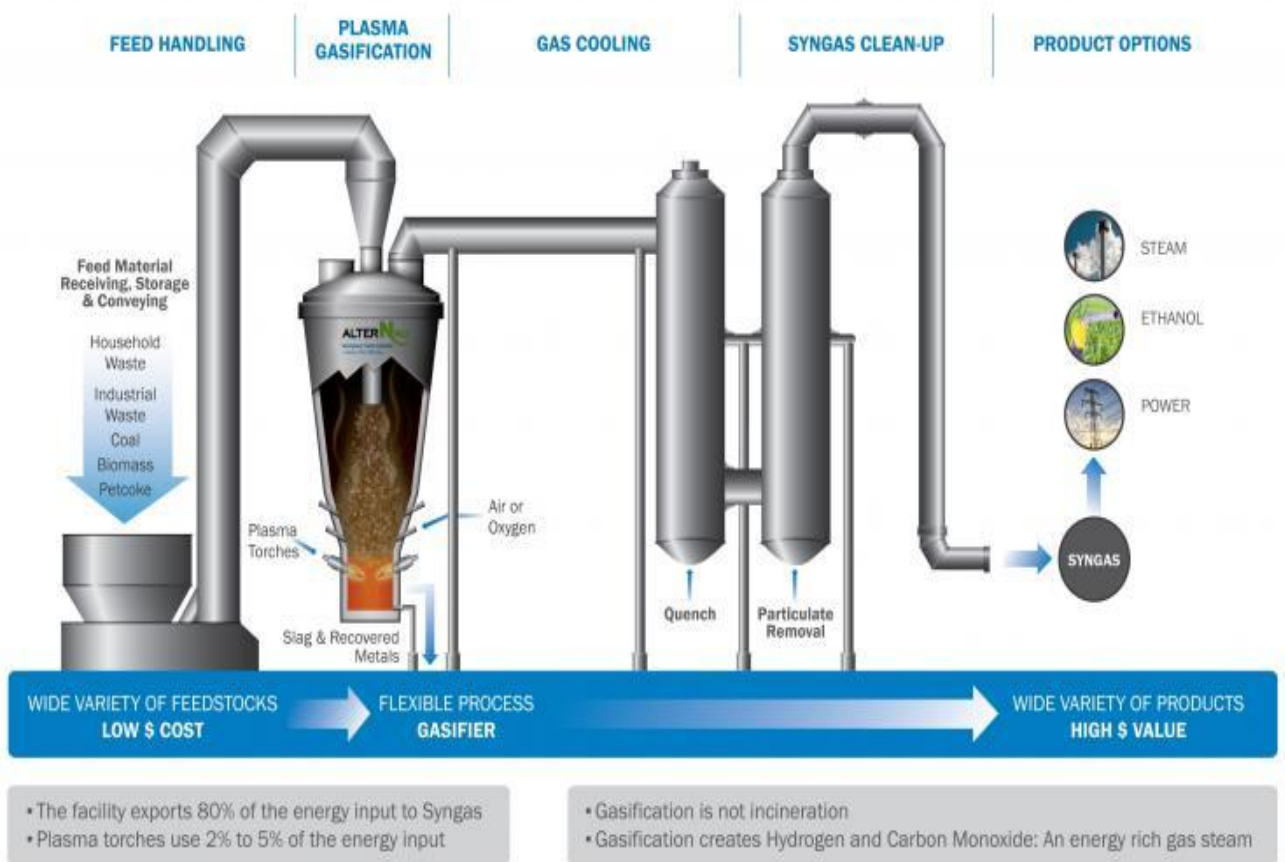


Plasma Technology

Plasma Gasification - Explanation

The Alter NRG Plasma Gasification System using Westinghouse Plasma Corp. (WPC) Technology is designed to provide users with a Syngas tailored to the downstream process needs of the customer. The major components of the Alter NRG Plasma Gasification System are included in Alter NRG's scope of supply, while the balance of plant engineering is completed by an engineering procurement construction and management (EPCM) firm using equipment proven in power and gas processing applications throughout the world. The components displayed in the green box in the diagram below indicate the scope of supply for Alter NRG's Plasma Gasification System.

