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Special Report: Tests on a flame-trap, designed and submitted by Chatterley-Whitfield Unit, West Midlands Division, National Coal Board

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SUMMARY

A ring-relief assembly, intended to act as a flame-trap during recovery operations at Chatterley-Whitfield Colliery, has been found on test to be quite useless for the purpose for which it was designed and used.

The results of these tests emphasise the desirability of colliery managements requesting, at an early stage, the comments of the S.M.R.T.B. on the design of any device which is intended to function as a flame-trap in dangerous locations.

1. Introduction

During the recovery, at Chatterley-Whitfield Colliery, of an area which had been sealed off because of fire, it was decided, in order to remove the firedamp with which the area had become filled, to allow air to enter the area through a pipe, six inches in diameter, fixed in the intake stopping, and so to displace the gas through a similar pipe fixed in the return stopping.

This procedure entailed the possibility that part, at least, of the atmosphere in the sealed-off area would be rendered explosive, and that an inflammable mixture might also be formed on the outbye side of the return stopping. In the event of an ignition of either of these mixtures, flame reaching the ventilating pipes could not fail to pass through them and to ignite any inflammable mixture that might exist on the other side of the stopping. As an intended protection against such an occurrence, the outbye end of each pipe was fitted with a 'flame-trap', designed and made at the colliery, and described later in this Report.

The recovery operations were completed successfully, without the flame-traps being called upon to perform the function for which they were designed. Later, however, some doubt appears to have arisen as to whether

they would in fact have acted as intended, and the Chatterley-Whitfield Unit therefore asked for tests to be carried out to establish the efficacy of the device.

2. Description of Chatterley-Whitfield flame-trap

The flame-trap submitted for test was of simple design, and had been produced in the colliery workshops. It consisted of a six-inch length of standard six-inch steel pipe, fitted at one end with a standard flange (for connection to the similarly-flanged pipe built into the stopping), and at the other end with a flange of fifteen inches diameter. Mounted on the latter were eighteen annular rings of mild steel sheet, one-eighth of an inch thick, each eighteen inches external and six inches internal diameter. Each annulus was separated from its neighbours by spacing washers, one-eighth of an inch thick, located on the six bolts which held the assembly together; the end was closed by a steel plate, eighteen inches in diameter and three-quarters of an inch thick. The flame-trap thus consisted of eighteen annular gaps, each six inches in internal diameter, six inches in radial breadth, and one-eighth of an inch in width.

3. Comments on the design

Devices of the type described in the previous paragraph received a considerable amount of attention from the Safety in Mines Research Board in 1925-1927, when their use was proposed as a safe means of reducing the pressure to which flameproof enclosures would be subjected by the explosion within them of mixtures of firedamp and air. The work carried out by Rainford and Wheeler on ring-relief devices is described in S.M.R.B. Paper No. 35 (1927), Figure 7 of which illustrates a design, intended for mounting on a flameproof enclosure, which resembles very closely the flame-trap devised at Chatterley-Whitfield. It is noteworthy that on all the occasions recorded in S.M.R.B. Paper No. 35, when the ring-relief device passed flame and ignited the surrounding mixture, the width of gap between successive plates was 0.050 inch or more. It is true that instances were recorded in which a gap width of 0.050 inch proved to be safe (in a restricted number of tests), but the results clearly indicated that gap widths of 0.050 inch could not be relied upon to give protection. In order

to give an adequate factor of safety, the maximum gap width acceptable to the Inspectorate when ring-relief devices were proposed for use underground was fixed at 0.020 inch. In the light of the results recorded in S.M.R.B. Paper No.35, little doubt was felt that the Chatterley-Whitfield design of flame-trap, having gap widths of 0.125 inch, would prove on test to be unsafe.

4. Programme of tests

4.1. Apparatus and method of test

The open end of the flame-trap, i.e. the end intended to be coupled to the pipe built into the stopping, was closed with a steel plate carrying a pair of insulated electrodes which terminated in a spark gap inside the flame-trap. The latter was mounted in a cubical chamber of four feet side, the front and roof of which were provided with panels of thin cellophane sheet, to act as pressure releases in the event of an explosion occurring within the chamber.

The cubical chamber was filled with an explosive mixture which contained, over the range of tests, between 8.2 and 9.0 per cent. firedamp, the interior of the flame-trap being also filled with the same mixture. More stringent conditions would have been imposed if the mixture inside the flame-trap had contained 9.0 per cent. and the mixture surrounding it 7.5 per cent. of firedamp, but the preparation of two different mixtures involved some experimental complication and, as will be seen, proved to be unnecessary for the purpose in view.

Each test consisted in igniting the mixture within the flame-trap and noting whether or not the external mixture surrounding the trap was ignited by the hot gases ejected through the gaps between the annular rings. In one series of tests (Series III), the mixture surrounding the flame-trap was ignited first, (by means of a spark gap mounted on one side of the cubical chamber) and observation was made whether ignition of the mixture <u>within</u> the flame-trap resulted from the external explosion.

4.2. Results of tests

Three series of tests, each consisting of ten experiments, were made. Series I and II were designed to ascertain whether an explosion within the flame-trap could ignite the external mixture surrounding it. In Series I the spark gap was fixed close to the inside surface of the thick steel plate which closed the outbye end of the trap. In the ten tests of this Series, ten external ignitions resulted.

In Series II, the conditions were less severe, the spark being fixed close to the inner surface of the steel plate which closed the opposite end, i.e. the inbye end, of the trap. Nevertheless, ten external ignitions resulted from ten tests.

Series III was designed to ascertain whether the device had any virtue as a flame arrestor in the opposite direction; that is, whether it would have been able to prevent the passage of flame from an explosion on the outbye side of the stopping to an explosive mixture on the other side. For these latter tests a knot of guncotton yarn was fixed to the inside surface of the steel plate which closed at the end of the short length of six-inch pipe. If, when the external mixture was ignited, flame passed inwards through the annular gaps and ignited the mixture within the flame-trap, the internal explosion would be propagated along the six-inch pipe and would in turn ignite the guncotton yarn. The disappearance of the guncotton yarn thus provided clear evidence that an internal explosion had occurred. Ten such tests were made; in nine of them the mixture within the trap was ignited; in the tenth, the guncotton yarn was found to be intact. In this tenth experiment, therefore, some doubt existed as to whether an internal ignition had in fact occurred.

5. Conclusions

The results of the tests leave no doubt that the device is quite ineffective for the purpose for which it was designed and used, and emphasise strongly the desirability of colliery managements seeking, at an early stage, the comments of the S.M.R.T.B. on the design of any device which it is proposed to use as a flame-trap in dangerous locations.

If such reference had been made in the present instance, the colliery management would have been advised to reduce the width of the annular gaps to 0.020 inch. This would, of course, have necessitated the use of a greater number of annular rings in order to maintain the same open area for ventilation purposes, but protection against the passage of flame, even under the worst conditions, would have been certain. Flame-traps which are known to be safe against firedamp explosion are now articles of commerce, since their use has been made obligatory on both the intake and the exhaust sides of Diesel locomotives intended for use underground.