# WORK REPORT

## FOUNDATION REPAIR, RE-ALIGNMENT AND REGROUT K-6510 COMPRESSOR

## COURONNAISE DE RAFFINAGE PETIT COURONNE REFINERY

**Customer:** Couronnaise de Raffinage

**End-User:** Shell Petit Couronne Refinery

**Location:** Petit Couronne, Rouen, France

**Project:** Repair of damaged foundation, replacement of all anchor bolts, redesign of crosshead support base, and regrouting of all elements.

**Equipment:** K-6510 Recycle Gas Compressor

**Work Period:** 11 July 2005 - 21 July 2005

## 1. Project Summary

The compressor in question is a Burton Corblin type 164 ME 250 single cylinder compressor, driven through belts by a 45 kW electric motor at 500 rpm. The machine was installed in 1977, without using any proper grout - i.e. directly on the concrete, and has been operating practically continuously for years. During this time the lubricating oil leaking out from the crankcase has worked its way into the concrete, and down the separations between anchor bolt and the concrete fill material used as grout, and between this grout and the foundation itself. The concrete under the crankcase has lost its resistance to compression, so the machine has been shimmed with thick steel plates. Since these steel plates were resting on deteriorated concrete, they did not help the situation. The vibrations have been increasing and the anchor bolts have been deformed by the impacts of the crankcase. Finally one of the crankcase anchor bolts sheared completely, and the unit came to an undignified and catastrophic halt. The crankcase and the crosshead casing were both severely cracked, and have since been repaired by metal stitching.

The original brief was to repair the foundation, remove the damaged grout/concrete, and replace the crankcase and crosshead support anchor bolts. However, after removal of the motor mounting slides, the anchor bolts were found to be badly corroded, and these were also cored out and replaced. Since there is the possibility that the crankcase may be replaced by a new or reconditioned unit in future, a soleplate installation was recommended, and designed. There was some confusion about the exact dimensions of the crosshead support, since the existing damaged support did not match up with the original drawings. Eventually a consensus was reached as to the probable correct dimensions, and the client accepted the fact that these were possibly not accurate, and that in-situ machining might be required when the repaired unit is returned.

The crosshead support, the soleplates, and the motor bases were therefore aligned in vertical and horizontal planes, and grouted in place with ALPHATEC® 800 Epoxy Grout. Grade 8.8 fully threaded rod was used as the replacement anchor bolt material, and was fully grouted to a depth of at least 12 diameters. The upper part of each anchor bolt was isolated from the grout to allow for a proper stretch length of at least 6 diameters.

Once the machine has been reinstalled it is important that the bolts should be tightened to the proper loading, which we define as 50% of the yield strength. Grade 8.8 bolt material has a nominal yield strength of 640 N/mm$^2$, so the recommended fastening load is 320 N/mm$^2$. The size, cross-sectional area, fastening load, and torque to apply for the bolts used are as follows:

| | | | | |
|---|---|---|---|---|
| Crankcase anchor bolts: | M27 | 459 mm$^2$ | 146,880 N | 793 N.m |
| Crosshead anchor bolts: | M22 | 303 mm$^2$ | 96,960 N | 427 N.m |
| Motor base anchor bolts: | M22 | 303 mm$^2$ | 96,960 N | 427 N.m |

In order to protect the foundation concrete from further oil ingress, the top surface and a short distance down the sides was chipped, and epoxy grout poured overall as a protective capping.