Alter NRG Plasma Gasification System



Key Components of the Alter NRG Plasma Gasification System

Plasma Torch Systems

Through WPC, Alter NRG offers four models of plasma torch systems each designed to operate over a wide range of power inputs. This breadth of product offering allows Alter NRG and WPC to best match the plasma power requirements to customer applications.

WPC Plasma Torches



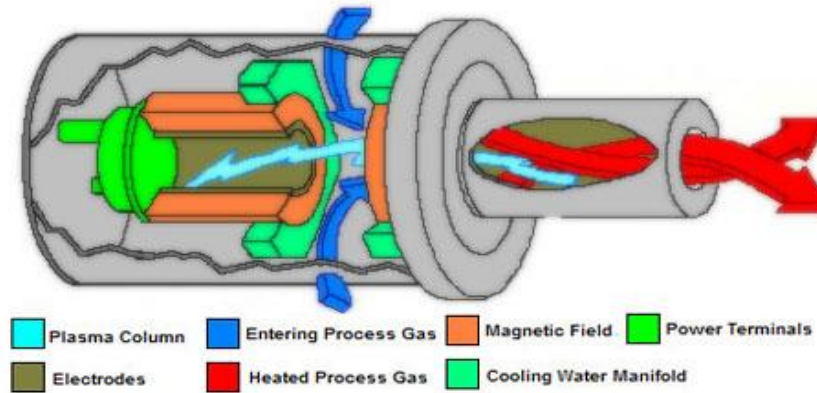
Plasma Torch Power Requirements

Plasma Torch Model	Minimum Power Input	Maximum Power Input
Marc-3a	80 kWe	300 kWe
Marc-11 (Low)	300 kWe	1,000 kWe
Marc-11 (High)	800 kWe	2,400 kWe

kWe = Kilowatt (Electrical)

Inside the plasma torch, a plasma stream is created by the interaction between air (other gases can also be used) and an electric arc created between two electrodes. The interaction of the gas with the electric arc dissociates the gas into electrons and ions enabling the gas to become electrically and thermally conductive. Torches can be turned up and down to maintain reaction temperatures as feedstocks with higher and lower Btu values are processed and/or feedstocks with higher or lower values of ash/glass/metals are processed.

WPC Plasma Torch Schematic



The Key Advantages of the Westinghouse Plasma Gasification Technology

- Self-stabilized and non-transferred arc
- Operation on many gases – air, oxygen, nitrogen, etc.
- Wide variety of torches available with power input from 80 kW – 2,400 kW
- High thermal efficiency
- Plasma torches have no moving parts resulting in high availability
- Torch consumables are quickly replaced without shutting down the gasifier
- Long electrode life

Alter NRG Plasma Gasifier

The Alter NRG Plasma Gasifier provides unmatched flexibility to process a variety of feedstocks including **municipal solid waste (MSW), industrial waste, biomass, coal, petroleum coke and tires**, when compared to most other gasification technologies.

Alter NRG Plasma Gasifier



The Plasma Gasification Process Inside the APG

The APG is a refractory-lined vessel that stands about 60 feet tall (based on Alter's largest reactor size). Plasma torches, which provide heat for gasification and melting, are located around the periphery near the bottom of the reactor. The heat from the torches is used to heat up a bed of foundry coke. The temperature at the center of the coke bed very near the plasma torches is greater than 3,000°C (5,400°F). The temperature at the top and bottom of the coke bed is approximately 1,650°C (3,000°F). Air and/or oxygen inlets are located just above and below the top of the coke bed.

After the feedstock is converted to syngas it exits the top of the reactor at a temperature of approximately 900-1,000°C (1,650-1,830°F) where it begins several gas clean-up steps before the syngas can be converted into various energy products.

The extreme temperatures within the reactor ensure that:

- All organic material is converted to syngas
 - Any material that cannot be gasified is melted and flows out as molten slag.
- Long residence times within the reactor ensure there is sufficient time to crack any tars and minimize particulate carryover, a systemic problem for many other gasification systems.

Feedstock materials enter the APG through the feed port which can be located on the side of the reactor or at the top. The feedstock either gasifies immediately upon entering the reactor or falls onto the coke bed where complete gasification occurs.

