. The project did not need to impose upon the existing dock, as there are substantial dolphins with a catwalk access that could be utilized for support.

Each festoon system is comprised of two festoon systems, arranged to meet at a tractor/hoist that is remotely operated by a pendant control on the catwalk below. The total length of span available for each festoon system is about 65'-6"; its working length is about 35'-0" to 38'-0". The tractor/hoist supports the length of cables/hoses required to make entrance to the ship as well as positions the cables/hoses for entry into its port. With each festoon system, one festoon system shall be designed to serve the large bend radius shore power cables and shore steam hoses, the other festoon system shall serve small bend radius power, control and instrumentation cables. Similar hardware is utilized for both festoon systems. The manufacturer of the festooning gear, a German based company called Wampfler, created saddles twice as large as any of their previous models to handle the bend radii. Key elements that keep the cables/hoses from spinning into hockles are the like are the cable/hose clamps that attach these cables/hoses to the saddles as well as clamps placed intermittently in the bights between saddles. These simple devices keep the cables and hoses arranged in good order.

The Civil Engineering Consultancy, Petrovitch, Nottingham and Drage of Juneau, adapted the gantry concept to the existing dock and dolphins. They made one key change where they abandoned a proposed truss work structure in favor of the large steel pipe arrangement that was built. The pipe structure was more cost effective to build and provided much better torsional strength to allow offset of the trolleys for festooning the cables and hoses towards the ship. The two sections of the gantry enable the shore power and steam to make separate entries into the ships. The trolleys and hoists also provide the necessary control and flexibility in handling the cables and hoses.

The Gantry was fabricated in "kit" form in Seattle by a Washington based Company, Pederson Brothers, and barged to Juneau for construction by a Juneau based company, Trucano Construction Co. The Festooning system came from Wampfler and the Tractor Units and Hoists from Washington Crane and Hoist, based in Washington State. The gantry HV cables were supplied by Callenberg Engineering together with custom made Plugs. The power being supplied from the new substation was via three, 5 inch HV cables to the dock switch. From the dock switch were installed four, 4 inch HV and one, 2 inch neutral earth cables terminating in the custom made connection plugs.

Onboard Installation

The third element of this project that was being progressed in parallel to the above two was the onboard ship modifications. All four Sun Class ships *(Sun Princess, Dawn Princess, Sea Princess* and *Ocean Princess*) were to be prepared for receiving shore power. Work began at the end of March 2001 while all four ships were operating in the Caribbean. The existing bunker station was to be used as the point of entry for the steam connection. It had already been determined that the point of entry for the power cables was to be within the existing technical office area on deck 4, which had determined the length of the festoon gantry. The arrangement of the

Technical Offices on each ship was different, thus different configurations where developed to install the new connection room. In two instances the Chief Technical Officer had his office completely relocated. As the connection equipment would be accepting 6.6K, it was necessary for the boundary of the connection room to be A-0 fire class, thus a steel boundary had to be erected between the two steel decks.

Before work commenced on this, the ship's personnel stripped out the section of their office space where the new room was to be constructed. New 1.5m x 1m side shell doors were supplied by McGregor's and these were delivered to the ships during their visits to Ft. Lauderdale and St. Thomas. The operation involved the installation of the doors while in service and then the construction of the Steel bulkheads to create a room 4m x 2.5m. Construction Services Inc. (CSI), based in Miami, performed this work. They provided two teams of steelworkers, each team doing two ships each. Their work involved the completion of the bulkheads to A-0 fire class, the installation of the side shell doors and the installation of drains within the new room to deal with any intrusion of rainwater that might occur.

On completion of CSI's work, the ships personnel reconstructed the decorative bulkheads and installed A-0 class fire doors to the shore connection room. Meanwhile, the connection equipment for each ship that was being supplied by Callenberg Engineering was being shipped from its manufacturers in Norway. These HV connection cubicles had been custom made in two sections, each section being small enough to pass through the new side shell opening. To install these large cubicles by loading them through the normal stores loading doors and then maneuvering them through the ship to the location of the shore connection room would have involved the dismantling of large sections of the internal bulkheads on deck 4 with massive disruption to the ship. These cubicles were delivered to the ships on their way to Alaska, two ships receiving theirs in San Francisco and two in Vancouver, BC.

