UDC 621.3-213.34 : 614.838

EXPLOSION-TEST INSTALLATIONS FOR FLAME-PROOF ELECTRICAL EQUIPMENT

Akinori Kotera
Syuichi Hoshino
Takanori Miyazaki
Masaaki Takeuchi

I. INTRODUCTION

With the remarkable development of the petroleum refining and petrochemical industries in recent years, the risk of fires and explosions due to explosive gases (inflammable gases or vapors) has greatly increased. This is also the same in areas in other industries where explosive gases are handled. To prevent this risk of fire and explosion, electrical equipment installed in dangerous locations where there might be explosive gases must be made flame-proof so that they do not present a source of ignition in dangerous atmospheres. Flame-proof electrical equipment must be used and this flame-proof equipment requires the maximum reliability with respect to safety and flame-proofing. This flame-proof equipment is designed and manufactured is accordance with the "Industrial electrical equipment fire-proofing policies", which are technical policies of the Industrial Safety Laboratory of the Ministry of Labor. The flame-proofing of the equipment supplied and used is confirmed by an official organization (the Industrial Safety Laboratory of the Ministry of Labor or its agencies). In 1969, a system of authorization by an official organization become obligatory and since that time, knowledge concerning the flame-proofing of industrial electrical equipment has increased and flame-proof electrical equipment has come into wide use. The importance of assuring this flame-proofing has become more important and the flame-proofing of various types of electrical equipment has been promoted. In particular, the demand for pressure-resistant flame-proof equipment has increased and pressure-resistant, flame-proof rotary equipment of large capacities up to the 2,000kW class are now possible.

The improved reliability of flame-proofing has been possible because products with greater safety are being produced by means of high level design and manufacturing techniques, as well as thorough quality control. For example, there are many items such as safety against explosions which are first confirmed in tests and therefore, for products of improved quality and reliability, it is essential that test equipment be provided and various tests be performed to confirm the flame-proofing. In September, 1975, in accordance with Notification No. 68 of the Ministry of Labor, manufacturers who produce flame-proof equipment must have test equipment to confirm the flame-proofing. For some time, Fuji Electric has had explosion test equipment for small and medium capacity pressure-resistant flame-proof rotary equipment, switches, instrumentation, etc. in its Mie, Fukiage and Tokyo Plants. However, because of the requirements for large capacity pressure-resistant flame-proof equipment (especially rotary equipment) and to develop and manufacture flame-proof electrical equipment with greater safety and reliability, the world's largest horizontal sealed explosion test equipment with an electrical switch door has been installed in the Suzuka Plant of Fuji Electric. This equipment is naturally used for explosion tests in large scale rotary equipment (up to 3,000kW class on F type 4-pole basis and 2,000kW calss on B type 4-pole basis) and it is also possible to perform explosion ignition tests during no-load rotation of rotary equipment as specified in various foreign standards (BS, VDE, IEC, etc.) and the American UL ratings. Rotational explosion ignition tests have already been performed using equipment authorized by the American Underwriters Laboratories Inc. (UL) and the West German PTB (Physikalisch-Technische Bundesanstalt), etc. The test time has also been made shorter for small pressure-resistant flame-proof electrical equipment by performing open type explosion tests in sealed explosion test equipment.

II. OUTLINE OF EXPLOSION TEST EQUIPMENT

There are two types of explosion tests for pressure-resistant flame-proof electrical equipment:

(1) Explosion strength tests to confirm the strength of the equipment against internal explosions.

(2) Explosion ignition tests for the escape of flames to the outside when there is an explosion inside the equipment.

Both are important tests for confirming that the electrical equipment is not a source of fire in areas of explosion risk.

