Air Station Launches Defense Against Fine Grit

Sugar sand removal from a wastewater stream.

Marine Corps Air Station (MCAS) in Cherry Point, NC, is one of the best-equipped all-weather air bases in the world. The air station, which played an important role in World War II, the Korean War, the Vietnam War, and Operation Desert Storm, is home to the 2nd Marine Aircraft Wing. Other major tenants at MCAS Cherry Point include Fleet Readiness Center-East, the U.S. Naval Hospital, and Marine Transport Squadron 1, which provides worldwide personnel transportation, as well as the famous search and rescue operations with helicopters often referred to as PEDRO.

The base was established in 1941, when congress authorized the clearing of 8,000 acres of land in Craven County, near the North Carolina coast. In the 66 years since, the air station and its adjoining facilities have expanded to occupy more than 29,000 acres and employ over 12,000 Marines, sailors, and civilians. As the base grew, its supporting infrastructure expanded to support its burgeoning population, including facilities such as the MCAS Cherry Point Wastewater Treatment Plant, which treats the sewage generated at the base. Wastewater is carried away from homes and office buildings through an underground pipe network. The sewage must then be pumped through lift stations (or pump stations) in order to enter aboveground wastewater treatment plants. Pump Station 4259, the main pump station at MCAS Cherry Point, had a grit system that could not remove very fine sand. It eventually became inoperable. In 2003, the Department of the Navy embarked on a challenging retrofit grit upgrade project.

Previous System

The previous grit removal system at MCAS Cherry Pump Pump Station B4259—a paddle wheel-type device installed circa 1990—experienced operational efficiency problems almost immediately after startup and eventually failed to perform at all. Even though the other components of the lift station complex, including an automated bar screen, grit classifier, wet well, and pumps, were functioning normally, the paddle wheel grit removal system had been inoperable for a number of years.

The grit removal system is comprised of the Grit King unit and a grit washer/classification unit. Valving, grit classifiers, grit pumps, dewatering decanters, and control systems are available to provide a comprehensive grit removal package.

Grit removal is a process required at wastewater treatment plants and within both separate and combined sewer systems due to sediment transport by stormwater runoff. Grit gets into collection systems when surface water runoff from the early stage of a storm carries sediments and other particle-size debris from parking lots, roadways, and other impervious surfaces into the drainage system. Industrial activities and construction also generate large volumes of grit that find their way into collection systems. State-level funds for water quality improvements are typically not accessible for wastewater treatment plant owners who are having stormwater-induced grit issues because grit removal is generally viewed as a maintenance issue, not a water quality compliance issue. Insufficient grit removal can create expensive and maintenance-intensive problems for a wastewater treatment plant. Grit has been shown to cause the premature attrition of treatment plant equipment, including pumps and other mechanical equipment. Records from MCAS Cherry Point show that there were frequent pump maintenance issues at Pump Station B4259 during the time that the grit removal system was inoperable. These issues were probably caused by grit.

In June 2003, MCAS Cherry Point issued a Request for Proposal (RFP) for a design-build project to replace the grit system. The project was to use equipment of the contractor's choice as long as performance requirements were met. The replacement grit removal systems would have to be designed to remove the very small grit particles, commonly referred to as "sugar sand," which congregate in much of eastern North Carolina. The design parameter was to remove 95 percent of grit down to 100 microns in diameter, at flows up to ten

mgd. The RFP also stipulated that after in-field start-up, field testing would be conducted to ensure that the new grit removal device was meeting the 95 percent removal performance specification. Cieszko Construction Company (CCC, Trent Woods, NC) formed a design-build team consisting of CCC as the prime contractor with McKim & Creed, PA (www.mckimcreed.com), as the engineer.

Five Phases

The project was broken down into five phases: a preliminary engineering evaluation, system design, equipment procurement, construction and startup, and post-construction performance evaluation. The design process started immediately after award and took about one year, as the design-build team faced a significant challenge retrofitting the existing set-up. The project required integrating the new equipment into an existing flow line, and strict pre- and post-installation performance testing measures were required by the client to ensure product performance. Most manufactured grit removal devices could not operate within the limits of the drainage system's low operating head. The design-build team sought to design a reliable system that would last for at least 20 years. The team aimed to reduce costs incurred by MCAS Cherry Point by maximizing the re-use of the existing grit removal facilities and use of American-made system components, and by minimizing energy requirements for the new grit removal system. The team also aimed to control odor problems through efficient removal of organics and contain the environmental impacts during the construction phase.

Ultimately, the team chose to implement as its grit removal device a Grit King® hydrodynamic vortex separator supplied by Hydro International Inc. (www.hydro-international.biz). Pete Duty & Associates of Durham, NC, acted as the local sales agent.

Before installation could begin, the design process encountered a delay due to a lack of accurate flow and grit characteristic data provided by the client to support the design calculations. To overcome this problem, the design-build team performed a detailed preliminary engineering evaluation, consisting of a hydraulic assessment of the pump station, grit sampling and analysis, chemical sampling and analysis, pre-fabrication factory testing, and reporting. The flow study revealed that Pump Station 4259 would not accommodate a peak flow of ten mgd and the more realistic design flow was in the seven mgd range.

This hydrodynamic vortex separator removes fine sand from the wastewater flow at the Marine Corps Air Station in Cherry Point, NC.