Working in parallel to CSI, Callenberg Engineering had two teams of electricians each working two ships per team to install the onboard HV cabling. This is the cabling that connects the connection cubicles to the Ships Switchboard. Luckily, each of the Sun Class ships were provided with one spare 6.6KV breaker on the ship's switchboard when built. The distance between the location of the new connection cubicle and the spare breaker was approximately 45 m and the installation of this heavy cable involved a team of eight electricians per ship. A total of five, 3½ inch cables would transmit the 6.6 KV power from the connection cubicle to the spare breaker at the switchboard.

As well as dealing with the high voltage side, these teams also installed the control cabling required. The location of the new shore connection room was adjacent to the Engine Control Room. As the connection and disconnection from shore power was to be controlled from the Engine Control Room then control cabling had to be installed between the shore connection room, the engine control room and the switchboard. By the time the ships started arriving in Alaska all onboard HV cabling and control cabling had been installed and two of the four connection cubicles were installed and connected with the other two being completed within the next week.

Thus, from the middle of March until the middle of May 2001, a new substation had been installed close to the South Franklyn dock, with power cables installed down to the dock terminating in a dock switch. A 135 foot long, 25 foot high gantry had been constructed supporting the festooning equipment, connection cables and plugs. The four Sun Class ships had been modified, in service, to accept shore power. In addition the steam piping had been installed from the location of a yet to be constructed boiler house to the base of the new gantry. All the above work had to be completed by mid May so as not to inconvenience the visiting cruise ships.

Software

Another aspect of this project that was running in parallel to all of the above was the software modifications and additions to the onboard Power Management System (PMS) that would be necessary to enable the shore power and ship generated power to synchronize, combine and then transfer.

Closing down the ships generation plant in order to connect the shore power cables and then turn on the shore power was never an option. The disruption to passenger services for even a short period of time is not acceptable, and those that have witnessed this operation in a refit situation will know that the resetting of control equipment around the ship can mean hours of disruption.

Callenberg Engineering worked closely with ABB Automation and Alsthom to define the logic that would be necessary to accomplish this automatic transfer. It was decided early on that the best way forward was to modify the onboard software such that the PMS would recognize the shore power supply as an additional onboard generating plant. The Sun Class ships have four generating plants consisting of four Sulzer engines (16ZAV40S) driving four Alsthom GEC generators delivering 6.6KV, 3 phase, 60 Hz power. When alongside the hotel load is supplied by one generating plant that can produce a maximum of 11 MW, noting that in Juneau the demand is around 7 MW.

The task of this group was to develop the software to synchronize the onboard power with the shore supplied power. The software allows connection of the two power sources over a set period of time to replace one power source with the other. To do this the software would have to adjust the onboard voltage until it matched the shore supply and then control the onboard frequency and phase until it matched that of the shore supply. When this had been achieved the system would have to automatically activate the connection cubicle breaker to join the two power sources and then start a process of running the shipboard generator down until it would reach a point where it's supply breaker would be opened by the software thus shutting off the shipboard power. During the running-down process the onboard demand would be met by the shore power that would steadily increase, making up the shortfall caused by the ship's generator decreased supply.

The idea behind making the PMS believe that the shore supply was a fifth onboard generating plant was that the existing software would continue to do what it was designed to do when the load increases or is suddenly lost. That is load shed in the case of an increase in load that approaches a set maximum. Or in the case of a sudden loss of shore power it should immediately start one of the ship's engines.

This phase of the project required the most coordination. The Main Engine governor control software had originally been supplied by Alsthom of France, the onboard PMS by ABB Automation and the onboard control cabling and the software for controlling the shore power was supplied by Callenberg Engineering. Representatives of all the above companies had to be present during trials for problem solving and debugging purposes. In addition to these people the local power utility, AELP, would need to know the status of the engine being used for the transfer, the status of the various breakers and the power parameters; thus their software personnel were present also. During the rigging of the cables on the festooning system, control cables were installed that would relay the status of the shore connection to the Thane substation, 8 miles away. The control screen on the onboard ABB PMS would be duplicated at the Thane Substation but for observation purposes only.

This stage of the project could only be undertaken when the ships were at the South Franklyn Quay and the power cables connected. Thus the time available for each ship was limited to the ships visits to Juneau. Though on the plus side there were four ship visits in succession thus what was learned on one day on one ship would be acted upon on the others within days, thus this phase of the project proceeded more rapidly than it might otherwise have done.