1. Explosion Strength Tests

The explosion strength test is used to check the strength against the explosion pressure and is performed by causing an explosion by filling the equipment with mixed fluids designated to obtain the pressure specified in *Table 1*

Table 1 Internal withstand pressure (in gage)

Explosion class \ Internal capacity	Over 2cm³–100cm³	Over 100cm³
1	$8kg/cm^2$ or over	$10kg/cm^2$ or over
2	$8kg/cm^2$ or over	$10kg/cm^2$ or over
3	1.5 times or more of the explosion pressure measured in the explosion test; however, minimum value is: $8kg/cm^2$	$10kg/cm^2$

Note: This explosion test is a preliminary test performed before the explosion strength test to determine the test pressure. The housing of the tested equipment is used and the explosion test is performed at normal pressure with the gas concerned. The maximum pressure at which the explosion occurs is measured.

in accordance with the equipment volume and explosion class. This test is repeated 10 times and the results are used to confirm that there is no damage to the housing or deformations which might be harmful to use.

2. Explosion Ignition Test

The explosion ignition test is used to determine if any flame escapes outside the equipment and is performed by causing an explosion inside the equipment by filling the inside and outside of the equipment with mixed fluid in accordance with the explosion class. This test is repeated 15 times and it is confirmed that there is never any escape of flames.

The relation between the mixed fluid and the explosion class for this equipment is as follows:

Hydrogen concentration of 57–60 vol% forexplosion class 1

Hydrogen concentration of 47–50 vol% for explosion class 2

Hydrogen concentration of 29–32 vol% for explosion class 3

III. EXPLOSION TEST EQUIPMENT

1. Characteristics

This equipment has the following characteristics:

(1) The test tank is horizontal.
(2) The cover of the test tank is operated electrically.
(3) A rotary clutch with an air cylinder is used to fix the test rank and cover in position.
(4) The explosion ignition test can be performed during no-load rotation.
(5) Open tests can be performed inside the sealed test tank.

Normally, large test tanks are vertical but this tank is horizontal for the following main reasons:

(1) A majority of the large-scale pressure-resistant flameproof are horizontal and the tests can be performed at as close to actual conditions as possible.
(2) Compared with vertical type tanks, opening and closing of the tank cover is easier and electrical operation is also easy in consideration of equipment safety.
(3) Unlike for the vertical type, it is not necessary to dig a pit for construction and the construction costs are low.
(4) Test pieces can easily be accomodated in the test tank.
(5) Since internal wiring and piping are possible with the cover open, operation is easy.

However, there are also difficulties involved with the horizontal type. Because the cover moves, piping can not be fixed. In addition, very heavy test pieces must be supported with the cover open. Centering of the test tank body and cover must be quite accurate. To solve these problems, flexible piping is used, along with the pantograph system shown in *Fig. 3* which assures free expansion and contraction. To support heavy objects, the support cylinder system shown in *Fig. 7* is used. For centering, the body and cover are placed on the same foundation surface. Centering adjustment and setting are assured by a method whereby the body is fixed in place first, and then the rail for cover movement is welded to the foundation reinforcement rods.

2. Equipment Layout

The equipment layout is arranged so that the components are each in independent rooms because explosive hydrogen gas is used. In all rooms where hydrogen might enter, there are gas alarms to assure safety. This laoyt is shown in *Fig. 1*.