The most critical parameter determining the design was establishing the particle size distribution of the grit within the wastewater influent to the pump station headworks. Five grit samples were collected from various sampling points within the MCAS Cherry Point wastewater system. The grit analysis revealed that the particle size distribution of grit in the MCAS Cherry Point wastewater contained a larger percentage of fine particles than was originally expected. The grit analysis enabled Hydro International to accurately size the Grit King separator to ensure compliance with the 95 percent removal performance specification.

The chemical analysis was conducted on the grit samples to determine Total Organic Content (TOC) and Total Suspended Solids (TSS). The TOC and TSS contents were much lower for the pumped samples than the bailed samples. It was determined that the higher concentrations reflected the heavier and relatively inert particulates found in the bed load of the channel bottom flow—a situation that did not appear to present any performance issues for the proposed unit.

In April 2005, before finalizing the design of the new grit system, the manufacturer carried out the pre-fabrication factory testing of the proposed unit at the company's hydraulics testing facility in Portland, ME. The factory testing, which was independently witnessed by the engineer, showed that the proposed unit would remove up to 99.61 percent of the 106-micron particles of the MCAS Cherry Point grit at an instantaneous peak flow of 7.32 mgd—meeting the performance specifications.

Preliminary Report

In May 2005, the engineer submitted its preliminary engineering report to the client. The report summarized the findings of the preliminary engineering evaluation and concluded that the 14-ft unit would be a suitable replacement grit removal system for MCAS Cherry Point Pump Station 4259. MCAS Cherry Point reviewed the report and concurred with its findings. The final engineering report, design, and specifications were submitted by September 2005, and construction of the new grit removal facilities began in early 2006.

The installation required integrating the new equipment into the existing flow line to the pump station. The contractor was challenged by having to work with the existing flow gradation through the influent headworks. In order to insert the separator into the existing flow line, the contractor had to construct a new 14-ft diameter cylindrical concrete vessel five ft lower than the surrounding structure. The cylindrical vault would serve as the new wet well for the unit.

Once the new concrete cylinder was installed, it was tied into the existing flow channel system. The internal components had been removed from the former paddle wheel-type grit removal system, which allowed the contractor to use the empty chamber as flow channel.

The contractor was able to use the empty chamber of the former grit removal system once all the components had been removed.

The contractor poured concrete into the chamber to create a weir wall to separate the chamber into a front half and a back half. The weir wall would divert wastewater flows entering the front half of the chamber to the separator inlet pipe. The degritted overflow (outlet) from the separator was returned to the back half of the chamber, where it would flow out of the chamber to the pumps at Pump Station 4259. In all, the concrete work took about five months to complete.

Although the concrete construction proved difficult, the contractor found the installation of the stainless steel internal components of the separator system quick and easy to install, completing the installation in one day. Construction on the project was completed in September 2006, and the newly installed grit chamber and its auxiliary equipment were started up without incident on October 17, 2006.

Immediately following the successful startup of the newly completed grit removal facilities, the engineer was challenged with creating a protocol for the field testing and performance evaluation of the grit removal system. The method of evaluating the grit removal system in the field had to be different that the method for evaluating the system in the factory. Under the protocols of the factory testing methodology, 100 percent of the grit chamber underflow was collected, dried, and analyzed. The total mass of grit captured in the underflow was then analyzed and compared to the total mass of grit fed into the influent stream during the testing process. This method could not be applied to the field unit. In the field, the captured grit is deposited on the base of the sump in the grit chamber and forced into suspension by water jets from the sparger ring component. This suspension creates concentrated grit slurry, which is pumped out of the grit removal vessel into a grit classifier using a submersible pump. Both the engineer and manufacturer concluded that it was unlikely that the submersible pump would pump out all of the grit captured in the sump of the unit during a given time period.

The grit slurry is pumped to a grit classifier, where organics are washed out of the grit slurry. This washing process can result in very fine grit particles getting conveyed back into the influent channel to the grit chamber. Said David Heiser, PE, of McKim & Creed: "The dewatered grit that is delivered by the classifier may be composed of several days worth of grit, and should not be taken as a representative sample of the grit recently entering the grit chamber."

Testing Protocol

To evaluate the performance of the grit removal system given the complications posed by the fluidizing line and the classification system, the engineer wrote a testing protocol in which the influent and effluent streams would be sampled for grit content above 100 microns. To be finally accepted, the new chamber had to prove that it could remove 95 percent or greater of the grit particles 100 microns and greater in size from raw sewage in an open channel. The 100-micron sugar sand is fine and difficult to remove. It is even more difficult to sample from open channel flows. It was determined that a large amount of feed sand should be introduced to the channel, upstream of the chamber, and that during the test samples should be taken both upstream and downstream of the unit. These samples were then decanted, fully dried in a furnace to burn off all organics, and analyzed for volume and gradation of the sand particles. The engineer recommended confidence limits of ten percent using this testing methodology, due to variability in the flow stream.

The final in-field performance testing of the grit chamber was conducted on November 29, 2006, by CCC, the engineer, and Hydro International representatives. The results showed the new grit chamber performed well above the required 95 percent removal of sediment 100 microns and greater. These results were obtained even without the expected five to ten percent limits of error, which could easily be realized with the method of sampling used for this testing.

As part of the design build contract, the general contractor is handling the operation and maintenance of the new grit removal system for the first year after start up. Feedback on the system's operation thus far has been positive. "There have been no repairs required since start-up," general contractor Marty Cieszko said. "We find that most rags or objects that get through the bar screen are removed by the Grit King as well as the sand. It is certainly meeting all of our expectations."

The maintenance crew at MCAS Cherry Point will take over maintenance of the system in October 2007. GE