Pt21 86261
Publicly Available
ALLISON - Part 21

COOPER INDUSTRIES

**COOPER-BESSEMER RECIPROCATING**

F. Bruce Stolba
Vice President and General Manager

June 20, 1986
Our Ref: QCG-3073

C 634

Office of Inspection and Enforcement
U.S. NUCLEAR REGULATORY COMMISSION
Washington, D.C. 20555

ATTENTION: Director of Inspection and Enforcement

In accordance with the requirements of the Nuclear Regulatory Commission, and in particular 10CFR Part 21, we wish to inform you of an incident involving one of our engines used for driving a standby power generator.

The engine in question is known as a KSV-16-T. The sixteen cylinders of this pure turbocharged diesel engine have a bore of 13.5 inches and a stroke of 16.5 inches with a rated 6100 BHP approximately at 600 RPM. There are two such engines installed at the Nine Mile Point. (Unit 2) Plant of Niagara Mohawk Power Corporation. The incident being reported involved the engine bearing the serial no. MO 7190.

Recently an attempted start was aborted when the engine would not roll. Subsequent investigation revealed that this incident was associated with a very loose air starting valve insert in the number 3 left cylinder head. A few days later a second insert was found to be loose on the same engine.

Lincoln Avenue
Grove City, Pennsylvania 16127
(412) 458-8000 Telex: 86-6613



IE19

Currently an investigation is under way with respect to the integrity of all other such inserts and will be completed shortly. Within a few days of finishing this investigation a complete report will be prepared and sent to you. In the meantime the following activities have, or are, taking place:

1. Repair of the two cylinders involved.
2. Investigation into the cause of valve insert looseness.
3. Physical check to ensure all inserts are tight.
4. Cause of engine failing to start.

Sincerely,

F. Bruce Stolba

F. Bruce Stolba

cc: D.T. Blizzard-GC
P.R. Danyluck-GC
R. Doubrava-Houston
W. Haass-NRC
P.W. Hodge-New Orleans
W.H.A. Lambert-GC
T.W. Kearns-GC
G.L. Miller-GC

July 21, 1986
QCG-3072

REPORT

NIAGARA MOHAWK POWER CORPORATION
Nine Mile Point (Unit 2)
KSV-16-T S/N MO-7190
Starting Air Valve, Valve Seat Insert

## 1.0 Introduction

1.1 Two KSV-16-T diesel engines are installed at the Nine Mile Point (Unit 2) Plant of the Niagara Mohawk Power Corporation (NMPC) for standby power generation. They are identified as follows:

| C-B Serial No. | NMPC Ref. |
|---|---|
| MO 7190 | 2-101 |
| MO 7191 | 2-103 |

1.2 Both engines were built and tested in 1980, and were shipped to the plant site in January, 1983.

1.3 On May 5, 1986 an attempt to start engine MO 7190 was aborted when the engine would not crank on starting air. A series of checks was made, and it was determined that if the engine stopped in one certain position it would not crank for starting with anything less than the maximum starting air pressure of 250 psi. Subsequently it was determined that the starting air valve insert in no. 3 left cylinder was loose and was the reason for the engine not cranking under certain conditions (see para. 6.0). In view of the foregoing the safety of the plant was jeopardized, and so the incident was deemed to be reportable under the provisions of 10CFR Part 21.

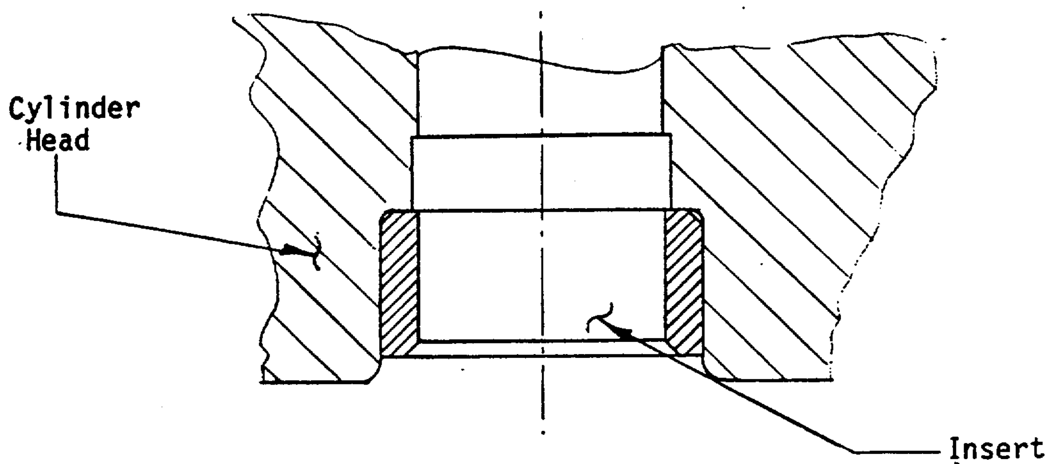
1.4 The number 3 left head was returned to Cooper-Bessemer (C-B) where it was determined that failure of a repair to the insert bore had caused looseness of the insert. Records indicate the repair to be an isolated incident (see also paragraph 2.2). The head was repaired and returned for service.

