A combustion safety solution compliant with the revised JIS B 8415

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Key words

Combustion safety, safety standard, revision of JIS B 8415, protective system

The JIS B 8415 safety standard, "General safety code for industrial combustion furnaces," was revised in 2020. The safety functions of industrial combustion furnaces must now constitute the protective system type of safety instrumented system. However, it is not easy to bring industrial furnaces into compliance with the revised JIS standard, and this has become a major issue for industrial furnace manufacturers.

In response, Azbil now provides a method of complying with the revised JIS in the form of a combustion safety solution consisting of products such as a burner controller, flame sensor, and automatic shut-off valve.

1. Introduction

An industrial furnace is a piece of equipment used to change the physical and chemical properties of materials such as iron and aluminum as desired by heating them. Since processed metal is used in objects all around us, such as automobiles and construction materials, industrial furnaces are indispensable for our daily lives.

On the other hand, since the heating process uses a large amount of energy, which may lead to a disaster in the event of an accident, safe operation is a must. Consequently, industrial furnace manufacturers design furnaces that conform to safety standards as one of the main measures to ensure safe operation.

2. Safety standards pertaining to industrial furnaces

2.1 Standards in Japan and abroad

JIS B 8415, *General safety code for industrial combustion furnaces* [1], is a Japanese safety standard established in 1982. It was revised in 2008 for the first time in 26 years to reflect safety criteria accommodating industrial furnaces with improved performance, and to ensure alignment with European and American standards (EN 746-2 [2], NFPA 86 [3]).

This revision made major changes from the point of view of safety, including the implementation of risk assessments on industrial furnaces, prohibition of programmable logic controllers (PLCs) performing safety functions (interlocks, etc.), prohibition of the use of relays in principle, requirement of redundant fuel safety shut-off valves, and of monitoring flames alone. It is still fresh in our memory that industrial furnace manufacturers and related device manufacturers were pressed to deal with the revision.

On the other hand, although there were regional safety standards overseas like the European EN standards and US UL standards, for a long time there were no safety standards under an international framework. For that reason, ISO/TC244,[1] which promotes international standardization pertaining to high-performance industrial furnaces, was established in 2008 with the encouragement of the Japan Industrial Furnace Manufacturers Association; and ISO 13577, the *Industrial furnaces and associated processing equipment - Safety* - series [4] began to appear in 2012.

2.2 Second revision of JIS B 8415

In 2020, JIS B 8415 was revised a second time to reflect the ISO 13577 series.

The relationship between the 2008 version of JIS B 8415 (hereinafter "the old JIS"), the 2020 version of JIS B 8415 ("the revised JIS"), and ISO 13577 is shown in table 1.

Table 1. Correspondence between the revised and old JIS standards and ISO standards

Old JIS	Revised JIS	ISO
JIS B 8415	JIS B 8415-1	ISO 13577-1
	JIS B 8415-2	ISO 13577-2
(None)	JIS B 8415-3	ISO 13577-4

1. An expert committee on industrial furnaces established by the ISO (https://www.iso.org/committee/561961.html).

The old JIS is covered by the revised JIS standards, but it was divided into JIS B 8415-1 and JIS B 8415-2 in an attempt to ensure alignment with the structure of ISO 13577.

JIS B 8415-1, *Part 1: General requirements*, provides almost the same requirements as the old JIS and does not include any major changes.

JIS B 8415-2, *Part 2: Combustion and fuel handling systems*, also covers the provisions in the old JIS, with some changes including new provisions and detailed specifications. The main change is the addition of a stipulation about safety functions requiring compliance with the functional requirements for protective systems.

The new JIS B 8415-3, *Part 3: Protective systems*, stipulates the requirements for protective systems, which are a new concept.

2.3 Protective systems

The protective system is not a completely new instrumentation system, but rather a new way of thinking about safety instrumentation such as existing circuits for control and operation.

The revised JIS defines a protective system as an "instrumentation system for performing one or more safety related instrumentation functions that is composed of sensors, logic solvers, and final elements." The combination of these three elements is also found in conventional instrumentation, so they are not new elements.

