CITY OF SANTA BARBARA WATERFRONT DEPARTMENT

MEMORANDUM

Date: May 19, 2011

To: Harbor Commissioners

From: John N. Bridley, Waterfront Director

Subject: **Preliminary Corrosion Study for Santa Barbara Harbor**

RECOMMENDATION:

That Harbor Commission review and consider a Preliminary Corrosion Study concerning electrolysis in Santa Barbara Harbor by Far West Corrosion Control Company.

BACKGROUND:

Electrolysis is a term commonly used by boaters referring to corrosion of submerged metallic parts due to stray electrical current. Complaints of rapid corrosion of zinc anodes, propellers, shafts, outdrives, through hulls, and blistering paint are infrequent but not uncommon. Waterfront staff has received such complaints periodically over many years.

In 2006, staff hired a well known and self-proclaimed expert in this field to conduct a seminar in Santa Barbara Harbor. Harbor maintenance workers from several ports and harbors attended what turned out to be a rather confusing approach to diagnosing corrosion problems on boats and stray electrical currents in the harbor. A fortunate outcome was the introduction of a marine electrician from Channel Islands that understood how to diagnose and correct problems. Staff hired him periodically to address sporadic complaints for several years until the individual moved out of the area.

Shortly after the completion of Phase 1 of the Marina One Replacement Project which included the complete replacement of the main electrical feed to the marina, staff received several complaints of serious corrosion of large aluminum outdrives on three separate vessels located in different areas of Marina One. Coincidentally, almost half of the 16 new water line fittings installed with stainless steel pipe collars (a type of hose clamp) as part of the Marina One Project also failed. Many assumed that the corrosion of the outdrives and failure of the pipe collars were a result of corrosion from stray electrical current or “electrolysis” possibly caused by the recently installed electrical system. In consideration of these serious problems and accusations, staff hired Far West Corrosion Control Company to prepare a study (attached) assessing the new electrical system and investigating the causes of the pipe collar failures and corroded outdrives.

STUDY FINDINGS:

Stainless Steel Pipe Collars

Several of the failed stainless steel pipe collars were provided to Far West for analysis. The pipe collars are made of 316 stainless steel and fit over a flexible rubber hose that fastens to the domestic water distribution system along the main headwalk. This system was used during Phase 1 as a temporary water system that would eventually be replaced with each phase of the project. Unfortunately, almost half the pipe collars failed within six months indicating a serious problem.

Far West analyzed the pipe collars and concluded that the cause of the corrosion was not due to stray electrical current but from what is known as crevice corrosion. Stainless steel is normally a suitable product in a marine environment but there are unique circumstances in which it rapidly corrodes. The corrosion occurred between the rubber hose and the inside of the pipe collars making it impossible to view the aggressive corrosion. Additional tests were conducted to determine if stray electrical current could be contributing to the corrosion. Far West concluded that the corrosion of the pipe collars was solely from crevice corrosion and stray electrical current was not a factor. All of the fittings have since been replaced with plastic.

New AC Electrical System

A key component of Phase 1 of the Marina One Replacement Project was installation of a new AC electrical system for the entire marina. This included a new transformer behind the building with five submarine cables feeding a new 480v distribution panel at the foot of the gangway. Temporary electrical service was provided during construction with a switchover to the new electrical system at the end of the project in July 2010. The electrical service from the new distribution panel to each of the reused transformers was replaced. Each of these transformers will be replaced as the various phases are completed. For example, Phase 2 included the replacement of “O” and “P” fingers which now have new transformers.

As previously mentioned, the pipe collars failed several months after installation of the new AC electrical system coincident with several cases of what appeared to be very serious corrosion of the aluminum outdrives on three separate vessels in Marina One. The vessel owners and other members of the harbor community assumed that the failed pipe fittings and corroded outdrives were the result of stray electrical current due to faulty installation of the new AC electrical system.

Typically AC electrical systems have all exposed metal parts connected to a common ground to prevent personnel contact with dangerous voltage if there is insulation/isolation failure on the system (commonly referred to as ground faults or short circuits). In theory, any insulation/isolation failure would result in current flowing on the ground wire back to a copper rod inserted into the ground behind the 132 building. If the current is high enough, excessive heat causes breakers to trip thus shutting down

the circuit. It is not uncommon to have lower levels of current on the ground wire indicative of a low level fault in the electrical system.

Far West, working with Waterfront staff, measured the AC and DC currents on the various system ground wires. At the time of the tests, there were five transformers on the main headwalk (two transformers have recently been added to "O" and "P" fingers). Higher than expected currents would indicate some level of insulation/isolation failure on the system. The failure could be from the marina's AC electrical system or from a failure on an individual boat that would dump current onto the ground wire. All boats that plug into shore power are connected to the same grounding system as the marina. The electrical current generated from the insulation/isolation fault can also take another path through the water. The current passing through the water can pass through underwater metallic fittings causing corrosion. This is what is commonly referred to as electrolysis but technically speaking is "Stray Current Corrosion".

