VIBRATION EVALUATION FOR DEIONIZED WATER PUMPS IN TPS*

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Abstract

The purpose of this paper is to evaluate the vibration level and spectrum for TPS deionized water pumps. The utility systems started to operate from the beginning of 2014, some of deionized water pumps produced higher vibration and noise level during operation. The possible reason could be inappropriate installation and commission adjustment. In order to figure out the status of these deionized water motors and pumps, the vibration analysis was tested. After vibration measurement, some of the booster (BO) and copper (CU) deionized water pump systems generate higher vibration level and exceed ISO 10816 standards. According to the vibration test results, the unqualified motor system is maintained. Although there is some remain problems for TPS deionized water pump systems, the periodical vibration test is still one important way to preventive maintenance for utility systems. The rotational utility systems could prevent malfunction through regular vibration inspection.

INTRODUCTION

The TPS utility systems started to operate from the beginning of 2014, before TPS commission started. In order to provide accelerator test requirement, the whole utility systems needed to be keep stable operation. 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, TLS has also investigated on water induced vibration and vibration propagation by piping system [3]. According to the experience from TLS, the vibration amplitude and spectrum for the TPS utility systems also can be applied the similar criterion.

TPS LAYOUT OF DEIONIZED WATER SYSTEMS

The main utility system is located in B2 floor of activity center (D building) and the main power station via water/AHU system located in different area. There are several subsystems in utility area, chiller, cooling and deionized water systems, for instance. Because of most of the utility system are rotational machine and needed 24-hour operation, the maintenance for whole system require lot of manpower and money. The prevention maintenance therefore could be one way to increase stability of the whole system.

The layout of deionized water systems are shown in Fig. 1. There are two booster (BO), two copper (CU), two aluminium (AL), and two RF deionized water pump systems from the right to left respectively. Each deionized pumping system pump deionized cooling water directly to the subsystems in the tunnel. The BO deionized water system provide cooling water for magnets and other elements in booster ring. The CU deionized water system provide cooling water for magnets and AL system supply cooling water for vacuum chambers in storage ring. The RF deionized water system supply cooling water to both SR/BR RF system. There are two motors for every subsystem is for redundant operation. In among them, the BO, CU and RF system use horizontal split-coupled end suction pumps type. The AL system use vertical split-coupled in-line pumps type.

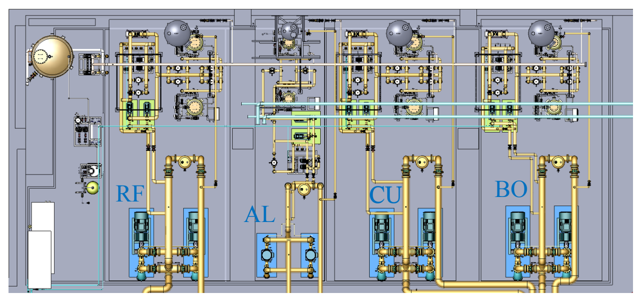

Figure 1: Layout of TPS deionized water systems.

TEST POINTS FOR MOTOR AND PUMP VIBRATION MEASUREMENT

The motor energy provide pump to increase water pressure by coupling. The BO, CU and RF system use horizontal split-coupled end suction pumps. The alignment of coupling between motor and pump could affect the stability of the system. Besides, for energy saving, all the motors are variable frequency drive. The variable frequency drive motor also could affect vibration frequency and amplitude. In order to verify the vibration status, the vibration test for each system in 4 different section is specified in Table 1.

Table 1: Vibration Test Points

Motor	Motor Non-Drive-End (MO)	V-vertical H-horizontal
	Motor Drive-End (MI)	V-vertical H-horizontal A-axial
Pump	Pump Drive-end (PI)	V- vertical H- horizontal A-axial
	Pump Non-Drive End (PO)	V- vertical H- horizontal

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The position of the vibration measurement location was illustrated in Fig. 2. The vertical and horizontal vibration level were tested in non-drive end of motor (MO). The vertical, horizontal and axial vibration level were tested in drive end of motor (MI). On the other hand, the vertical, horizontal and axial vibration level were tested in drive end of pump (PI). And the vertical and horizontal vibration level were tested in non-drive end of pump (PO).