The revised JIS also requires that the process control system and the protective system be completely independent. This requirement ensures that any failure or malfunction in the control system will not affect the safety functions. The idea of isolating the control functions from the safety functions was also adopted for some safety functions in the old JIS, including the prohibition of software interlocks in general-purpose PLCs and restrictions on the shared use of a temperature controller (with a temperature detector) for control and as protection against furnace overheating.

Thus, the major changes are the requirements that devices that are compliant with relevant product standards for sensors, logic solvers, and final elements be used as shown in figure 1 or that devices with SIL[2] or PL[3] capabilities be used, and that the connection methods between devices have been defined.

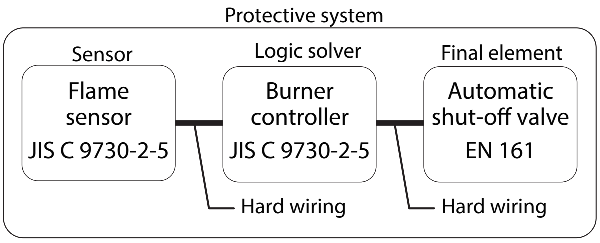

Fig. 1. Sample protective system configuration

2.4 How to construct a protective system

A protective system can be constructed by selecting from the four methods (A–D) show below and in figure 2.

- A: Compose the system of devices that are compliant with the relevant product standards
- B: As method A, plus the use of SIL/PL-capable components
- C: As method B, plus the use of an SIL/PL-compliant PLC and other devices
- D: Design a system that is fully compliant with functional safety standards

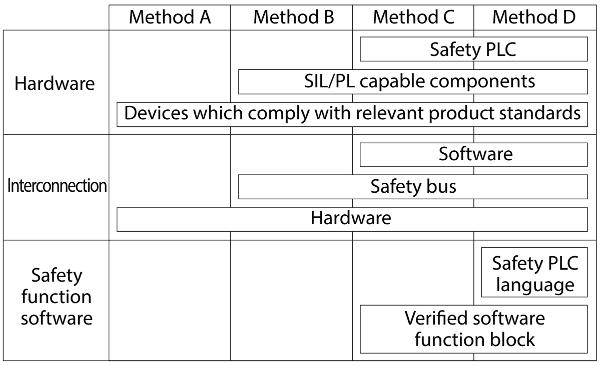

Fig. 2. Overview of methods

The simplest construction is method A, in which devices that are compliant with relevant product standards listed in the revised JIS are hardwired into the system. An instrumentation example described below uses method A.

Using SIL/PL-capable components that are not in compliance with the relevant product standards or using safety bus communication[4] for the connection between devices corresponds to method B, which requires risk analysis to determine the SIL required by the safety function.

Using a safety PLC[5] corresponds to method C, which requires safety design of application software to be implemented in the safety PLC.

Method D will not be discussed in this article.

3. Azbil's combustion safety solution

3.1 Lineup

One of the risks defined in the revised JIS is the risk of explosion. An explosion can be prevented by controlling at least one of the three elements of fuel, air, and ignition source. Since air is everywhere on earth, it can easily get into a furnace. In addition, an ignition source is present if a furnace is red hot from combustion, so that is also difficult to control. Azbil's combustion safety and control systems prevent explosion by controlling the fuel so that it does not build up in the furnace.

Our combustion safety and control systems, which comply with requirements for a protective system, consist of a flame sensor and gas pressure switch in the sensor section, a burner controller in the logic solver section, and automatic shut-off valves, etc., as the final elements. This equipment is compliant with the respective relevant product standards or SIL/PL.

2. Safety Integrity Level (SIL) is a scale that indicates system safety performance under JIS C 0508 [5].
3. Performance Level (PL) is a category describing the performance of the safety related sections of a system under JIS B 9705. [6]
4. A field bus system with a mechanism that can be used between safety devices, designed in accordance with JIS C 0508 or JIS C 9730-2-5. [7]
5. A PLC that has been certified by an accredited, nationally recognized testing laboratory organization and that is compliant with JIS Q 17025 [8], with a safety function corresponding to SIL 2 or SIL 3 in JIS C 0508-1.