APG benefits include:

- Feedstock flexibility – operation at ambient pressure and high temperature (greater than 5,000°C/10,000°F) from plasma results in:
 - Ability to use heterogeneous feedstocks such as MSW
 - Ability to mix feedstocks like MSW, tires and plastics
 - Minimal feedstock preparation
 - Operation at ambient pressures allowing for simple feed systems and online maintenance of the plasma torches
 - Low gas velocities allowing for greater feed flexibility and eliminating most expensive pre-treatments of feed stock
 - Environmentally responsible operation since syngas that is created has very low quantities of NO_x, SO_x, dioxins and furans
 - Inorganic components get converted to molten slag which is removed as vitrified by-product – safe for use as a construction aggregate
 - Lower capital and operating costs because air is used as an oxidant – some competitors’ designs require air separation units
 - Syngas composition (H₂ to CO ratio, N₂) can be matched to downstream process equipment by selection of oxidant and torch power consumption

Industrially-Rugged Design

At the General Motors Foundry in Defiance, Ohio, the original plasma torches have been operating reliably since 1989.

http://alternrg.com/plasma_technology/products_and_services/plasma_gasification

“Plasma Gasification can create more renewable energy than the projected energy from solar, wind, landfill gas and geothermal energies combined”

Georgia Tech Research Institute

Plasma Market Solutions

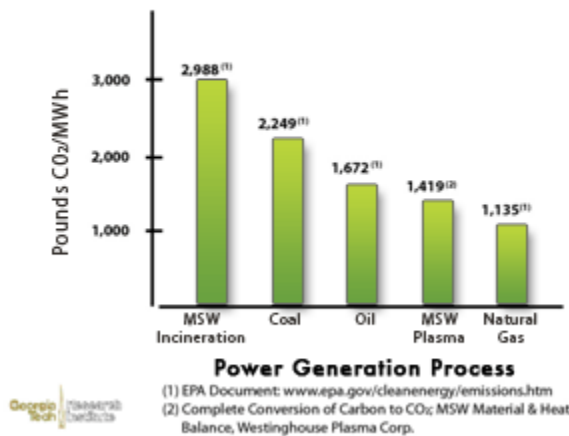
Environmental Benefits

Plasma gasification is an environmentally superior method of treating waste for the air and land.

- It has fewer emissions of greenhouse gases, and harmful elements that cause acid rain and smog.
- **Generates non-hazardous slag as the solid product. In the larger Japanese facilities, for every 120 trucks of waste going in, only 1 truck of slag is produced.**
- **Generates more energy per tonne of waste processed than other technologies such as incineration.**

Reduced Greenhouse Gas Emissions

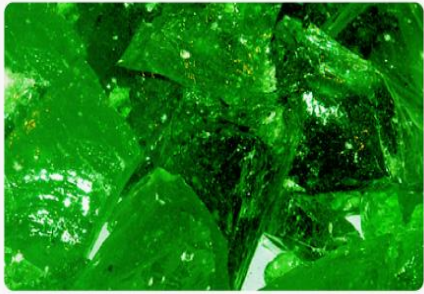
Pounds of CO₂ Emissions per MWh of Electricity Produced



The Alter NRG solution helps reduce the methane gas emissions associated with landfills, which "are 21 times more potent than CO₂ as a greenhouse gas." (Environment Canada, Greenhouse Gas Inventory 1990-2000)

Criteria Emissions Reductions

Given plasma gasification's extremely high operating temperatures, potentially **harmful air emissions are virtually eliminated** when impurities such as SO_x, NO_x and HCl that lead to acid rain, smog and corrosive air pollutants are removed.



The inorganic byproducts of gasification are vitrified into an environmentally benign and glasslike slag, which can be used in construction.

At the operating plasma gasification facilities in Japan, less than 0.01 ng/Nm³ of dioxins/furans are reported. The United Kingdom's Environment Agency estimates that during the Millennial celebrations in London the emissions from one 15 minute, 35 ton firework display equaled 120 years of dioxin emissions from the SELCHP waste-to-energy facility in Deptford, England. (Source: APSWG briefing on Energy from Waste; UK Environment Agency 2000)

Inorganic Byproduct is Reusable

Solid byproducts of the plasma gasification process are slag and recovered metals. Non-gaseous, inorganic and mineral constituents in the MSW are converted to a vitrified slag, typically composed of metals and silica glass. This vitrified material can be used to produce metals and other byproducts, including rock wool, floor tiles, roof tiles, insulation, landscaping blocks or road aggregate.

The vitrified slag material is non-leaching and exceeds EPA standards.

