

Technical report

Development of High Pressure Steam Cleaning Jet Test Equipment Compliant with International Protection Code (IPX9K)

Hiroyuki ENOKI, Satoru YAMAUCHI, Makoto YANAI, Hirokazu TANAKA
Development Headquarters, ESPEC CORP.

1. Introduction

One of the issues we have today concerning reliability of electronic equipment in operating environment is protective structure of electrical equipment's enclosure. In particular, with high-density onboard board, ingress of water into the enclosure is critical in view of its reliability.

To simulate watery environment, a test equipment unit compliant with IPX9K (High pressure steam cleaning, ISO20653/JIS D 5020) combining a temperature chamber and a high pressure injection module is developed and this document reports the various verifications that have been conducted.

The content of this document is based on rearrangement and some additions to the presentation given at the 30th Annual Conference of the Japan Institute of Electronics Packaging.

2. IP test standard

IP stands for International Protection and is standardized. Purpose of the IP test is to grade protection structure with an enclosure of electronic equipment specified in "JIS D 5020 Automotive parts -- Degrees of protection (IP Code) -- Protection of electrical equipment against foreign objects, water and access" and "JIS C 0920 Degrees of protection provided by enclosures of electronic equipment (IP Code)".

Protection codes and their names are shown in Table 1. The first digit of the code after "IP" indicates solid particle protection and the second digit indicates liquid ingress protection. To show liquid ingress only, it is expressed, for example, as "IPX9K". In particular, for onboard IP test, "K" (complementary code) is added after the second digit.

Table 1. IP protection code (water proof) and name

Protection Code	Name of the Standard
IPX1、IPX2	Dripping water
IPX3、IPX4、IPX4K	Spraying, splashing, pressurized splashing water
IPX5、IPX6、IPX6K	Water jets, powerful water jets, pressurized powerful water jets
IPX7、IPX8	Immersion, submersion
IPX9K	High-pressure/steam-jet cleaning

3. Test equipment and performance evaluation

3.1 IPX9K test equipment

Based on the IPX9K standard, a test equipment unit with specifications in Table 2 is developed.

Table 2. Major development specifications

Conforming standard	ISO20653/JIS D 5020 (High pressure steam cleaning jet IPX9K test)
Technology	High temp water jet for 30 sec each from the 4 nozzles
Water temperature	80 ±5°C
Water flow rate	14 to 16 l/min
Water pressure	8 to 10 MPa
Jet angle	0, 30, 60, 90°
Specimen rotation	5 ±1 rpm

This equipment unit has the following capabilities: (1) Temperature control of the test environment (10 to 100°C), (2) Recording of test conditions (chamber temp., water temp., flow rate, and water pressure), (3) Quantification of jet impact force, and (4) Tests in energized conditions.

Configuration diagram of the developed equipment is shown in Figure 1, and exterior view of the high pressure steam nozzle and the specimen rotator are shown in Figure 2.

The developed equipment unit has measurement and recording functions such as pressure gauge, flow meter, temp sensor for chamber air measurement, water temp sensor, and recorder in addition to the test chamber, pump and 4 nozzles.

During the test, high pressure water is injected to a specimen at certain intervals by adjusting the valves of the 4 nozzles.

The specimen is placed on the rotating table and rotated at certain intervals to check water ingress protection at each part of the enclosure (specimen).