The connection process and procedure had been agonized over more than any other single entity of this project. What would be the easiest way to get the cables onboard, how were they to be handled once onboard, what was the safest procedure for connecting the cables? Then there was the disconnection to consider. This part of the project contained the greatest risks of damage to the equipment and injury or death of the operators. Numerous methods of handling the cables were considered, an area of concern being the weight. Each of the four power cables had a 70 lb plug on the end and the bend radius of the 4 inch cables was expected to add to the difficulty of handling. The position of the cables hanging from the festooning system placed them eight feet from the ships side shell. After deploying several different methods of handling the plugs the simplest method was found to be the quickest and that was to hook each cable with a boat hook and haul it through the side shell door using a roller arrangement at the lower sill to prevent damage to the cable. Once all four power cable and the single neutral earth were onboard just inside the shell opening, the hoist that was supporting the cables was lowered thus allowing the plugs to be carried one at a time to the connection cabinet and plugged in.

As with all High Voltage equipment a strict operating procedure for connection and disconnection was established and this was run through several times on each ship without shore power being supplied. This was done during the trial phase of the onboard software and enabled AELP to contribute to the debugging process to ensure that their substation was receiving the correct information via a SCADA link. It also enabled the ship staff on each ship to become familiar with the connection/ disconnection process before doing it for real.

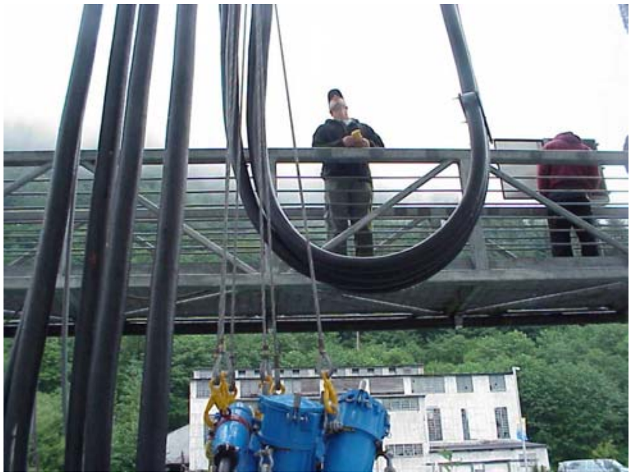
The responsibility for the connection/disconnection of the cables was placed with the ship and the Chief Electro-Technical Officer (CETO). He would control the whole process and be responsible for the tagging of the various switches. The safety of this operation was enhanced by the double set of switches both onboard and shore side. The ship had a connection cubicle in the connection room that housed a "rack able" breaker, this was connected to the ships switchboard via another breaker and thus another switch. Shore side the dock switch is the first switch then at the substation there is a second switch.

Shore Power Connection

The trials and completion process continued throughout June and into the beginning of July. Gradually all the issues were resolved and the time came to connect one of the ships and transfer power. During this trials period each ship was fitted with a specific UHF radio to communicate direct with the Thane Substation and the AELP line men who would be ensuring the safety of their part of the system (up to and including the dock switch).

About thirty minutes before the ship is due to arrive at the quay in Juneau the Chief Technical Officer calls the

Thane Substation on the UHF to inform them of their arrival. The Thane Substation then dispatches two linemen to the quay to prepare for the connection. They will check that dock switch is open and grounded, as the Thane substation has control of the substation switch. As the ship comes alongside the linemen maneuver the cables and plugs on the festoon system to line up with the side shell door that has been opened by ships staff. The CETO has already started to run through his connection checklist ensuring that both shipboard breakers are open and that the connection system is grounded.



Before the cables are brought onboard the ship and handled by the crew, the connection room breaker is tagged and the CETO then proceeds ashore to check that the dock switch is open and grounded. He then tags this switch and the go ahead to handle the cables is then given. At first the process of pulling the cables aboard and connecting them to the connection cubicle took around 30 minutes. Towards then end of the season this had been reduced to 20 minutes.

Once the plugs are connected the Chief Technical Officer calls the Thane substation to inform them that they are ready to take power. This is also confirmed by the turning of a "Permission Switch" in the Control Room that provides an electronic signal to the Thane substation to be prepared to increase its supply of power. This action also initiates the onboard software to start the synchronization process, which takes around two minutes. As soon as synchronization is achieved, the software activates the connection room breaker and the switchboard breaker, closing them, thus connecting the ships 6.6KV supply to the shore side 6.6KV supply. The software then starts to run the ships engine down, also referred to as "ramping" down. This is done over a period of five minutes and is necessary to allow the Thane Substation to provide the power that is being lost due to the ramping down of the Shipboard power. As the shore side supply is hydroelectric, this involves the Thane Substation remotely operating sluices at the unmanned Snettisham Power plant 40 miles away.