Table 2. Product standards and SIL/PL compliance for Azbil products

Product	Relevant satisfied product standard and SIL/PL
Burner controller Model RX-L80/90 Model RX-R40/20 Model BC-R15/25/35	JIS C 9730-2-5 EN 298 SIL3
Burner controller Model AUR455	JIS C 9730-2-5 EN 298
Burner controller Model AUR255	JIS C 9730-2-5 EN 298 (pending)
Burner controller Model AUR890	JIS C 9730-2-5
Advanced ultraviolet flame detector Model AUD300C1000 Model AUD100/110/120	JIS C 9730-2-5*1 EN 298*1
High-performance gas solenoid valve for industrial applications Model GV-A_ _ _	EN 161 [9] SIL2 and PLd*2 SIL3 and PLe*3
Regulator with solenoid valve Model GV-D_ _ _ Model GV-G_ _ _ Model GV-H_ _ _	EN 161 EN 88-1 [10] EN 1854 [11] SIL2 and PLd*2 SIL3 and PLe*3
Gas pressure switch Model C6097A	JIS C 9730-2-6 [12] EN 1854

*1. Compliant in combination with a burner controller. Refer to the respective specification sheets for details.

*2. When used alone.

*3. When two units are connected in series.

Azbil has been providing combustion safety solutions that save wiring and space while isolating the control system from the safety system [13], and we consider the concept of a protective system in the revised standard to be in line with our previous efforts.

Table 3 shows protective systems that can be provided by our combustion safety solution. For connections between sub-systems, method A, which uses hard wiring, is adopted, and so a protective system can be created by wiring Azbil products.

Table 3. Protective systems

Safety function	Protective system
Protection from decreased gas pressure	Pressure SW – Burner controller – Automatic shut-off valve
Protection from increased gas pressure	Pressure SW – Burner controller – Automatic shut-off valve
Automatic shut-off valve	Pressure SW – Burner controller – Automatic shut-off valve Flame sensor – Burner controller – Automatic shut-off valve
Automatic shut-off valve closure check (verification)	Automatic shut-off valve POC SW – Burner controller – Automatic shut-off valve
Air flow rate and pressure detection	Pressure SW – Burner controller – Automatic shut-off valve
Automatic burner control system	Flame sensor – Burner controller – Automatic shut-off valve
Prepurge in combustion chamber	Pressure SW – Burner controller – Automatic shut-off valve

3.2 Supported burner operation methods

Table 4 shows burner operation methods compliant with the revised JIS that Azbil's burner controllers support. For individual ignition burner operation methods, Azbil has been providing the RX-R burner controller module for continuous and batch operation, the AUR455 burner controller for continuous operation, and others. Recently, the AUR255 batch operation burner controller, which supports a simultaneous ignition burner operation method and upstream shut-off burner operation method, has been added to our product lineup.

The next section gives an example of instrumentation in compliance with the revised JIS using these methods of operation.

Table 4. Methods of burner operation compliant with the revised JIS

Operation method	Description	Burner controller	
		AUR255	Other
Individual ignition burner	Redundant automatic shut-off valves are installed for each burner.	Compliant	Compliant
Simultaneous ignition burner	Multiple burners with redundant automatic shut-off valves at the root are simultaneously ignited.	Compliant	Not compliant
Burner with upstream shut-off	System has a single automatic shut-off valve with POC function downstream and a single automatic shut-off valve upstream.	Compliant	Not compliant

4. Instrumentation compliant with revised JIS using method A

4.1 Individual ignition burner operation method

Figure 3 shows an example of instrumentation that is compliant with the revised JIS using the individual ignition burner operation method.

With this instrumentation, the prepurge begins after the purge controller determines that there are no limit/interlock errors. When the prepurge is complete, safety output notifies the burner controller that ignition is permitted.

This instrumentation can be constructed using the RX-L for limit/interlock and as the purge controller and the AUR255 or RX-R as the burner controller, a configuration that is unchanged from the old JIS instrumentation. (The BC-R35 burner controller, which has a purge function, can also be used.)