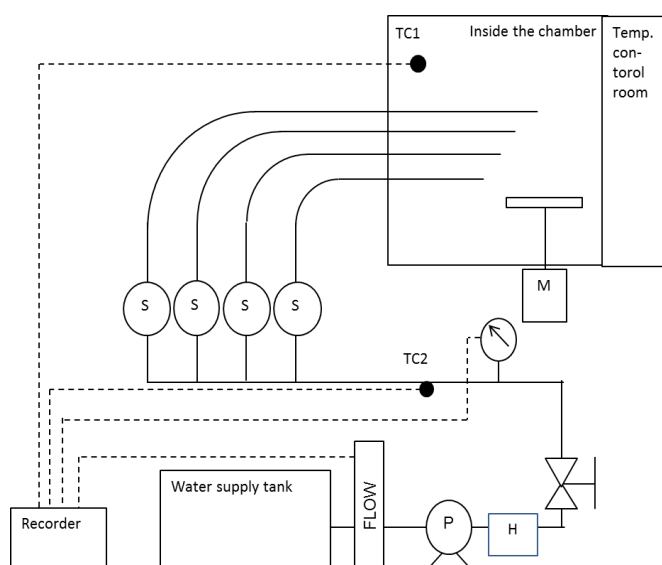


Figure 1. Configuration diagram of the developed equipment



Figure 2. High pressure steam nozzles and the specimen rotator

3.2 Evaluation method

Various experiments have been conducted to check the performance and functions of the developed equipment unit.

(1) Water pressure-flow rate performance

The relation between pressure of high pressure water and flow rate is confirmed so that the equipment specifications can meet the standard.

ESPEC Technical Information

The evaluation method is as follows: Read values on the pressure gauge attached on the nozzle head. Collect water ejected from the nozzle to understand the amount, and read the flowmeter.

(2) Capability of recording test conditions

Because records of water pressure, flow rate, water temperature, and chamber temperature will be important evidences in test result report, evaluation is made to see if reliable recording is possible.

Measurement is made in two conditions (condition (1): water temp. $80 \pm 5^\circ\text{C}$, chamber temp. $23 \pm 5^\circ\text{C}$, and condition (2): water temp. left to the course of nature, chamber temp. 80°C).

Purpose of these conditions is to simulate the phenomena where inside of the enclosure shows positive pressure by sudden injection of 80°C water in the condition (1), and negative pressure by injection of normal temperature water inside the chamber at 80°C in the condition (2).

(3) Quantification of jet impact force

Because the water jet from the nozzle is so powerful that sealing part of the enclosure may be broken, quantification of the impact force is critical. This time, load cell is used to investigate the jet impact force.

4. Results and discussion

4.1 Water pressure-flow rate performance

Measurement results of water pressure and flow rate are shown in Figure 3. It indicates that tests beyond the scope of the standard as well as those within the scope are possible.

As the trend is toward tougher tests, we believe that this equipment unit is useful for tests at a water pressure and a flow rate more than the values specified in the standard.

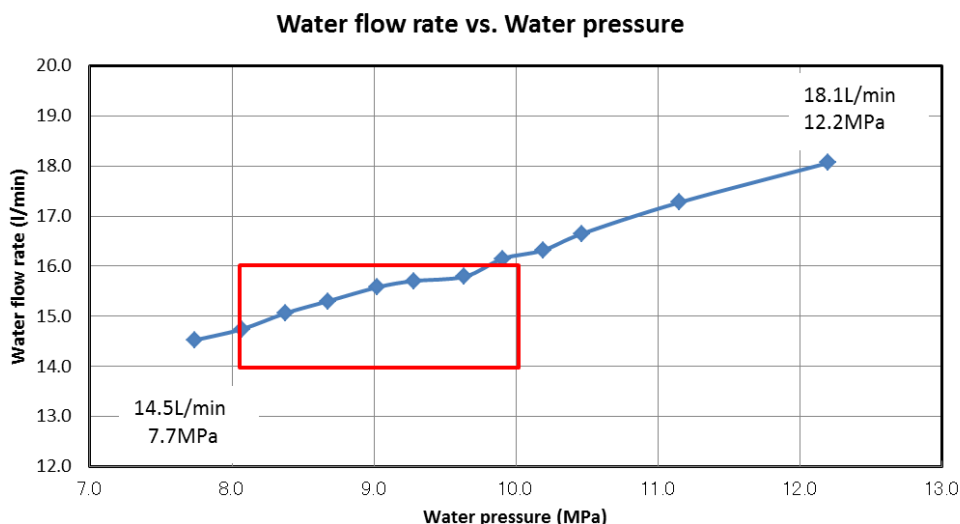


Figure 3. Evaluation results of flow rate vs. water pressure

4.2 Recording test conditions

Measurement results for condition (1) (water temp. $80 \pm 5^{\circ}\text{C}$), and condition (2) (chamber temp. 80°C) are shown in Figure 4 and 5, respectively. In both conditions, verification has been made that water pressure and flow rate compliant with the standard can be recorded.

