

THE DATA ACQUISITION SYSTEM AND INSPECTION EQUIPMENT ON VIBRATION EVALUATION FOR DEIONIZED AND COOLING WATER PUMPS IN TPS *

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Abstract

The purpose of this paper is to evaluate the vibration amplitude and spectrum for TPS water pump systems. The utility systems operate continuously since 2014, some of deionized and cooling water pumps produced higher vibration amplitude and noise during operation. The possibly reason could be poor system accuracy, inappropriate installation and commission adjustment. The data acquisition system on vibration evaluation for deionizes water pumps was established in 2016. According to the long-term vibration amplitude recording, the system operational status could be clarified. After vibration test for several months, the bearing of booster deionized water pump was found abrasive since coupling between motor and pump misaligned. Besides, the foundation of copper deionized water pump system was broken and observed by rapidly increase vibration amplitude in short term. The water pump systems were repaired and maintained base on vibration evaluation. There is still some remain problems for deionized and cooling water pump systems. The utility systems could prevent malfunction through regular vibration inspection and daily data acquisition.

portant way to preventive maintenance for utility systems. The rotational utility systems could prevent malfunction through regular vibration inspection.

INTERNATIONAL VIBRATION STANDARDS - ISO 10816

The ISO 10816 vibration standard released in 1995 and amended in 2009 specified in Table 1. The standards describe vibration amplitude measured in situ for industrial machines with power above 15 kW and rotation speeds between 120 to 1500 rpm. The frequency range of vibration measurement is from 10~1000 Hz when machine operate over 600 rpm.

The power of TPS BO and CU DIW pump systems were 160 kW and 200 kW respectively. The maximum rotation speed is 1750 rpm with 379.5 m³/h flow rate and the lift head of motor is 115.82 m for CU DIW pump system. The foundations are flexible type with damping spring support. According to vibration standards, the vibration amplitude tested in any location in irrotational point exceed 11.2 mm/s means system damage

Table 1: ISO 10816 Vibration Standards

ISO 10816	Part 3: Industrial machines with normal power above 15 kW and nominal speeds between 120 r/min and 15000 r/min when measured in situ			
	Group 1		Group 2	
Machine type	Large machines 300kW<P<50MW		Medium sized machines 15kW<P<300 kW	
Velocity mm/s rms	Motor H > 315 mm		Motor 160 < H < 315mm	
Foundati on	flexible	rigid	flexible	rigid
>11.2		D		
11.2				
7.1		C		
4.5				
3.5		B		
2.8				
2.3				
1.4		A		
A: Newly commissioned machines B: Unrestricted long term operation C: Restricted long term operation D: Vibration causing damage				

INTRODUCTION

The Taiwan Photon Source (TPS) utility systems already operate continuously over three years. The rotational machine includes motors, pumps, chillers and air handling unit (AHU) needed to operate sustained without any break. In order to provide synchrotron accelerator operation requirement, the whole utility systems needed to be keep stable. The vibration inspection become one method to preventive maintenance [1]. In 2004, ANL [2] studied the mechanical vibration control systems and the specifications for all rotational facilities. In 2007, the investigation of Taiwan Light Source (TLS) on water induced vibration and vibration propagation by piping system also be studied [3]. The ISO 10816 established vibration standards on industrial machines with normal power above 15 kW and nominal speeds between 120 to 15000 rpm when measured in situ [4]. According to the experience from TLS, the vibration amplitude and spectrum for the TPS utility systems can also be applied the same criterion. After vibration measurement, some of the booster (BO) and copper (CU) deionized water (DIW) pump systems generate higher vibration amplitude and exceed ISO 10816 standards [5]. The unqualified DIW system is maintained and periodical vibration test is still one im-

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VIBRATION MEASUREMENT POSITIONS FOR MOTORS AND PUMPS

The BO and CU DIW pump systems used horizontal split-coupled end suction pumps and the power energy supplied from motor to pump by coupling. The alignment and accuracy of coupling between motor and pump could affect the status of the system. In order to verify the detail of pump system vibration status, the vibration test for each system in 4 different section in three directions is specified in Fig. 1.