A hint for HK Electric Holdings and CLP ?

Plasma Market Solutions

Power Plant Retrofits

Related Links

- NRG Energy

Alter NRG's plasma gasification is an ideal solution for retrofits of coal-fired plants, while ensuring emissions are below environmental standards. The net result of power plant retrofits is:

- Extending the life of baseload power facilities
- Significantly improving the environmental performance
- Ensuring the facilities remain profitable

Power plant retrofits using plasma gasification is a clean coal solution, while also allowing the facilities to blend renewable feedstocks such as biomass.

Market Drivers for Power Plant Retrofits

- Retrofit is less costly than new plant
- Existing site is retrofitted which has
- Quicker and easier permitting
- Key agreements, labor force, etc.

READ WHAT THE HK ENB'S APPOINTED CONSULTANT AECOM HAS TO SAY ABOUT PLASMA

Clean Coal Technology + Renewable Energy Technology = Alter NRG Solution

"Clean coal plasma gasification is an innovative application of proven technology. The commercial application of plasma gasification as a clean coal technology is the collaboration of a number of advanced technologies "

ENSR-AECOM

Setting the Industry Standard with our Product Offering

Alter NRG's Plasma Gasification Technology is a Market Leader

Alter NRG "is pursuing opportunities to use its own plasma gasification technology, which has recently been acquired from Westinghouse Plasma Corporation, who are widely regarded as a leading supplier of plasma torch technology."

Juniper

Plasma Gasification is a Clean Energy Solution - Energy Recovery from Waste

Alter NRG's 750 tonne-per-day waste-to-energy plasma gasification facility "will result in substantial renewable energy production from post consumer waste streams that would normally have to be land filled, while providing state-of-the-art emission control...

"These emissions will be substantially lower than traditional mass burn or refuse derived fuel processes commonly used in the waste to energy industry. Diversion of MSW from solid waste landfills (where the potent greenhouse gas methane is formed) will result in substantial net decreases in greenhouse gas emissions as CO2 equivalent. Since the proposed organic feed stocks are post consumer waste streams, the project represents a renewable and sustainable clean energy resource."

ENSR-AECOM

Alter NRG's Plasma Gasification Technology is Commercially Proven

Utashinai and Mihama-Mikata are the only plasma gasification plants processing MSW in the world on a commercial basis at this time.

Juniper

Plasma Gasification Design Validation - Power Plant Retrofits

Clean coal plasma gasification technology is an innovative application of proven technology. The commercial application of plasma gasification as a clean coal technology is the collaboration of a number of advanced technologies...

ENSR-AECOM

...the Plasma Technology appears to be a sound method of gasifying organic feedstocks and producing fuel gas compatible with boiler combustion.

RW Beck

FULLY ENGINEERED SOLUTION

COMPANY	COMPANY CREDENTIAL	RESULTS FROM THE REVIEW OF ALTER NRG
	Juniper Consultancy is recognized as one of the leading independent analysts of emerging technologies in the waste management field.	Juniper conducted a thorough review of the Westinghouse Plasma Gasification technology and the technology in application at the Mihama-Ukata and Utashina WTE facilities. Juniper recognizes these facilities as "the only commercial plasma gasification facilities in the world processing MSW." Juniper acknowledges the Alter NRG/Westinghouse Plasma Gasification technology as more proven than direct competitors and views Alter NRG as becoming a world leader in the design and supply of plasma-based systems.
	ENSR, a division of AECOM, is a global provider of environmental and energy development services.	ENSR – AECOM completed an engineer's review that verifies Alter NRG's assumptions of emissions from a 750 tpd MSW Plasma Gasification Combined Cycle WTE facility will be below emission limits for North America. The report confirms that processing waste through plasma gasification results in "emission levels substantially below mass burn processes."
	AMEC provides scientific, environmental, engineering and project management support in more than 30 countries.	AMEC completed Design Basis Memorandums that included complete process flow diagrams and CAPEX estimates for three different facility configurations: combined cycle, steam cycle and WCCAS .
	Golder Associates provides civil/geotechnical and environmental consulting services worldwide.	Golder reviewed emissions data from Utashina and Mihama-Ukata and confirmed that the existing plants operate below their regulated emissions limits in Japan, as well as below North American Standards.
	R.W. Beck is a group of technically based business consultants serving public and private infrastructure organizations worldwide.	RW Beck reviewed Alter NRG's plasma gasification technology for power plant retrofit and MSW applications and identified no major technical challenges and opined that "the plasma technology appears to be a sound method of gasifying organic feedstocks and producing fuel gas compatible with boiler combustion" and "the review did not identify major design issues."
	Shimadzu Techno Research is an analytical research service provider in the health, environment and product and material testing markets.	Shimadzu Techno Research tested slag from the Mihama-Ukata plasma gasification facility in Japan. The results of this study showed that this vitrified slag composition is considered inert and does not contaminate soil or drinking water.
	Uhde is one of the world's leading engineering companies in the design and construction of chemical, refining and other industrial plants.	Uhde Engineering Shanghai continues to promote and market the Westinghouse Plasma technology and Alter NRG plasma gasification solutions throughout Asia as well as supporting Alter NRG with Chinese and other SE Asia procurement. Uhde has performed advanced 3 dimensional modeling on several WTE configurations.
	Hatch is a world leader in high temperature furnace design and gasification engineering and support.	Hatch has worked with Alter NRG to optimize the best in class plasma reactor design resulting in 3 additional patents pending for Alter NRG.
	Technip is a world leader in engineering, technologies and project management for the oil and gas industry.	Technip has reviewed the WPC technology and will provide performance guarantees.



