Implementation for the safety of the DIAC cooling system during the experiment

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1. Introduction

The Daejeon ion accelerator complex (DIAC) is being constructed to meet demands for heavy ion beams. A facility for cooling the DIAC system was installed in 2014 as part of the construction. The cooling facility consists of primary and secondary water cooling circuit and the dedicated control panel. For the installation of the primary circuit, system transferred from the Tokai radioactive ion accelerator complex (TRIAC) in Japan was utilized. The secondary circuit and cooling facility related programmable logic controller (PLC) based control panel were newly built. Although the DIAC cooling system is in a stable state, there is a need for method to ensure that it is operating normally. Using the information provided by the various sensors and the status of the actuators, the cooling system can be operated in one of the predefined states. The operator can recognize the problem and change the state of the cooling system when the cooling system is out of the predefined state. That is, it is possible for the operator to check the status of the cooling system only when necessary.

This paper describes the introduction of the Experimental physics and industrial control system (EPICS) based DIAC cooling system and how to implement it so that the DIAC cooling system can operate safely during the experiment.

2. Status of DIAC Cooling System

Table 1 shows the primary cooling facilities that have been transferred in Japan. In addition, cooling tower and chiller were installed outdoors, and pumps were installed so that they could supply the cooled water to the primary cooling facilities.

Table 1: Transferred Circulator from TRIAC

name	L×W×H(m)	EA	Weight(t)	Remarks
circulator of pure water for RF Power	0.90x2.00x1.60	1	1	C4
circulator of pure water for measurement magnet	0.90x2.00x1.60	1	1	C1
circulator of pure water for scRFQ and IH cavity	1.5x4.2x2.3	1	2.3	C3,C6
circulator of pure water for accelator magnet	0.90x2.00x1.60	1	1	C5
circulator of pure water for charge breeder	0.90x2.00x1.60	1	1	C2
circulator of ordinary water for IH cavity	1.5x3.6x2.15	1	1.65	C7,C8

2.1 Control system of DIAC Cooling System

To increase reproducibility and stability for the beam experiment, all of the control system for the DIAC will be upgraded to the Experimental Physics and Industrial Control System (EPICS) based accelerator control system[1].

The newly installed cooling facility, such as pumps and chiller, can be controlled via Ether-IP communication using PLC. Multiple sensors and inverters were installed for various reasons, which made it easier to operate and monitor remotely. Table 2 shows the sensor and driver information that can be remotely monitored and manipulated at present. And Fig. 1 shows the monitoring information for the DIAC cooling system through the Control System Studio (CSS).

Table 2: Function List of DIAC cooling system

name	Function	Remarks
Chiller	refrigerator	485 Communication
TT-201	Temperature	Sensor
TT-202	Temperature	Sensor
TWP-201	Pump Control	Actuator
TWP-202	Pump Control	Actuator
TNK-201	Level Status	Sensor
PT-201	Pressure	Sensor
FT-201	Flow	Sensor
CTF-301 Start	Cooling Fan	485 Communication
TT-301	Temperature	Sensor
TT-302	Temperature	Sensor
TWP-301	Pump Control	Actuator
TWP-302	Pump Control	Actuator
PT-301	Pressure	Sensor
FT-301	Flow	Sensor
CV-301	Valve Cotnrol	Actuator
RTD-01	Temperature	Sensor
RTD-02	Temperature	Sensor
RTD-04	Temperature	Sensor
RTD-05	Temperature	Sensor
C01 Ready or Not	Circulator Status	Sensor
C01 Run or Stop	Pump Control	485 Communication
C02 Ready or Not	Circulator Status	Sensor
C02 Run or Stop	Pump Control	485 Communication
C04 Ready or Not	Circulator Status	Sensor
C04 Run or Stop	Pump Control	485 Communication
C05 Ready or Not	Circulator Status	Sensor
C05 Run or Stop	Pump Control	485 Communication

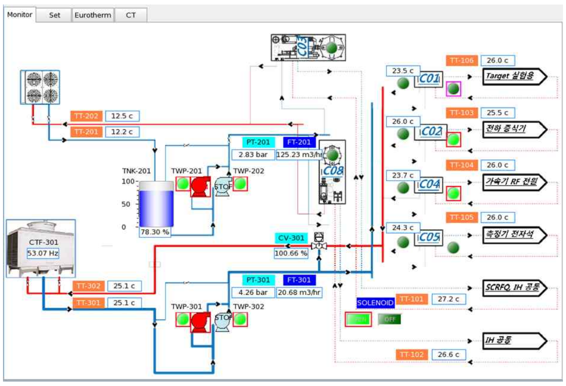

Fig. 1. Monitoring Tab for DIAC cooling system

Fig. 2 shows the operating part of the pump and cooling tower. It also shows the current applied to the pump and the rpm of the cooling tower fan, and can set the alarm limit of the flow rate or pressure.