1.5 A few days after identifying a problem with no. 3 left cylinder, the insert for no. 7 left was determined to be also loose (not quite as loose as no. 3). Upon return of the head to C-B it was concluded that inspite of the system (see paragraph 2.0) an error was made with the selection of the insert part no. (The installed insert part no. agreed with the inspection records).

1.6 In order to be sure that no other inserts were loose NMPC proposed to physically check all starting air valve inserts on the total complement of 32 heads.

## 2.0 Valve Insert - Method of Machining and Assembly

2.1 The sketch below shows the valve insert assembly (Approx. full size)




2.2 The insert bore is required to be held within a tolerance of .003". Inserts are selectively fitted to ensure a .001" to .0025" interference fit. Six part numbers of inserts are available, three of which are available as "standard" for production use. Each is bigger in diameter than the next smallest by .0005". The counterbore is measured and the required insert part no. is selected. This number is stamped on the cylinder head. After a complete inspection, the selected insert is frozen and shrunk into the head counterbore.

2.3 Insert - Upon completion of manufacture a "Quality Control Inspection Plan" (QC/IP) is completed. A sample for a typical valve insert is attached as Appendix "A". In particular, note columns 1 and 5 which record a serial no. and check the outside diameter. Column 13 requires verification of identification on the insert.

2.4 Head - The QC/IP for a cylinder is very comprehensive and comprises seven sheets of detail. among the items checked are the following:

A. Confirmation that part no. for required insert is stamped on head.

B. Insert counterbore geometry checked.

C. Outside diameter of insert checked for correct application.

D. Verification of correct part no. on insert.

In all there are eleven inspection operations involved with inserts.

An inspection of all heads at NMPC revealed that for some head assemblies the stamped number did not match the actual number on the insert(s) or the insert number was missing. Two aspects of the part numbering should be noted. Firstly, the marking is lightly applied so as not to destroy the geometry of this precision made part. After an engine has been run, the exposed surface will be covered with carbon, and in order to read a number, the carbon is removed with emery cloth. This process frequently obliterates the number. Secondly, only one part number of insert is made - the largest. If a smaller insert is required it is ground to the smaller size. Sometimes when the part number is changed it may become somewhat illegible, or due to the lightness of the remarking, the original number may show through.

2.5 Should a deviation occur during manufacture a well defined procedure has to be followed for the purposes of record and disposition. A A cross reference is applied to the appropriate QC/IP form by recording the Material Review Request (MRR) number. The MRR records details of both the deviation and the disposition of it.

## 3.0 No. 3 Left Head

3.1 Inspection records indicate that the insert counterbore was machined oversize, and that it was brought back to size by copper plating. The process used has a wide industrial application and is known by the trade name "Dalic". It is incorporated in the design of many components as well as used for salvage. Various materials such as copper, cobalt, nickel, etc. may be deposited by the process.

3.2 Invaribly a finished valve seat insert counterbore is matched with a suitable insert (within drawing tolerance) due to the range of inserts available (see para. 2.2). Rarely is a counterbore machined oversize, but if it is, it is brought back to size by plating. Until recently we considered copper to be a suitable material for such an application. We now use iron. The reason for not using copper is that its coefficient of expansion is incompatible with that of cast iron. The coefficients of expansion are:

| | |
|---|---|
| Cast Iron | $6.77 \times 10^{-6}/^{o}F$ |
| Copper (plated) | $9.82 \times 10^{-6}/^{o}F$ |

The starting air valve insert is located in an area subject to thermal cycling. Although residual temperatures would be between 300 and 400°F there would be expansion of the insert, copper plating and cast iron head. The copper being trapped between the head and the insert would have nowhere to go and so would yield in compression and ultimately would lose its fit, and loosen. The sensitivity of an insert to loosen under such circumstances would be a function of the thickness of the copper plating and the temperature to which the assembly would be subjected. Higher than normal temperatures for example, would increase this sensitivity.

3.3 We therefore understand why this particular insert loosened. It was removed, the copper bored out and a .030" oversize insert shrunk into place.

4.0 <u>No. 7 Left Head</u>

4.1 This head was returned to C-B for repair. in order to keep the turn around time to a minimum internal paperwork was generated while the head was in transit.

4.2 Attached as Appendix "B" is a copy of the Material Review Request no. 05831 and its companion QC/IP for the repairs. In order to enter the anticipated repair into the C-B paperwork system, to avoid inherent time delays, the MRR was initially written based upon the presumption that it had been copper plated (like the first one) but without actually confirming the fact. Upon arrival the head was properly checked and found to have no copper plating. The top of the counterbore measured 1.6267" and the bottom 1.626" diameter. The insert diameter measuread 1.626". This indicated a metal fit at the bottom of the counterbore and .0007" loose at the top. The counterbore was then machined oversize, and the machinist involved confirmed that he removed only cast iron (no copper).

4.3 A check of the head records show that the insert selected had been fitted correctly. It is therefore concluded that the wrong part no. of insert for the proper interference was initially selected, and the mistake not found until the insert came loose in the engine.