Project Information

Location: Peterborough, U.K.

Status: Completed

Peterborough Energy Park, U.K.

Located behind Peterborough Power Station in the U.K., this innovative energy park transforms waste into energy or reusable materials (glass, metals, acids, aggregates), leaving nothing in landfills, and generates enough electricity to power 60,000 homes a year.

The energy park includes a research and development center and two three-story main buildings, each accommodating a waste-receiving hall, combustion chamber and plasma treatment chamber.

This 25-acre energy park complies with strict Environment Agency guidelines, which means sound, smell and emissions are negligible, and there are no adverse effects on the surrounding environment and wildlife. AECOM provided project management, cost management, engineering services cost management, grid connection advice, tax and enhanced capital allowances, planning, legal support and funding/investment introductions.

http://www.aecom.com/About/Public+Private+Partnerships+and+Alternative+Delivery/Contractor+Services/_projectsList/Peterborough+Energy+Park,+U.K.

Energy Park Peterborough, which was granted consent by the Government Department for Energy and Climate Change (DECC) in November 2009, will take in mixed waste and - through a combination of recycling, gasification and plasma-enhanced waste recovery - recycle and remanufacture it, producing reusable products and renewable energy in the process. Energy Park Peterborough alone will save 600,000 tonnes of CO2 per year, create over 100 green collar jobs in the local community and produce enough renewable energy to power 60,000 homes

<http://www.prweb.com/releases/2010/11/prweb4789064.htm>

Milwaukee Gasification-WTE Project Unveiled

Mike Zebell of **Aecom** “The site AFE has chosen for this project is well suited for this facility”, said Mike Zebell of Aecom, a technical, environmental and management support services company advising AFE on permitting. “We believe that this technology is not only environmentally friendly but ready for large-scale commercialization. ”

<http://www.worldfuels.com/wfExtract/exports/Content/c159768d-785f-4a78-9ec5-e32a9c47084a.html>

Mike Zebell of **Aecom** “We are excited to partner with an entrepreneurial firm like AFE, one of the industries leading developers focused on building environmentally responsible energy projects using plasma gasification technology.”

<http://www.wisconsinbioindustry.com/category/bio-power/>



Plasma arc power – what Georgia Tech (GTRI) research chief said 10 long years ago.

<http://qtalumni.org/Publications/magazine/sum02/article2.html>

Plasma Power

Lou Circeo, right, director of plasma research programs at the Georgia Tech Research Institute, and Bob Newsom, senior research technologist show samples of soil the plasma arc torch has reduced to glass.

By Kimberly Link-Wills

Think of **a plasma arc torch as a man-made continuous lightning bolt. Hotter than the surface of the sun, plasma is a tool so powerful that it can melt or vaporize contaminated soil, diseased animals, piles of garbage — and leave behind only pebbles of glass.**

Plasma technology isn't new. **NASA developed it in the 1960s to test heat shields' ability to withstand spacecraft re-entry** into Earth's atmosphere. With temperatures exceeding 7,000 degrees Centigrade — three times hotter than fossil fuels — the plasma arc torch's potential is incredible.