Far West found some higher than expected levels of AC and DC current on some of the marina's electrical system ground wires. Far West concluded that the levels were too low to indicate a fundamental problem with the new AC electrical system but were more likely caused by individual boats.

Outdrive Corrosion

Three vessels in Marina One with aluminum outdrives experienced rapid corrosion at about the same time as the failure of the pipe fittings. As previously mentioned, the vessel owners believed the corrosion was caused by stray electrical currents passing through the water. Far West, along with Waterfront staff, conducted a series of tests on the individual boats, as well as many others, to determine if the boats had adequate cathodic protection and/or had apparent insulation/isolation faults on their electrical system.

It is important to note that whenever a boat is connected to shore power, the hull and drive systems are connected to the shore grounding system and to other adjacent boats also connected to shore power. This connection, required for safety, can create a galvanic corrosion cell involving dissimilar metals between boats and/or between a boat and the shore grounding system. There are two methods of protecting underwater metallic fittings, sacrificial zinc anodes and coatings.

Underwater metallic parts (outdrives, propellers, prop shafts, etc.) are usually fitted with a sacrificial zinc anode that corrodes much more rapidly and instead of the underwater metallic fitting. The level of protection from zinc anodes can be measured and is referred to as potential. If there is not enough protection from zinc anodes, underwater metallic fittings can corrode rapidly.

Some underwater metallic fittings are coated to prevent galvanic corrosion. The study suggests that there are several conditions that must be met for coatings to be effective. Surface preparation of the metallic part and applying the coating under the right environmental conditions are essential in protecting the underwater fittings. Far West

did not evaluate the adequacy of the coatings on the individual boats but identifies inadequate coatings as one of several variables that can contribute to corrosion.

Far West also tested individual vessel's shore power cords for AC or DC current on the ground wires. As previously noted, higher than expected currents indicate insulation/isolation failures with the vessel's electrical system. More often than not, severe corrosion of underwater metallic fittings is the result of a failure in the vessel's DC electrical system.

Far West was unable to determine the cause of the outdrive corrosion. One reason was that two of the vessels installed isolation transformers (see Study Recommendations). Another was possibly because each vessel had been hauled out and the corrosion repaired prior to the study.

Study Recommendations

Far West recommends some basic tests of individual boats and the marina's AC electrical system to determine if there is any obvious source of stray current corrosion.

The simplest and most indicative test that Waterfront staff can conduct is measuring the amount of current on an individual vessel's electrical ground system. Staff has made up a short section of shore power cable exposing the individual wires that can be measured for electrical current. The short section of cable plugs into the power center on the dock and the vessel's shore power cord is plugged into it. Using a simple electrical tester, staff can measure the amount of current on the ground leg and determine if higher than normal current is present. If the current is high, this indicates an insulation/isolation failure on that vessel's or an adjacent vessel's electrical system. It is imperative that several vessels on each side also be measured since all vessels plugged into shore power are connected through the ground system.

It is possible to isolate an individual boat from the marina's shore power electrical ground system by installing an "Isolation Transformer". This is a common remedy for low level insulation/isolation failures that are difficult to diagnose.

Waterfront staff is also capable of measuring the level of cathodic protection on an individual boat. This test is not as reliable and should normally be conducted by a marine electrician. As a courtesy, Waterfront staff can conduct a cursory test giving a vessel owner some basic information as to the adequacy of protection provided by their sacrificial zinc anodes.

Far West has prepared Corrosion Control Evaluation Guide with a test form filled out by Waterfront staff that will be provided to vessel owners. Since it is the responsibility of each vessel owner to maintain their electrical systems, this guide will help them understand all the different variables associated with corrosion. The guide also recommends that vessel owners hire qualified marine electricians to diagnose and repair problems.

Far West also recommends regular inspections of the marina's AC electrical system. The typical tests are described above and indicate if there is current on the ground system. Regular inspections of the marina's electrical system are also required per the terms of the loan from the Department of Boating and Waterways for the Marina One Replacement Project.

Conclusion

Stray AC or DC electrical currents significant enough to cause corrosion of underwater metallic fittings are rare in a facility like Marina One. None of the tests performed by Far West indicate a "Hot Harbor" or "Hot Slips". Each report of corrosion problems likely have their own unique causes that can be identified by specific tests.

Waterfront staff will consider development of a programmatic approach to diagnosing potential stray current corrosion in Santa Barbara Harbor. Such a program may involve testing every vessel in the harbor to establish a baseline condition for each vessel as well as identifying obvious problems in need of immediate attention. Assuming problems are identified with individual vessels, staff will work with the vessel owners to remedy the problem in a timely manner. Without owner cooperation, the Waterfront should consider requiring correction of problems via the slip rules and regulations or via an ordinance in Title 17 of the Municipal Code. Similar programs exist in other ports and harbors throughout California. Staff will consult with our colleagues in these ports and harbors to determine the need for an enforcement tool and the efficiency of the various programs.

Attachments:

1. Preliminary Corrosion Study, Santa Barbara Harbor Marina 1

Prepared by: Karl Treiberg, Waterfront Facilities Manager