

Confirmation of Diagnosis

Exhaust Valves Phase Shift

Summary - This document consists of the report of detection and verification of the failure of an exhaust valve in a Waukesha P9390 GSI engine with 4000 running hours. The engine was monitored with Windrock technology, the results were analyzed by detecting a phase shift in the closing signal of the exhaust valve.

I. INTRODUCTION

The engine condition analysis is based on vibration and ultrasonic measurements taken with the WINDROCK 6320 PA equipment to the cylinder head and engine frame. The analysis results in the following priority repair recommendation:

Cil 1L the signal of the closing of the exhaust valve is observed out of phase, we suggest to check valves clearance and inspection of hydraulic tappets.

II. DEVELOPMENT

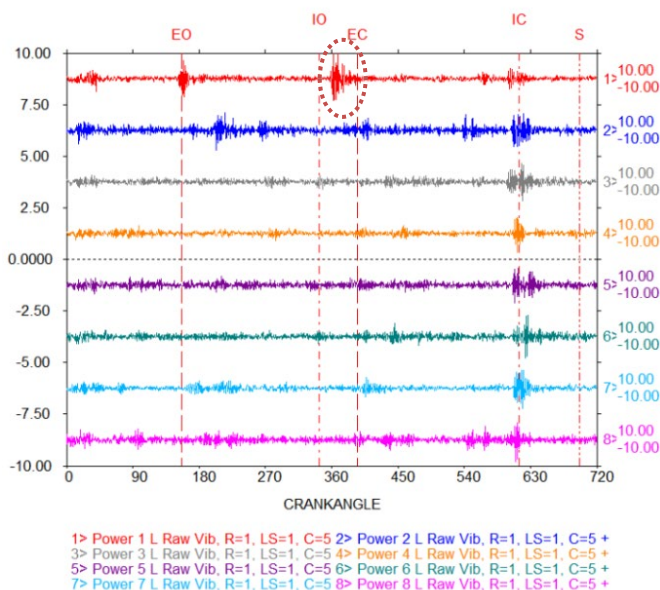
1. Detection.

i. Theoretical references:

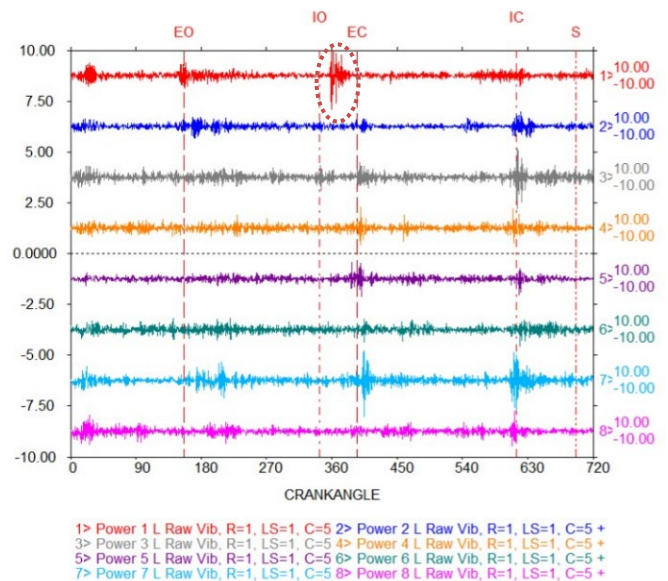
Early closing of the exhaust valve indicates a problem of excess clearance or damage on the hydraulic tappets.

ii. Measurement:

Graphics are obtained from the measurement done with the WINDROCK equipment on the Waukesha P9390 GSI gas engine.



Graph 1: Measurement Ref 1: Vibrations Raw (unfiltered) in drive heads L, cylinder 1L (red), sensor in vertical direction respect to piston displacement direction.

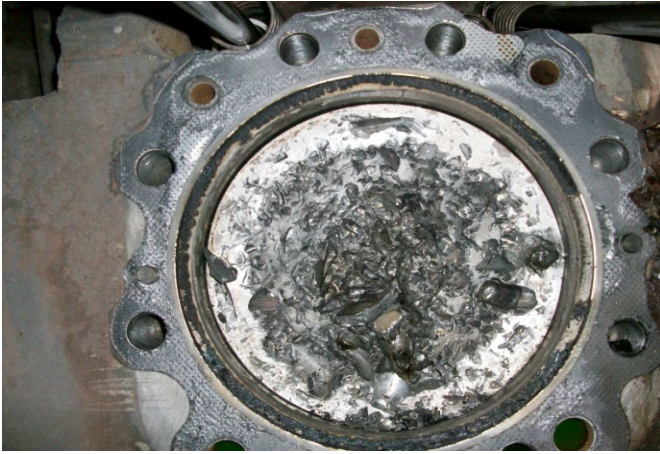


Graph 2: Measurement Ref 2: Vibrations Raw (unfiltered) in drive heads L, cylinder 1L (Red), sensor in vertical direction respect to the movement of the piston.