Accordingly, if an individual ignition burner system was constructed with a combustion safety solution that was compliant with the old JIS, it meets the requirements of a protective system without any change of instrumentation.

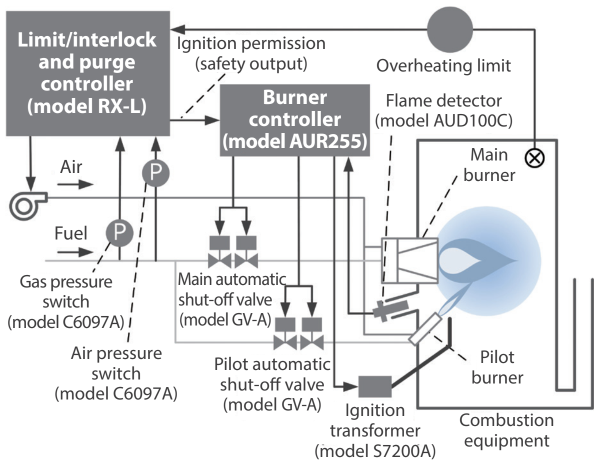

Fig. 3. Sample instrumentation using the individual ignition burner operation method

4.2 Simultaneous ignition burner operation method

4.2.1 Example of non–JIS-compliant instrumentation

An example of instrumentation using a batch ignition method of burner operation is the combination of a general-purpose PLC and a flame relay (a device that detects a flame and uses that result as relay output). In the instrumentation example in figure 4, a general-purpose PLC receives a flame signal from the flame relay and shuts off the automatic shut-off valve at the root within the safety time in the event of an error.

However, the use of a general-purpose PLC for a safety function is prohibited in the old JIS, and the flame relay is not compliant with the relevant product standard. Therefore, this combination cannot meet the requirements of a protective system.

If a flame relay that is compliant with the relevant product standard or SIL/PL can be found and the general-purpose PLC is changed to a safety PLC, the combination can meet the requirements of a protective system using similar instrumentation. However, method C must be adopted, which requires safety design of the application software and will take more man-hours than method A.

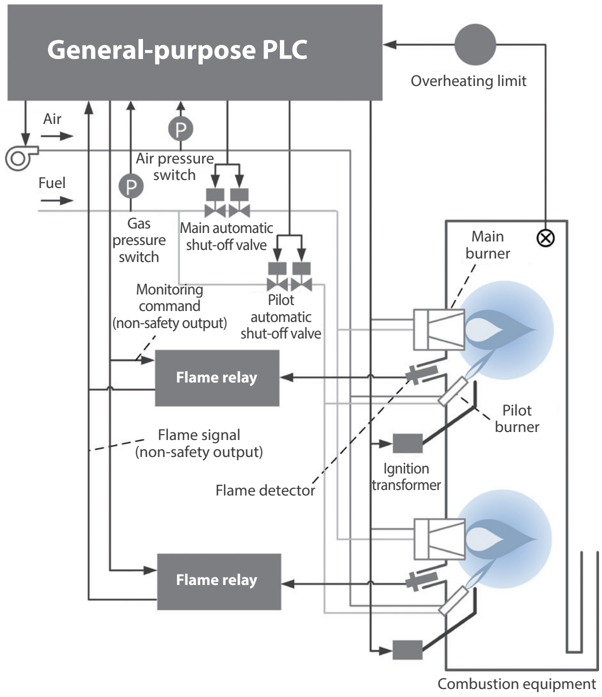

Fig. 4. Example of non–JIS-compliant instrumentation

4.2.2 Example of JIS-compliant instrumentation

Using the AUR255, which supports simultaneous ignition in method A, the requirements of the revised JIS can be met easily. Figure 5 shows an example of instrumentation in compliance with the revised JIS that uses a batch ignition burner operation method.

With this instrumentation, the prepurge begins after the purge controller determines that there are no limit/interlock errors. When the prepurge is complete, safety output notifies the burner controller and all the flame controllers simultaneously that ignition is permitted.