The transfer of power is quite transparent, the only indication that anything is happening is the movement of the power indication dials in the Engine Control Room showing the shipboard electrical power reducing and the shore supply power increasing and in the main engine room the running engine is slowing down and then stopping, and all the lights are still on. The disconnect procedure is the reverse of the connection procedure.

During the trial phase right up to the first connection five companies were involved and eight different nationalities making this event a truly international event. Once this had been achieved on one ship the other ships followed in quick succession.

SHORE STEAM

While the trials process was underway the construction of a suitable building to house the shore side boiler was in progress. The electric boiler and its ancillary equipment had been barged to Juneau arriving in mid June. The planning permission and then the grading of the site meant that erection of the prefabricated building was not started until the beginning of July. The Boiler was rated to provide 10,000 kg of steam per hour at 9 bar and operates as an Electrode Boiler

In the operation of an electrode boiler, the primary voltage connections are made directly to the electrode terminals. Visualize a spray of water directed onto the electrode, which flashes the water into steam. Regulation of the steam output is accomplished by regulating the flow of feed water coming in contact with the electrodes. Regulation is step less between no-load and full-load. The steam generator can be programmed with a timing function to establish the response rate to the actual demand.

The market for electrode steam generators narrows very quickly. A used boiler, built in 1975, as well as a newly built where found on the current market. The used boiler, which underwent testing and inspection, was determined to be excellent value for its intended service and was selected by Princess Cruises. The boiler was rated at 6 MW maximum when operated on the available 12.5 KV, 3 phase, wye power supply.

The provision of a boiler room on shore for the steam generator became a civil and mechanical engineering matter, when considering the codes. MR&S engineered the steam and condensate pipelines between the boiler room and the ship, so as to integrate shipboard requirements with the land based facility.

The Boiler House was constructed locally in Juneau in prefabricated form and erected on site in a matter of days. Other local companies, Behrends Mechanical had the job of installing the boiler and its equipment and the electrical side was covered by Chatham Electric another Juneau based company who were also responsible for installing the HV cables, tractor units and hoists onto the Festooning system. They also assisted with the installation of the steam hoses onto their festooning system.

Shipboard Modifications

There are three, 4 inch steam hoses and one 4 inch condensate hose supported by the festoon for the provision of shore steam to the ship. These hoses connect to the ship in the existing bunker port. An existing shore steam connection was upgraded for the much higher steam capacity. The condensate return is new piping and includes a new condensate pump operating off the hot well to pump condensate ashore. It is interesting to note that the steam system is not a closed system. Rather, condensate is pumped ashore to a heat exchanger in the boiler room where the waste heat is given over to fresh water. The energy-depleted condensate is disposed of in the municipal water system.

Ships crew and contractors undertook the onboard modifications engineered by MR&S onboard. The boiler manufacturers, Precision Boilers of Tennessee were brought in to commission the plant right at the end of the Alaska Season, and one ship was connected to Shore steam before the end of the season. It is expected to have all four Sun Class ships connected to shore steam this May as well as a newcomer to Alaska, the *Star Princess*, a new Grand Class cruise ship that is coming into service in the USA this March.

CONCLUSION

This unique project had many positive aspects. It was undertaken for environmental reasons, which are advantageous to the residents of Juneau and provides certain political dividends for Princess Cruises. Every effort was made to employ local contractors and many were used throughout the project, which had some welcomed input into the local economy. The diversity of other companies used during the development and execution of this project indicates the international nature of difficult engineering projects undertaken today. As for the ship's themselves, the engineering staff will have a unique opportunity for maintenance when they are berthed in Juneau, once they get used to the silence.

The project achieved its goals by making strong use of the Internet and e-mail. This is mentioned because, without really realizing how it has come upon us, we seem to now rely upon e-mail to facilitate a vast array of functions. The benefits of these systems were apparent when the major team members were spread between California, Florida and Alaska. In addition various vendors, especially those who supported Callenberg, were worldwide. E-mail and the Internet kept this project fast track.