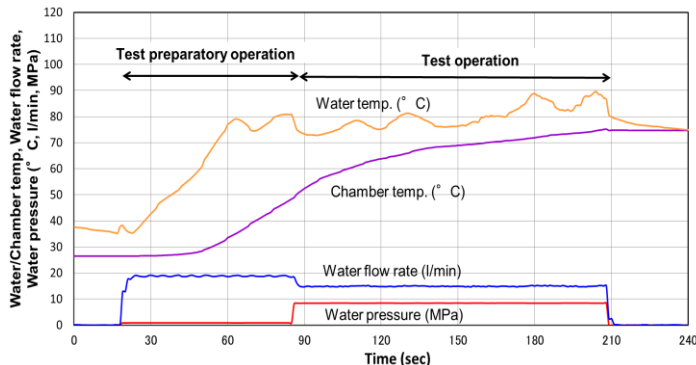


Figure 4. Test condition recording ((1): water temp. $80 \pm 5^{\circ}\text{C}$)

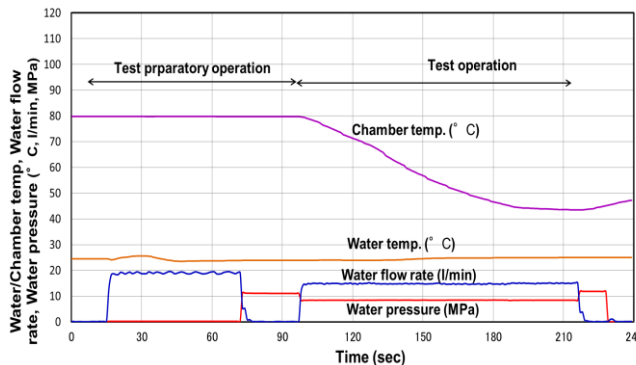


Figure 5. Test condition recording ((2): chamber temp. 80°C)

From the above, by combining with a temperature chamber, various situations that may occur in the field will become testable.

In conventional tests, it is common to take photos of specimen before and after tests. This time, it becomes possible to monitor all sorts of conditions and to keep their records. Keeping test history is very effective as evidences of test results and for test reproduction.

4.3 Quantification of jet impact force

As shown in Figure 6, measurement of jet impact force injected from the nozzle becomes possible. The impact force is high at the center of the nozzle and decreases toward the edge of the nozzle.

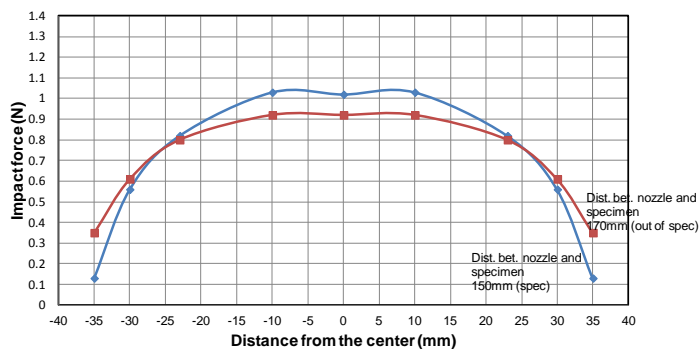


Figure 6. Result of jet impact force measurement

5. Summary

We have developed a test equipment unit compliant with IPX9K (High pressure steam cleaning, ISO20653/JIS D 5020) and verified that recording of the equipment performance and test conditions as well as measurement of the jet impact force of water is possible.

From the above, a highly reproducible test equipment unit for high pressure steam cleaning jet (IPX9K) has been developed that can perform not only standards compliance tests but also tests closer to real environment.