The flame controllers, which have received the ignition start command, run a start check to determine if devices are working normally, drive their ignition transformer, and send safety output to the burner controller to notify it that the shut-off valve may be opened. When the burner controller has received permission from all the flame controllers to open the shut-off valves, it opens the valves and supplies gas to all the burners.

If a flame controller detects an error, such as an ignition failure or flame failure, it sends a shut-off valve close command to the burner controller. When the burner controller receives the shut-off valve close command from any flame controller, it immediately closes the automatic shut-off valves and stops the gas supply to all burners.

This instrumentation can be realized by using the RX-L for limit/interlock and as the purge controller and the AUR255 as the burner controller and flame controllers. In this configuration, permission for ignition is sent to the AUR255 by safety output via an external safety relay.

When compared to the instrumentation example in figure 4, where all the inputs and outputs are concentrated in the general-purpose PLC, this instrumentation allows a distributed arrangement of devices by assigning the functions of loading the limit/interlock input to the purge controller, operating the automatic shut-off valves at the root to the burner controller, and igniting and monitoring the burners to the flame controllers. With this arrangement the flame relays can be put on the control panel near the burners, saving wiring and space.

The AUR255 uses a hardwired configuration for the safety output contacts, which are the means of sending permission to open the shut-off valves and the command to close the shut-off valves to the burner controller. This is because this configuration is faster than another communication method, is compliant with the timing stipulated by JIS, and enables a quick start of ignition.

Permission to open the shut-off valve of all the flame controllers and the command to close the shut-off valve from any one of the flame controllers is sent by a serial connection to the contacts of the burner controller.

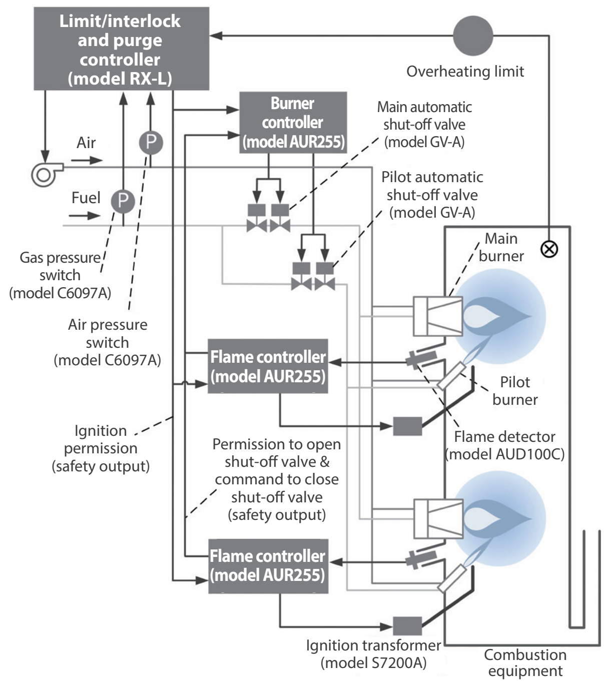

Fig. 5. Sample instrumentation using the batch ignition burner operation method

4.3 Upstream shut-off burner operation method

This method of operation is provided for the first time as part of the revision of JIS. JIS B 8415-2 provides the conditions for permitting the closure of a single automatic shut-off valve as "when one of the proof-of-closure (POC) switches mounted on individual automatic shut-off valves during low-temperature operation cannot confirm the closure of the burner valve and when the protective system closes the automatic shut-off valves (header valves) upstream with POC according to ISO 23551-1."

Azbil's automatic shut-off valve model GV-_ _ _ _ is compliant with EN 161, and Annex JB of JIS B 8415-3 lists ISO 23551-1 or EN 161 as the relevant product standard.

Figure 6 shows a sample instrumentation compliant with the revised JIS using the upstream shut-off method of burner operation. Here, direct ignition equipment, which we expect would be used, is shown as an example.