For **ALPHATEC ENGINEERING (EUROPE) LTD**,
ARONUI TECNOLOGIAS S L,

Giles Goldsbro,
Technical Director.
01 August 2005

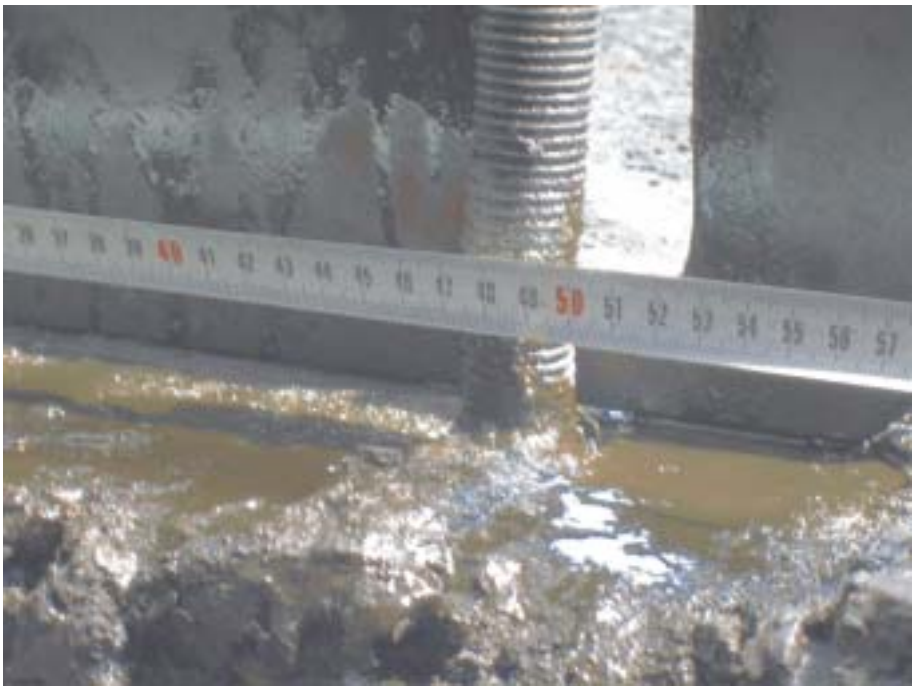
1.
5 July 2005. The Alphatec Engineering team was called in to evaluate the condition of the foundation after the compressor had already failed. The broken anchor bolt, and heavily oil-soaked concrete under the crankcase is immediately obvious.

2.
The compressor failure had been sufficiently violent to knock a piece of concrete out of place.

3.
The motor mountings initially appeared to be satisfactory.

4.
The foundation appeared to have been well constructed, with no obvious cold joints or separations.

5.
11 July 2005. Mobilization was rapid, and work started less than a week after the initial inspection. The first job was to check some critical dimensions.



6.
The centrelines of the anchor bolts, despite the distortions, appeared to correspond to the available drawings.

7.
When the motor bases were removed it became obvious that there was a considerable amount of corrosion of both the bases, and the bolts.

8.
Chipping off the corrosion products revealed significant necking of the bolts, and the decision was made that they should all be replaced as well.

9.
Since the crosshead support had been redesigned to use 4 anchor bolts, these damaged bolts could be simply cut off, and abandoned.

10.
Chipping of the damaged grout and concrete started the first afternoon, and went quickly, due to the oil-soaked condition.

11.
The blue-tinted cement which had been used for the anchor bolt grouting appeared to be a non-shrink grout mixed with aggregate - quite a good approach to the job, but the interface between grout and foundation concrete suffers badly from oil penetration.

12.
The amount of distortion of the crankcase anchor bolts was extraordinary.

13.
12 July 2005. A rotation-percussion rock drill was used to drill the new holes for the crosshead support anchor bolts, while the coring machine was being set up.

14.
Cores were drilled to 1000 mm from the foundation surface to ensure full removal of the existing bolts.

15.
Diamond core drilling is a tedious business that continued throughout the week, in order to complete the removal of 10 anchor bolts.

16.
15 July 2005. Chipping and coring complete. The PE plugs have been pushed into the tops of the holes to prevent the first pour grout entering.

17.
Formwork set in place, with a polypropylene liner stapled to the inside of the plywood as a release barrier.

18.
17 July 2005. ALPHATEC 800 epoxy grout poured to give a working level for installation of the soleplates.

19.
19 July 2005. All motor base bolts were finally removed, & the concrete under the bases chipped out and grouted for ease of re-installation. Note the copper tubing in the centre of the motor foundation. These tubes are set into a 1.5 m deep hole drilled into the foundation to ensure that the mass of concrete above the base of the anchor bolts is properly bonded to the mass below. Another hole is seen in the centre of the compressor plinth.

20.
20 July 2005. During injection of the ALPHATEC 370 resins into these injection holes, some resin outflow was seen on the foundation side, indicating good coverage.

21.
Resin outflow during pressure injection.

22.
Resin outflow was also seen at the compressor end of the foundation.

23.
The soleplates were set up at an appropriate height using the laser level, and then levelled and aligned accurately by precision spirit levels, and other measuring devices.

24.
Once the position of all the bases was fixed with reference to the centreline, and to one another, the formwork was reset for the main grout pour.

25.
ALPHATEC 800 epoxy grout was mixed and poured to embed the crankcase soleplates, the crosshead support base, and the motor bases, and allowed to cure overnight.

26.
21 July 2005. Forms were removed in the morning, and sharp edges ground off.

27.
In order to protect the remaining area of bare concrete under the crankcase, it was chipped back to sound concrete, and a layer of epoxy grout poured.