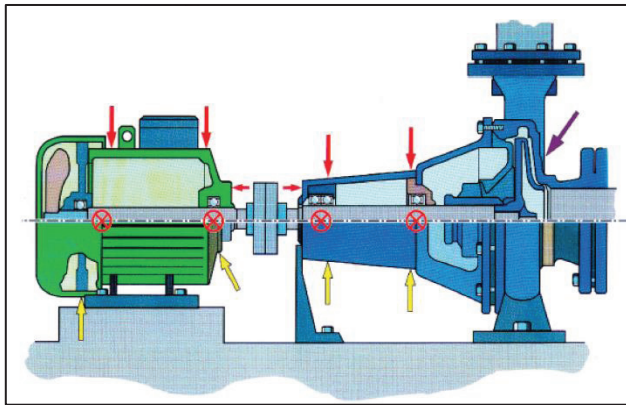


Figure 1: Vibration test locations.

Base on over one year inspection, the positions of the vibration measurement were 45° direction in non-drive end and vertical, horizontal and axial directions in drive-end of motor. It could demonstrate the motor whether stable, coupling abrasion and status of coupling alignment. In addition, the positions of pump vibration measurement are vertical, horizontal and axial directions in drive-end of pump. For maintain temperature fixed, the non-drive end of pumps was covered insulation materials, the non-drive end of pumps could not be measured.

VIBRATION MEASUREMENT RESULTS

The vibration inspection system (Pheonix Pacer) was built in the beginning of 2016. The system recorded vibration raw data for every test point and analysed frequency spectrum. According to the operation status, the vibration amplitude for all DIW pump systems were measured about every two weeks. The total frequency band from 10 to 1000 Hz vibration accelerator and velocity were measured, and the main operational frequency 15~40 Hz velocity was also recorded. The purpose of total vibration measurement is for ISO 10816 comparison and the operational frequency is for clarify the pump system condition. The difference between total and operational frequency vibration amplitude display the status of motor, bearing, coupling and pumping blade, whether the mechanical parts are abrasion or damage.

Copper (CU) Deionized Water System

The two motor systems DIWP-CU-1 and DIWP-CU-2 operated redundantly for CU deionized water supply in TPS. The motors of these two system are 270 hp (200

kW) with 380 V-3 phase electrical drive. The maximum rotation speed is 1750 rpm with 1670 GPM (379.5 m³/h) flow rate. The lift head of motor is 380 ft (115.82 m). Mechanical engineer recorded 7 different location for every pump system by vibration inspection system.

DIWP-CU-1 Vibration Test Results

Figure 2 showed the total vertical vibration velocity amplitude for DIWP-CU-1 in the drive-end of motor. The vibration inspection system started to operate from March 3, 2016, and regular inspection were conducted for about every 2 weeks. The vibration amplitude increased rapidly from April 2016. After DIW pump system operated continuously over one month, the vibration amplitude rapid increased over 10 mm/s approach damage amplitude.

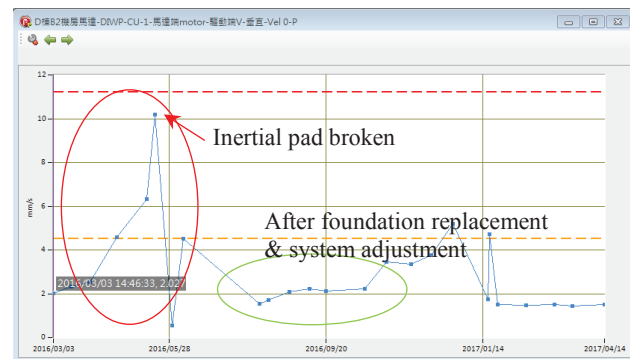


Figure 2: Vibration test for DIWP-CU-1 deionized water systems. (Vertical direction for drive-end of motor).

Figure 3 showed the total horizontal vibration velocity amplitude for DIWP-CU-1 in the drive-end of pump. The vibration amplitude also increased rapidly from April 2016, and the total vibration amplitude exceeded 26 mm/s much higher than ISO 10816 system damage amplitude. The foundation of DIWP-CU-1 pump system was found fracture through the middle of whole concrete base in May 17, 2016. The change of vibration amplitudes in different location gave clues that the pump system going to crash in some aspect. The vibration inspection could complete preventive maintenance in this case, and provide enough time (over 4 weeks) to shut down and repair pump system which is under abnormal condition.

