Diesel engines for firedamp mines

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DIESEL ENGINES FOR FIREDAMP MINES

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INTRODUCTION

The diesel engine protection principles used in firedamp mines have remained practically unchanged since they were originally introduced into mines. The protection used is aimed at preventing excessive temperatures, flames, and sparks from appearing and preventing the transmission of combustion inside the engine into the atmosphere. All the regulations in force in most mining countries require the limiting of surface temperatures and exhaust gases, a more or less flameproof design for the engine and safety equipment, and the installation of flame arresting devices in the intake circuit and exhaust circuit.

The old French mining regulations defined the requirements for the approval of liquid fuel locomotives in the ministerial order of 30th October 1961. A minimum length of 25 mm was required for the flameproof joints on the enclosures formed by the intake and exhaust systems.

The tests defined in this order had to prove that the enclosures could withstand a pressure equal to 1.5 times the maximum pressure developed by a mixture of air and 9.8 % of methane and prevent transmission of the internal combustion of a mixture of air and methane to the outside.

NEW FRENCH REGULATIONS

The introduction of foreign diesel engines (mainly German engines with 12.5 mm flameproof joints) into French coal mines, the need to make extensive modifications to the cylinder heads, the increase in our knowledge of the reliability of flameproof enclosures and the appearance of European standards for electrical equipment led the French administration to replace the order of October 1961 (Chapter III) by the order of 5th August 1987.

The main requirements of this order are as follows :

- flame arresters consisting of stacked plates with set gaps between them, at the intake and exhaust ;
- flameproof chambers between the flame arresters and the cylinder head, and a flameproof joint with a minimum length of 12.5 mm ;
- testing identical to that of European standard EN 50 018 of March 1977, for the flameproof enclosures of group I electrical equipment i.e.
  - * measurement of the pressure developed by the internal explosion of a mixture of air and 9.8 % methane ;
  - * a chamber resistance test under 1.5 times the maximum explosion pressure measured ;
- * tests for non-transmission of the internal combustion of a mixture consisting of air, 7.25 % hydrogen and 5.25 % methane. This type of mixture has a safety coefficient of 1.42 with respect to the air and methane mixture.

These new regulations have been in force since July 1988. Their application has not posed any problems in the case of classical diesel engines i.e. with natural aspiration. On the other hand, in the case of turbocharged diesel engines, we experienced the several difficulties, which are described below.

APPLICATION TO TURBOCHARGED DIESEL ENGINES

In a turbocharged diesel engine, the engine exhaust gases drive a turbine which, by

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compressing the air in the engine intake, increases the amount of oxygen for combustion. The gain in power for the same size engine can be 70 %. This is of considerable interest to French coal mines who need more and more powerful engines to drive their rubber tyred loaders. However, this type of engine is not clearly provided for in the French regulations which creates problems for the construction and certification of conformity of these engines.

We examined a CATERPILLAR 3306PCTA turbocharged engine which was designed for a WAGNER transport loader used in firedamp mines.

This engine had been adapted by PYROBAN to meet French regulations. It consisted of the following :

- at the intake, between the air filter and actual engine, a shutter, a flame arrester with stacked plates at an interval of 0.65 mm over a length of 50 mm, a connection pipe, the turbocompressor, a second connection pipe and the intake cooler ;
- at the exhaust, the cooled turbine, a cooled connection pipe and a flame arrester with stacked plates at an interval of 0.7 mm over a length of 50 mm in a gas scrubbing and cooling pan.