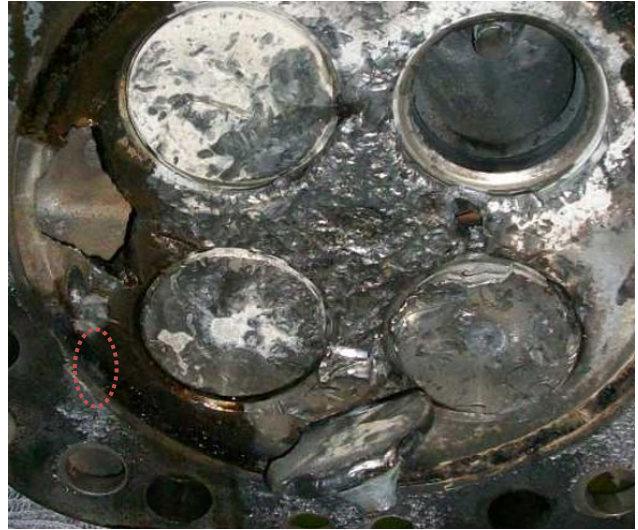
The measurements corresponding to both previous graphs were collected with a temporary time gap of 5 months. By not performing the maintenance suggested by the Consultant after the first measurement (Graph 1), it is corroborated that the magnitude of the vibrations in the exhaust valve increases when the second measurement is made (Graph 2).

2. Testing & checks

Because the engine continued the service knowing the existence of the valve phase shift and without taking preventative actions, the exhaust valve shaft is finally cut off. In figures 1 and 2 it can be visually verified that the diagnosis obtained from the previous measurements made and the corresponding analysis was adequate.



Picture 1: Piston & block face.



Picture 3: Cylinder head – Exhaust valve head



Picture 2: Cylinder head

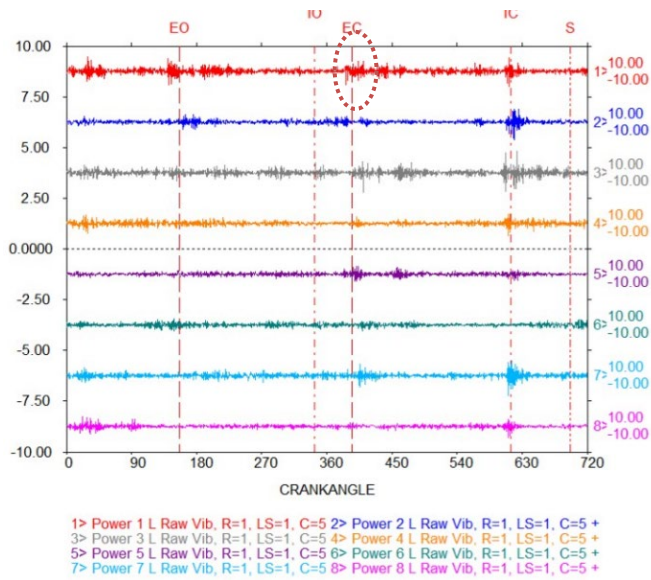
3. Repair

Faced with the destruction of the components, the costs of repair of the engine included the following items, where the construction parts were replaced in their entirety

- Cylinder head
- Liner
- Piston
- Air inlet turbo-compressor
- Engine oil replacement and carter cleaning
- Valves
- Manpower cost for complete repair
- Non-Production Operative cost for the compression unit hours stopped.

If, on the other hand, the maintenance had been carried out when the anomaly was reported, the expenses would have been:

- Hydraulic tappet replacement
- Valves clearance checks
- 1 hour compressor engine downtime.



Graph 3: Vibrations Low Freq in cylinder banks drive L

After the complete change of the equipment, the correction of the time lag in the closing of the exhaust valve of cylinder 1 of bank L is verified by a new measurement.