With this instrumentation, the purge controller checks for limit/interlock errors and for permission to open the shut-off valve from all the burner controllers, completes the prepurge, sends safety output to notify the burner controllers that ignition is permitted, and opens the upstream shut-off valve.

In addition, the burner controllers always monitor the POC input from the main automatic shut-off valve regardless of whether the status is shut-off, operating, or lockout. If the burner controllers cannot confirm closure of the automatic shut-off valve in a situation where it must be closed, they send a shut-off valve close command to the purge controller. If the purge controller receives this notification from any of the flame controllers while it is sending notification of ignition permission, it immediately closes the upstream automatic shut-off valve.

For this instrumentation the RX-L can be used for the limit/interlock check and as purge controller, and the AUR255 can be used as the burner controllers. In this configuration, the safety output notifying the AUR255 of permission for ignition comes via an external safety relay, and the upstream shut-off valve is controlled by the same output.

As in the case of the simultaneous ignition burner operation method, the AUR255 uses a hardwired configuration with safety output contacts as the means of sending to the purge controller a notification of permission to open the shut-off valve or a command to close it.

By connecting these contacts in parallel to the RX-L as the start-up interlock, it is possible to detect which burner's automatic shut-off valve experienced an error. If the contacts are connected in series, it is not possible to detect which burner's automatic shut-off valve has an error but, on the other hand, this configuration can be realized with only one input.

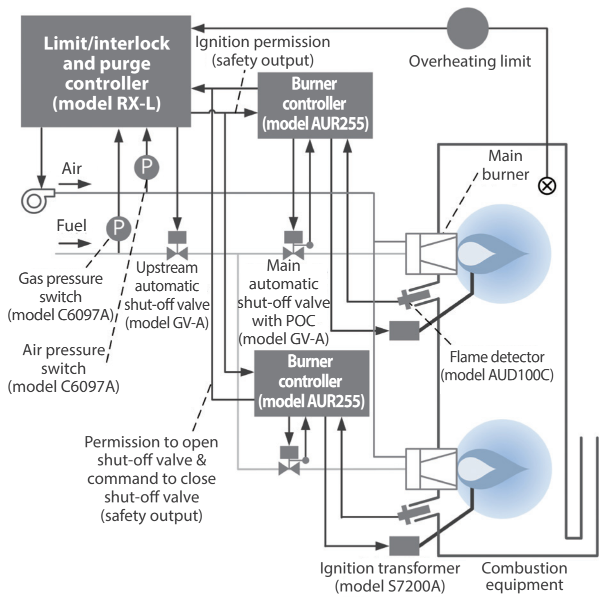

Fig. 6. Sample instrumentation using the upstream shut-off burner operation method

4.4 Summary

Focusing on examples of instrumentation, this article has explained about the revised JIS and, in particular, methods of complying with its requirements for protective systems. We have shown how a protective system can be constructed with almost the same design as the previous one using a combustion safety solution (our method A) in which the system is composed of devices that comply with the relevant product standards.

We have also shown that even simultaneous ignition burner operation methods, which have run as non–JIS-compliant systems in some cases, can be brought into compliance with the revised JIS by using our combustion safety solution.

Note that this article does not discuss risk assessment, which must be implemented during actual design, making reference to *Risk assessment guide for the design of automatic controllers for industrial combustion furnaces and collection of case studies* [14] and other documents.

5. Conclusion

Although it is important to observe safety standards both for safety and for conformance to the expectations of society, it would be the reverse of our intention to multiply the burden on designers and to make compliance with standards account for the majority of the work. Although only a few examples are presented in this article, we hope that it will be of help in ensuring compliance with the revised JIS.

At the moment, in the interests of carbon neutrality, as new methods of combustion using energy sources such as hydrogen and ammonia that emit no CO_2 are being promoted, it is not difficult to foresee a future revision of safety standards.

We will continue to watch the changes in safety standards and to offer combustion safety solutions that comply with those standards, thereby assisting industrial furnace manufacturers with compliance in order to provide safety, comfort and fulfillment in people's lives and to contribute to the preservation of the Earth's environment through "human-centered automation," in accordance with the azbil Group philosophy.

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