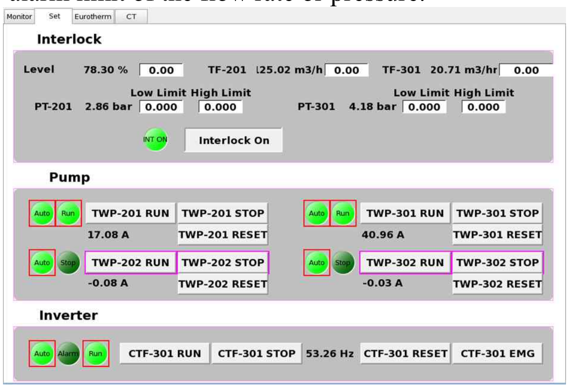

Fig. 2. Setting Tab for DIAC cooling system

2.2 State Transition of DIAC cooling system

The DIAC cooling system can be defined by a finite number of states, transitions between those states, and actions within each state such as Fig. 3[2].

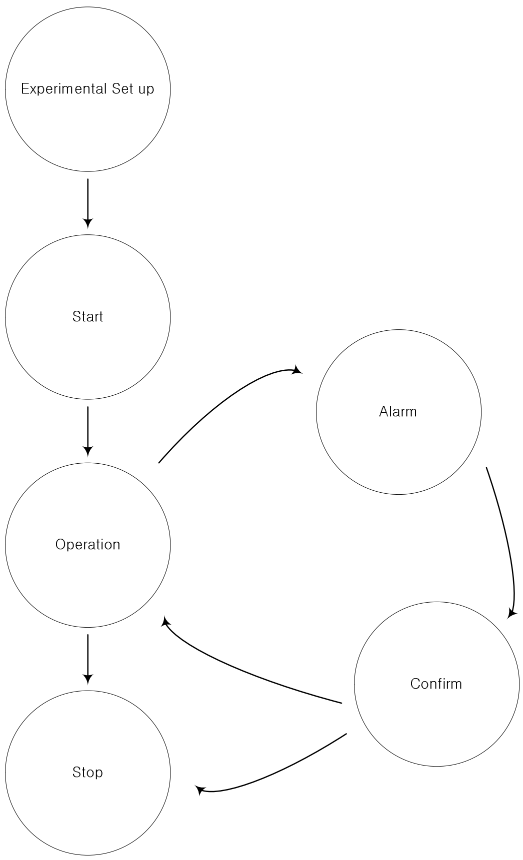

Fig. 3. State transition diagram of the DIAC cooling System

As shown in Table 1, among the six circulators, in state 1, the operator can select of the circulator to be used in the experimental and this state is called the “experimental set up” state. State 2 is the “Start” state. When the operator selects it, the circulator and its related facilities selected in State 1 are started collectively. When the time and conditions are satisfied, “Operation” state is entered.

State 3 is the “Operation” state and is normal operation state. If a serious event such as stop of selected facility occurs or a minor event such as occurrence of alarm limit in this state, the state transits into “Alarm” state so that the operator can recognize it through a speaker and a display. If the operator does not acknowledge, the state persists in “Alarm” state. If he acknowledges, the state enters the “Confirm” state. When a common behavior pattern has been generated by multiple experiments, this state transition will also be automatically performed and recorded in the log.

At present, the detailed alarm limit value to be used as a condition is obtained through the operation of the cooling system such as Fig. 4, and the state transition diagram of Fig. 3 will be implemented through EPICS sequencer.

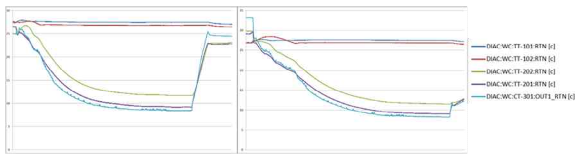

Fig. 4. Temperature monitor of cooling pipes according to chiller operation

3. Conclusions

The DIAC cooling system is made up of an EPICS-based control system. The control system of the DIAC cooling system will be improved to minimize the operator’s control, and if this is completed, we will be able to focus more on the DIAC beam experiment.

As a result of the study, we will identify sensors and actuators that need to be further automated and reflect them in our upcoming cooling system upgrades.

REFERENCES

[1] Anthony Andrews, Y. Kim, C. Eckman, P. Buaphad, T. Downer, C. O’Neill, B. Berls, K. Folkman, and J. Ralph, Epics Accelerator Control System for the IAC-RadiaBeam THz Project.

[2] Andrew J. Mason, State Machines: Brief Introduction to Sequencers.