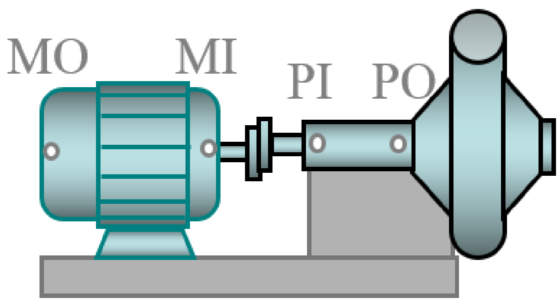

Figure 2: Vibration Test Locations.

VIBRATION MEASUREMENT RESULTS

According to the operation status, the BO, CU and RF pumping systems were tested. Base on the ISO 10816 standards [4], the frequency from 10~1000 Hz and 20~40 Hz velocity vibration level were recorded.

Booster (BO) Deionized Water System

There are two motor system for redundant operation, which are mark for DIWP-BO-1and DIWP-BO-2 respectively (see Fig. 3). The motor is 215 hp (160 kW) with 380 V-3 phase electrical drive. The maximum rotation speed is 1750 rpm with 1285 GPM (292.0 m^3/h) flow rate. The lift head of motor is 380 ft (115.82 m).

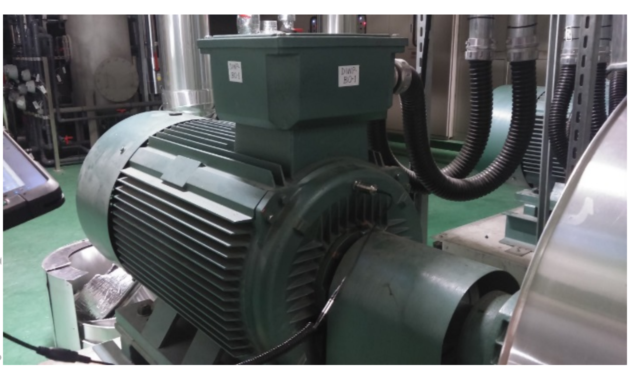

Figure 3: DIWP-BO-1 deionized water systems.

The experimental results are shown in Table 2. According ISO 10816 standards, the vibration velocity below 1.8 mm/s is good. The vibration velocity between 1.8 to 4.5 mm/s is allowable, and between 4.5 to 11.2 mm/s is tolerable. While the vibration velocity is exceeded 11.2 mm/s, the motor/pump system is under not permissible condition.

Table 2: Vibration Test for BO DIW System

Vibration level	0-P(mm/s)	RPM(mm/s)
	10-1000 Hz	20-40 Hz
DIWP-BO-1		
MO: V	7.7000	0.4724
MO: H	16.2800	0.9832
MI: V	1.5500	0.9204
MI: H	3.1380	2.7830
MI: A	1.6380	1.0110
PI: V	2.8030	0.9262
PI: H	6.3050	1.5110
PI: A	2.1130	0.4881
PO: V	2.3670	0.7441
PO: H	4.5330	1.1300
DIWP-BO-2		
MO: V	5.5690	0.7853
MO: H	19.3400	1.6570
MI: V	1.6320	1.3020
MI: H	2.2370	1.4300
MI: A	1.3410	0.7757
PI: V	2.1000	0.9556
PI: H	4.8740	2.5020
PI: A	1.8020	0.8599
PO: V	1.6290	0.6568
PO: H	3.3710	1.8360

From the experimental results, some of the vibration amplitude of BO deionized water system were quite high. The vibration amplitude is higher in frequency range between 10 to 1000 Hz. This indicated the part of motor for instance bearing is abrasion. The high frequency vibration not only multi-drive frequency, even higher than 80 Hz and hundreds frequency vibration contribute the total vibration magnitude of BO deionized water system.