4.4 SWEC audited appropriate records on June 18, 1986.

## 5.0 Insert Integrity Air Starting Valves

5.1 This incident of two inserts coming loose (both on the same engine) is the first such ever recorded by C-B out of hundreds of similar heads in service. C-B researched their records and found nothing to indicate that other insert problems could be anticipated with the NMPC engines. This fact considered with years of experience, led C-B to suggest that the likelihood of further problems arising was zero. Never-the-less SWEC/NMPC felt that the matter could only be positively settled by a complete physical inspection of all remaining (30) heads, to which C-B agreed.

5.2 An inspection tool was designed and manufactured by C-B, the purpose of which was to apply a "limited load" to an insert to check for tightness. A calculation was made to determine the force required to remove an insert with the minimum of .001" interference. Approximately 60% of this value would be applied to the insert. Appendix "C" is the procedure used in the field for the inspection.

5.3 All starting air valve inserts were checked using the procedure described in paragraph 5.2 and a checking tool made by SWEC. No inserts were found to be loose. This activity was witnessed by a C-B engineer - see Appendix "D".

## 6.0 Insert Integrity (Air Inlet and Exhaust Valves)

6.1 Concern was expressed by the client as to the integrity of all other inserts. A joint inspection of these inserts was undertaken. This comprised looking for signs of copper plating (none expected and none found) as well as for signs of distress in the inserts and the area surrounding them, and any unusual pattern of carbon deposition. One insert bore appeared to be iron plated and the Q.C. records at C-B confirmed the fact. See Appendix "D" for additional information.

## 7.0 Engine Not Cranking on Attempt to Start

7.1 The following is a chronological sequence of events as understood by C-B:

<u>1986</u>

May 5 Engine would not crank on a start command. The engine was barred over looking for water leaks (assumed to be an hydraulic lock). No water leaks found. Engine started. Tried to find the "dead" spot, but could not repeat it.

May 10 Started O.K.

May 15 Failed to crank. Position of crankshaft determined to be $20^{o}$ before top center (BTC) for no. 1 left cylinder. Air pressure applied to starting air systems at 150, 200 and 250 psi. The engine would not crank at 150 and 200, but did with 250 psi and it started. Several starts achieved, but with flywheel in a position other than $20^{o}$ BTC for number 1 left.

May 16 Four Attempted Starts O.K.
May 17 Started O.K.
May 18 Started O.K.
May 19 Started O.K.
May 22 Started O.K.
May 27 Started O.K.

7.2 The timing for the opening of the air starting valves was checked and found to be $2^{o}$ ATC for the left bank and $4^{o}$ BTC for the right bank. The timing should have been $5^{o}$ ATC with closing at $115^{o}$ ATC.

7.3 With no. 1 left TDC at $20^{o}$ BTC, and with air starting valve timing the air starting valve sequence would be:

(1L $20^{o}$ BTC reference)
6R $25^{o}$ ATC Air in cylinder - low torque.
3L $70^{o}$ ATC Air in cylinder - max. torque.
7R $115^{o}$ ATC Air closing, exhaust valve starts to open.
2L $160^{o}$ ATC No air.

7.4.0 The known facts summarized:

7.4.1 No. 3 left air start valve was so loose that it dropped out of the head.

7.4.2 Dead spot at $20^{o}$ BTC for no. 1 left.

7.4.3 Air starting valve timing too early - $7^{o}$ for left bank and $9^{o}$ for right bank.

7.4.4 Without accounting for timing error, pertinent air starting valve timing as per paragraph 7.3.

7.5.0 An analysis of the events has led us to the following conclusions at the instant of an attempted start under the above conditions:

7.5.1 3L - No air in cylinder. The insert depth is greater than the valve stroke. The insert was so loose that when the valve opened the insert would have traveled with the valve aided by air pressure, and acting more like a piston than a valve. It would therefore have blocked off the air supply resulting in no air pressure (at the max. torque position).

7.5.2 7R - With the right bank timing $9^{o}$ ahead, the valve would be closed at $106^{o}$ ATC instead of $115^{o}$ ATC. Therefore for the attempted start there would have been no high pressure in this cylinder.

7.5.3 Two out of three cylinders would have had no high pressure air and evidently the one remaining cylinder did not generate sufficient torque to break the engine away. The engine is not required to start under such adverse conditions.

7.6 On June 26, 1986 the right bank starting air timing was corrected, and there is evidence to suggest that the timing had not been changed since the engine was tested in Grove City. Our assembly and test procedures do not require the actual setting of this timing to be recorded. We demonstrated the adequacy of the timing on test by virtue of being able to start and load the engine within the specified time of 10 seconds.

## 8.0 Summary/Conclusions

8.1 No. 3 left air starting valve insert came loose because of the use of copper plating - the copper yielded due to thermal changes.

8.2 No. 7 left air starting valve insert did not have the correct fit because of a misapplication.

8.3 The engine "locked" in one certain position because the number 3 left valve insert moved down with the valve and blocked off the air supply to that cylinder, aggravated by the valve timing being too early.

W.H.A. Lambert

File/SO 0407/P5
11-1