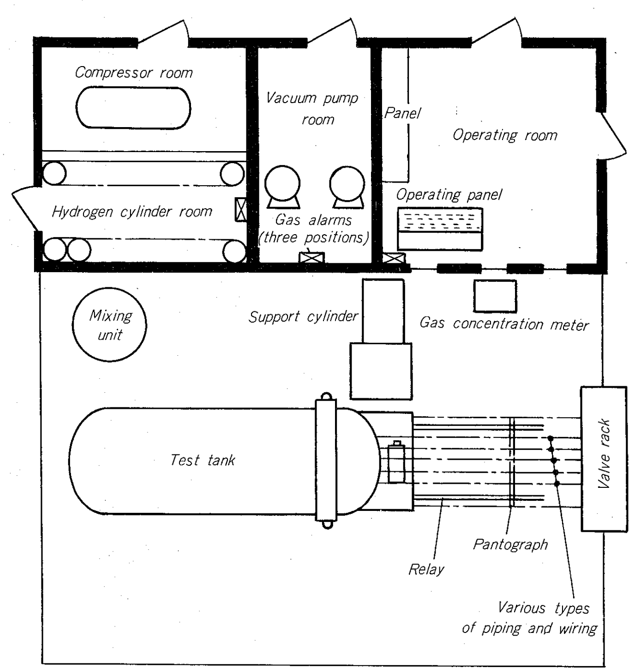


Fig. 1 Arrangement of equipment

3. Flow

The flow characteristics are such that the air for the mixed fluid used in large quantities and the air to clean the inside of the tested equipment (flame-proof equipment to be tested) and the test tank after the explosion are brought from the factory compressor and the equipment compressor is used only for control compressed air. Since the gas

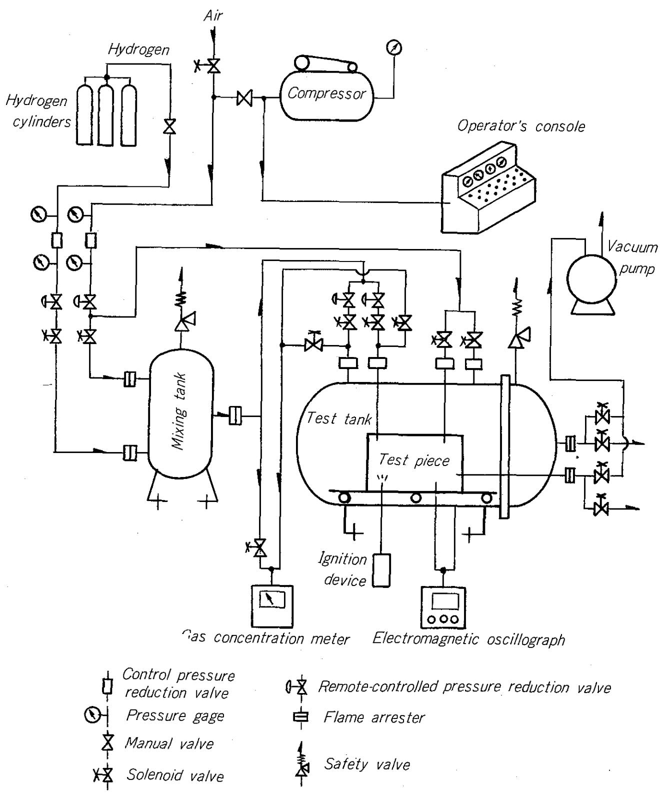


Fig. 2 Flow chart

concentration must be confirmed in accordance with the explosion class, the explosion takes place after measurements in the mixer, test tank and tested equipment. The flowchart is shown in *Fig. 2*.

4. Specifications of Each Component

1) Test tank

The test tank is horizontal, of the sealed type with a cover operated electrically and of the partial pressure mixing type. The size is an inner diameter of 2.5m, a straight length of 4.5m and a volume of 27.75m^3. The maximum operating pressure is 30kg/cm^2 and a test pressure of 45kg/cm^2 can be withstood by this pressure vessel. The tanks are produced in the Fuji Electric Kawasaki Plant and have passed the authorization tests for No.2 type pressure vessels of the Japan Boiler Association. The characteristics are as follows:

(1) A rotary clutch with an air cylinder is used for fixing the tank body and cover in position.
(2) The cover is opened closed electrically.
(3) To facilitate piping of the test piece, the joints for air supply and exhaust are in three positions each on the test piece base.
(4) There are two sets of ignition equipment, one of which is used as a spare.
(5) In the case of large test pieces, the explosion pressure differs depending on the location. Pressure heads can be attached in six places to measure these differences (measurement of pressure integration phenomenon).