It is possible to transform a landfill heaped with stinking rubbish into a glass boulder. Because all known hazardous and toxic chemical and biological agents are destroyed and reduced to their elemental components, it is possible to prevent radio nuclides from leaching into the groundwater around Chernobyl and thus reduce harmful exposures to the surrounding populace. It is possible to supply electricity to our homes with gases captured from garbage, old tires and junkyard cars.

Lou Circeo's hair has grayed as he has waited for the plasma arc torch to ignite wide-swept changes in the way Americans dispose of their garbage, fuel their factories and illuminate their homes. Circeo, director of plasma research programs at the Georgia Tech Research Institute, received his undergraduate degree from West Point and his master's and PhD from Iowa State

He began working with plasma technology in the early 1970s and came to Georgia Tech in 1987 as the founding director of the Construction Research Center in the College of Architecture, where he used the torch to harden and vitrify unstable soil into a rock foundation on building sites. "You could build a World Trade Center complex on this vitrified soil," Circeo said in an Atlanta Journal-Constitution article at the time. "It's much better than concrete. Hell, concrete may go out of style once we're finished." Tech launched its plasma research facility, with Circeo as its head, in 1991. It is arguably the largest university-based research program for plasma processing of waste materials in the country.

Circeo has watched as other countries have picked up the technology. "We developed the torches, we developed the ideas, but the Japanese and the Europeans are the ones who are commercializing it," he says. "In Japan, they're using their system for disposal of municipal solid waste and automobile shredder residue, what's left after they recycle all the metals and everything else they can. They're running out of landfill space in Japan. That's why Hitachi Metals was so interested in doing this.

"Anything they don't want is put into the hopper and it goes through a slight grinding process. Then it's squeezed into a bale that's pushed into the furnace. The only thing that comes out of there is a molten stream — no ashes, no cinders, just a molten stream. That's put into water. What they end up with, instead of a big block of hard rock, is a sand-like material. The fuel gases that come off — mainly hydrogen and carbon monoxide — are sent into a secondary combustion system. The hot gases are then mixed with water to form steam, which goes up and runs a turbine to produce electricity. After a treatment process, the gaseous emissions are essentially carbon dioxide by the time they get up in the stack," Circeo explains.

He says Japan's 25-tons-per-day facility has been so successful that a 200-tons-per-day plant is in the works. He says five facilities that size could probably get rid of most of the city of Atlanta's garbage. Tech hosted what Circeo says was one of the largest plasma waste disposal technology conferences in the world in 1995. "We had something like 90 papers and people from 13 different countries here." Circeo pitches plasma to whomever he can, whenever he can. He powers up the torch for lawmakers, federal funding committees and the media. He hands those treated to an up-close demonstration of the plasma torch protective face shields and earplugs. An overhead catwalk allows visitors to peer down inside a barrel, where soil is transformed into a boiling liquid within minutes by the 100-kilowatt torch, only 3 inches in diameter.

Circeo says a company has expressed interest in working with Tech to create a mobile plasma torch system. "We could go to a place like the collapsed World Trade Center and this technology would rapidly melt through girders and concrete. If somebody's stuck under a concrete or steel beam, this will cut it in just a few minutes."

"We've got a couple of proposals in on how plasma can be used. *One of them is to get rid of diseased animals, large quantities of them, up to several tons an hour. **We can feed the carcasses into a furnace to get rid of animals contaminated with mad-cow disease. If there was a bunch of cows infected with anthrax, this would get rid of them very, very quickly and very safely,***" Circeo says.

"The other proposal is to decontaminate large areas that have biological contamination or chemical agent contamination because **this technology will destroy anything.** This is why plasma is so important. All the hazardous and toxic compounds are broken down to their basic elements. These elements recombine into simple acid gases that are easy to neutralize," he says.

"The Department of Energy is especially interested because this technology will readily remediate their most difficult to treat contaminants and immobilize residual radio nuclides and heavy metals in the most difficult to melt soils and rocks," Circeo says. "**The U.S. Navy has selected plasma as a way to get rid of shipboard wastes for their big ships** because they can't throw most of it overboard anymore." A prototype system built for aircraft carriers is undergoing testing.