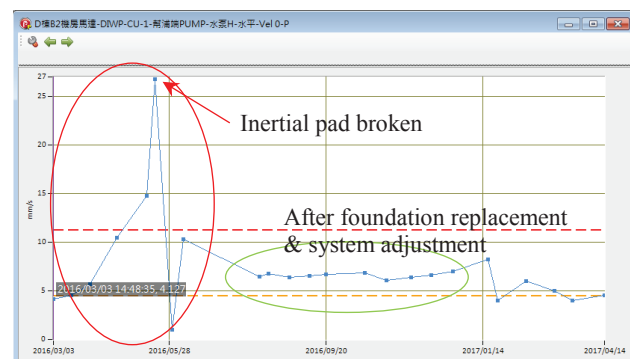


Figure 3: Vibration test for DIWP-CU-1 deionized water systems. (Horizontal direction for drive-end of pump).

DIWP-CU-1 INERTIAL PAD REPLACEMENT

Because the foundation of DIWP-CU-1 DIW pump system was broken through the middle of inertial pad, the new designed of inertial pad is needed. Figure 4 showed the fracture status of the original foundation. The apparently fracture in the middle of the inertial pad caused by poor structure design and unbalance of motor-pump system. The high vibration amplitude shown in Fig. 2 and Fig. 3 indicated the motor and pump operate separately because of broken inertial pad. The coupling of the system was dislocation and in very danger situation.

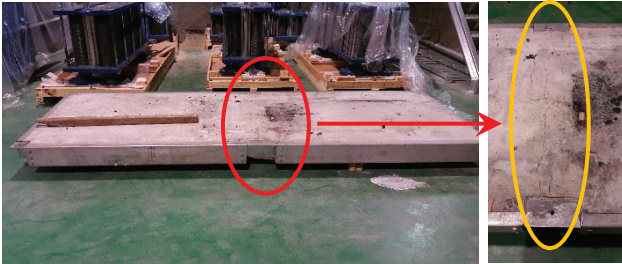


Figure 4: Original foundation for DIWP-CU-1 DIW pump system. (Broken inertial pad).

Figure 5 showed the status of DIWP-CU-1 DIW pump system after replacing new designed inertial pad. The new designed inertial pad strengthens the structure in the middle and move the damping spring to the outside. Thus, the length and width of inertial pad form a complete cuboid. Besides, the altitude and horizontal amplitude for motor and pump readjusted. The support in the end of pump was also changed to adjustable type in order to reduce the lift force from water pressure in pump end. After foundation replacement works, the coupling realignment and flexible joints adjustment were implement before operation.

The green area shown in Fig. 2 and Fig. 3 indicated the vibration amplitude after new inertial pad replacement and system readjustment. The total vibration in different locations reduced dramatically. The DIWP-CU-1 DIW pump system operate normally for recent few months.

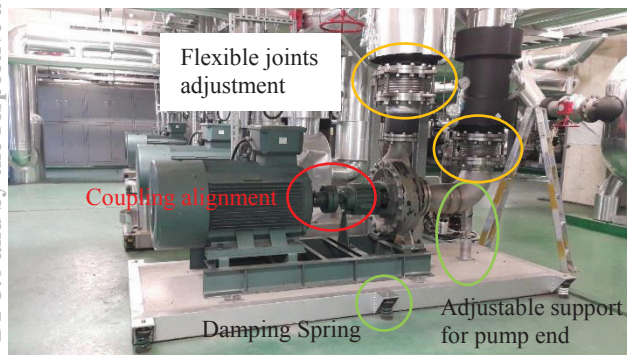


Figure 5: New designed foundation for DIWP-CU-1 DIW pump system. (Coupling alignment and system adjustment).

CONCLUSIONS AND DISCUSSIONS

The vibration inspection system for DIW pump systems was established and operated over one year. The measurement results give all kinds of message about the system status. In the case of inertial pad fracture, the vibration inspection system supplied many information from vibration amplitude and frequency change. It also provides sufficient time for operators to maintain the system in advance.

There are still some remaining problems for deionized and cooling water pump systems. The utility systems could prevent malfunction through regular vibration inspection and daily data acquisition.

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