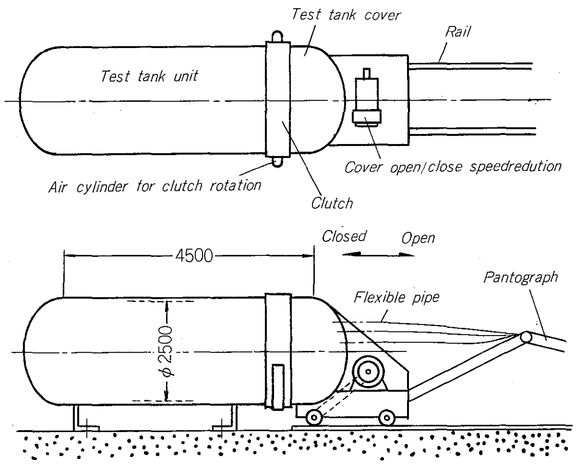
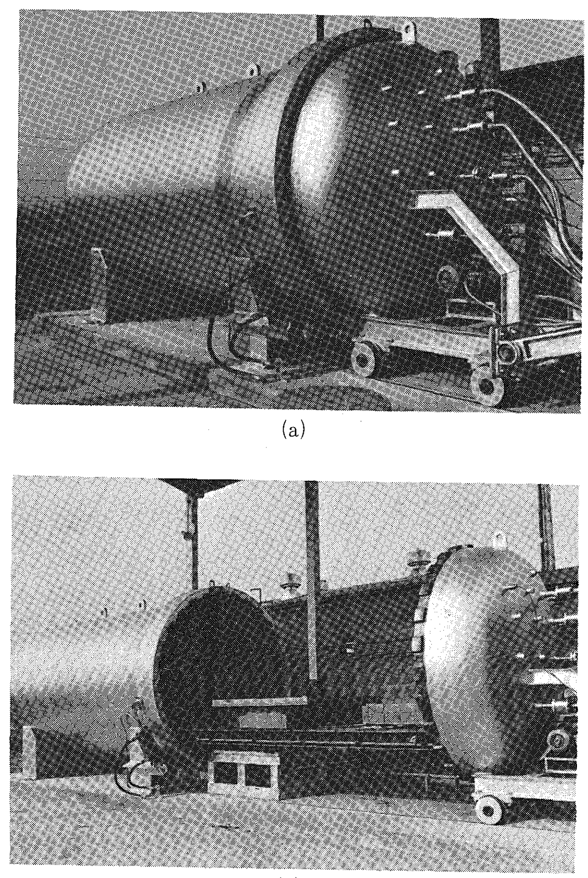


Fig. 3 Test enclosure



(a)

(b)

Fig. 4 Test enclosure

2) Mixer

The mixer is of the vertical type. Hydrogen gas enters from the bottom and air from the top and the mixed fluid corresponding to the explosion class is obtained from the center. The enclosure has an inner diameter of 1.4m, a straight length of 2.2m and a volume of 4.259m^3. The maximum operating pressüre is 50kg/cm^2 and the maximum test pressure which can be withstood is 75kg/cm^2.

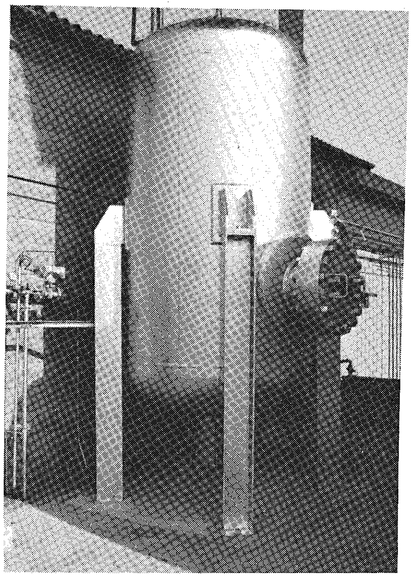


Fig. 5 Mixing enclosure

This enclosure is authorized as a No. 2 type pressure container by the Boiler and Crane Safety Association. The mixer is shown in *Fig. 5*.