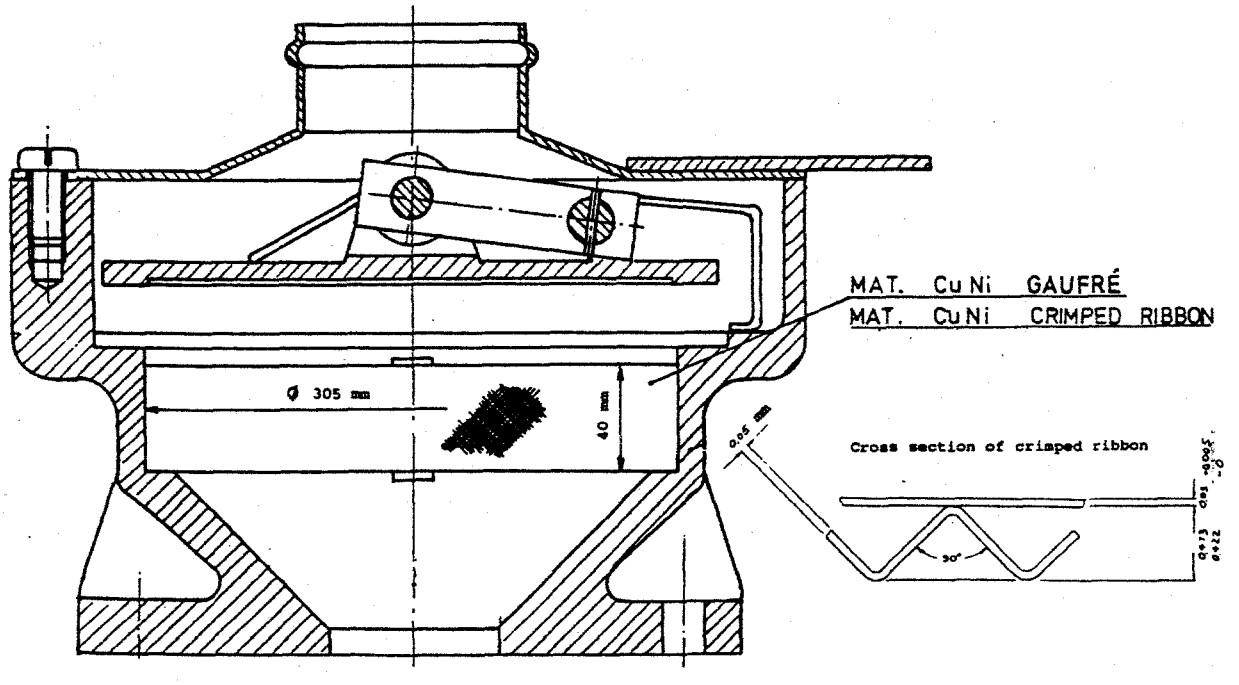
The dimensions of the flameproof joints were correct. The non-transmission tests gave satisfactory results for the exhaust part but not for the intake part.

In order to take the effect of the turbo-compressor into account, we precompressed the flammable mixture to the theoretical value given by the turbocompressor manufacturer (100 kPa) since it was impossible to reproduce the functioning of the turbocompressor in our test device. There was transmission of combustion as soon as the first explosion occurred in the intake chamber.

This led PYROBAN to change the type of flame arrester.

- A flame arrester with an interval of 0.5 mm between plates proved ineffective. Reducing the intervals even further was not possible since it would prevent the engine from working properly.
- A flame arresting device of a different design was tested. It consisted of a crimped band and a flat band. These two cupro-nickel bands were wound into a spiral and placed inside a collar. The intake air therefore had to pass through a number of conduits with a triangular section of 0.18 mm² over a length of 38 mm. The intake device, with this flame arresting device, came through all the tests for non-transmission of combustion with explosive mixtures pre-compressed to 100 kPa.

The French administration has accepted the equivalence of this flame arresting device with the stacked plate devices stipulated in the order of August 1987, which means the engine can be used in mines.



Air Inlet valve and flame arrester combination
fitted on 3306PCTA engine (constructed by PYROBAN)

COMMENTS

The European Standardization Committee (CEN) is currently studying a standard for the construction and testing of internal combustion engines used in areas where there are risks of explosion. This study, in which we are participating, is based on the experience and regulations in force in the different European Community countries and takes into account the essential safety and health requirements relating to the design and construction of machinery given in a directive of the Council of European Communities (89/392/EEC).

A survey of diesel engine manufacturers has enabled us to realistically define those situations which can produce combustion under normal operating conditions and under reasonable defect conditions.

The results of this the survey show the following :

- The main risks seems to be related to overheating of the engine.
- For a correctly, regularly maintained engine operating in an atmosphere free of inflammable gases, the appearance of flames at the intake and exhaust is highly improbable. This probability increases in the event of inflammable mixtures being ingested and under certain faulty conditions.
- Bursting of housing is very improbable for the types of engines used in mines.

It may therefore be asked whether the regulations that we apply are not too stringent, since anomalies are very rare.

CONCLUSION

A crimped band flame arresting device proved more effective than the stacked plate devices. This must be taken into account in the standard being prepared by the CEN.