Copper (CU) Deionized Water System

The two motor system for CU deionized water system are marked for DIWP-CU-1and DIWP-CU-2 respectively. The motor is 270 hp (200 kW) with 380 V-3 phase electrical drive. The maximum rotation speed is 1750 rpm with 1670 GPM (379.5 m^3/h)flow rate. The lift head of motor is 380 ft (115.82 m).

The experimental results are shown in Table 3. Some of the vibration amplitude of CU deionized water system were also high. The vibration amplitude is also higher in frequency range between 10 to 1000 Hz. Although the power of CU system is higher than BO system, the total vibration amplitude is lower than BO DIW system. Only some of the DIWP-CU-1 deionized water system needed to be checking.

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Table 3: Vibration Test for CU DIW System

Vibration level	0-P(mm/s)	RPM(mm/s)
	10-1000 Hz	20-40 Hz
DIWP-CU-1		
MO: V	7.8080	0.8369
MO: H	7.7850	0.7068
MI: V	1.3660	0.9354
MI: H	1.2240	0.3404
MI: A	2.0700	1.7000
PI: V	2.7490	0.8530
PI: H	4.5260	2.6850
PI: A	2.5170	0.2887
PO: V	2.7170	0.8946
PO: H	3.3920	2.0970
DIWP-CU-2		
MO: V	8.3080	0.6793
MO: H	18.6400	0.2780
MI: V	1.2800	0.6635
MI: H	4.1140	1.2800
MI: A	3.9950	1.2630
PI: V	1.8690	0.5609
PI: H	2.9770	1.0120
PI: A	1.1880	0.2225
PO: V	1.5900	0.4880
PO: H	2.3100	0.7994

RF Deionized Water System

The two motor system for RF deionized water system are marked for DIWP-RF-1and DIWP-RF-2. The size of motor is the same with CU DIW system. The vibration amplitude of RF DIW system is under allowable level. The only thing to do with RF DIW system is remain regular checking. The RF DIW system is under normal operation.

MAINTAIN AND REPAIRMENT

Base on the vibration measurement, the DIWP-BO-1 DIW system generated highest vibration level under normal operation. According ISO 10816 standard, the vibration amplitude is almost reach not permissible. In order to preserve long term operation, utility group request motor supplier to maintain the system.

Figure 4 shows the repair process of motor system. The whole motor is disassembled and replace the new bearing. For alignment requirement, the elastic base was also welding adjust screw block to micro adjustment. After system repair and laser alignment with coupling, the vibration level drop dramatically. For long-term operation, the system still need to be regular checking.

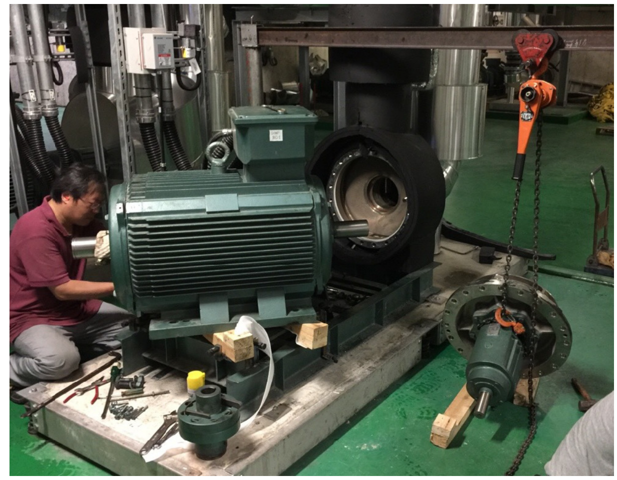

Figure 4: Maintain for DIWP-BO-1 DIW system.

CONCLUSIONS AND DISCUSSIONS

The evaluation of vibration amplitude and spectrum for TPS deionized water pump system was done. Some of deionized water pumps produced higher vibration and noise level during operation.

The booster (BO) and copper (CU) deionized water systems generate higher vibration amplitude and exceed ISO 10816 standards. The unqualified motor system is maintained.

Although there is some remain problems for TPS deionized water pump systems, the periodical vibration test is still one important way to preventive maintenance for utility systems. The rotational utility systems could prevent malfunction through regular vibration inspection.

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