3) Operating panel

This equipment uses both explosive hydrogen gas and heavy materials. Therefore, the main points are safety and ease of handling. These are combined in the operating panel shown in *Fig. 6*. This panel contains various types of gages and switches (including those for remote-controlled valves), These switches can perform all operations including opening and closing of the cover and the ignition explosions. To prevent accidents due to misoperation, all of the switches are provided with interlocks. A key switch is used for ignition and ignition is possible only if all conditions have been met.

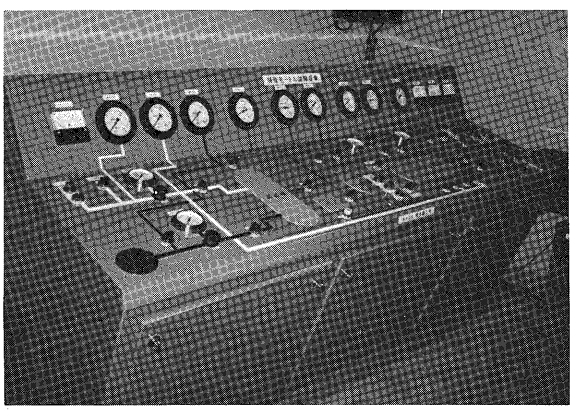
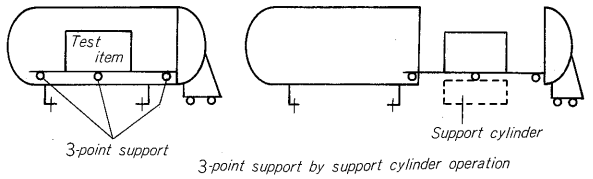


Fig. 6 Operating panel



(a) Accomodated in test tank (b) Test tank cover open

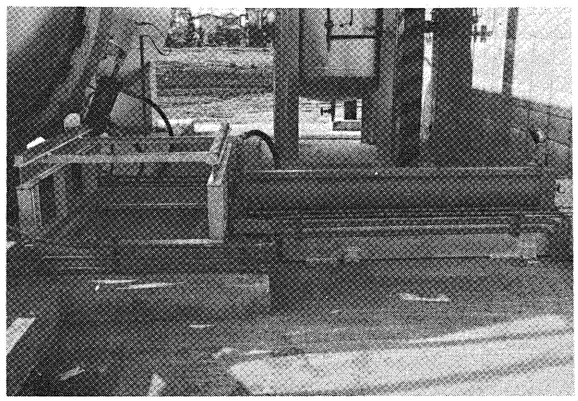


Fig. 7 Support cylinder

4) Vacuum pump

The vacuum pump is used to decide the test time since the clean air time is decided by the capacity of the vacuum pump. Therefore, the capacity of the vacuum pump is selected in accordance with this point.

5) Compressor

Since most of the air used by this equipment is supplied by the factory compressor, this compressor is of very small capacity.

6) Support cylinder

As can be seen in *Fig. 7*, the support cylinder is used to support heavy test pieces when the test tank cover is open and it is driven by compressed air.

7) Piping

To prevent ignition explosions in the joints of the test tank, test piece and mixer, flame arresters of 100 mesh made of sintered alloy are inserted in these opening. The piping is of copper or stainless steel to minimize corrosion and greatly extend the life of the equipment.

IV. CONCLUSION

This article has given an outline of the explosion test equipment for pressure-resistant flame-proof electrical equipment installed in Fuji Electric. In the future, attempts will be made to utilize completely the features of this equipment, and clarify the pressure integration phenomenon for large-scale pressure-resistant flame-proof rotary equipment and performing explosion ignition during rotation. Our intention is to supply more reliable products.