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WORK REPORT:
Foundation repairs and regrout for motor and compressor unit k2701-2

Customer: Shell CAPSA. Buenos Aires.

End User: Shell CAPSA. Buenos Aires.

Location: Refinería Buenos Aires - Sargento Ponce 2318 (1871) Dock Sud - Buenos Aires,

Project: 1412314 Foundation repairs and regrout for motor and compresor unit k2701-2

Work Period: 13-23 Marzo 2015

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1. DESCRIPTION.

The unit in question is a 4 cylinder reciprocating C25-4 Howden Thomassen compressor, with direct coupling through an inertia wheel to a Siemens electrical motor, P_n=1,750kW working at 372rpm.; total weight 60 Tn.

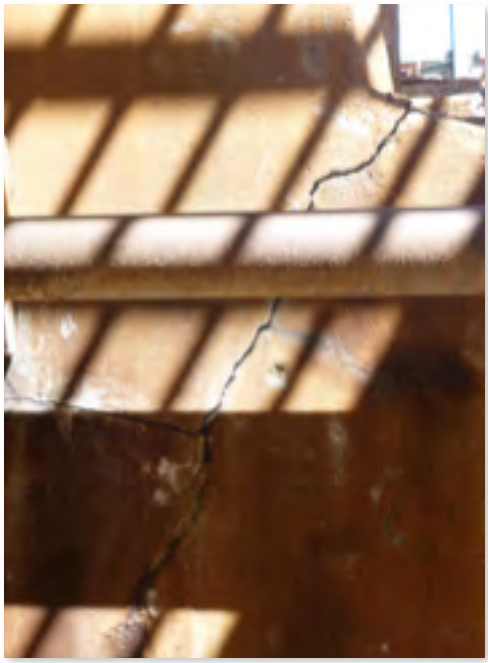
The foundation seems to be constructed from a sole block with two sections of different hight: one for the crankcase & cylinder supports and the other (lower) for the motor. Both sections rest on top of an underground mat, 900 mm. in thickness and with 9 x 7,2 m. according to the drawings provided.
The foundation drawings suggest that the total volume of concrete is approximately 93 m^3, reinforced, and including the underground mat the total weight is 223 Tn.

Both the crankcase and the base of the cylinders are anchored to the foundation with 1"1/2 grade 5.6 and 1200 mm long bolts. The anchor bolts are distributed 4 on each cylinder support and 6 in total for the crankcase, tightened up to 990 N·m,
The grouting made is "full bed" meaning that the grout is in direct contact with the base of the equipment, which is slightly embedded in it.

The electric motor is mounted on 4 support plates. Each one has a 1"1/2, grade 5.6 and 1200 mm. long anchor bolt, with the same tightening torque as the other ones.

2. EXISTING CONDITIONS.

The following points where highlighted as problematic, and individually or combined should probably be responsible of the strong vibrations experienced in the machine in question and will be addressed in the repairs.



2.1. A big crack appeared, starting from the foundation step between the motor and the compressor. This crack stretches from side to side of the foundation at 225 degrees and is approximately 900 mm in length. Oil is leaking through the crack, worsening its condition and accelerating the damage process. This type of crack has developed due to cyclical forces arising from an angular misalignment between motor and compressor, whose frequency doubles the rotating speed, and because the nature of a change in section, which acts as a stress concentrator.

2.2. There are also minor cracks developed throughout all the foundation. Many of those minor fissures follow a squared pattern that seems akin to rebar, and are caused by concrete retraction and a rebar that is too close to the surface. Other fissures follow a horizontal pattern at

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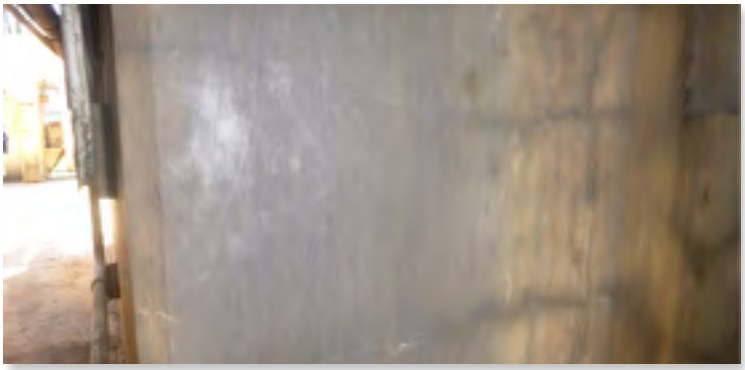
approximately 1200-1300 mm from the top of the foundation which corresponds to the depth of the anchor bolts termination. Those are called **cold joints** and are originated during the construction stage, when the pouring of concrete is stopped to check alignment and position of the anchor bolt recesses.



2.3. There is an obvious cold joint between the underground mat and the foundation.

2.5. The grout health supporting the crankcase and motor is quite poor. It's a cementitious grout, and appears to be cracked in multiple places, with defective adhesion to the foundation and not installed according to the API RP 686.

2.7. The grout should, but it's not:

A. Cover at least 3/4 of the base thickness.

B. Cover up all the crankcase, extending the footprint area as much as possible.

2.8. Adhesion failures in several places, mostly on the driven end.

2.9. Regarding the motor, the baseplates are completely corroded which could be one of the causes of the misalignment. They should be removed, machined and reinstalled properly, using proper INOX shims, rounded corners and epoxy grout.

2.10. Anchor bolts are of steel quality 5.6 and tightened to 990N·m. We recommend higher torque, between 60-70% yield so anchor bolts should be retightened to 1,450 N·m to hold down the machine, and the best grout AT800 to uphold it in place, maintaining long lasting alignment.

A resin injection near by every anchor bolt to ensure and strengthen the anchoring system of the compressor and near the motor to address all the cold joints will be applied.

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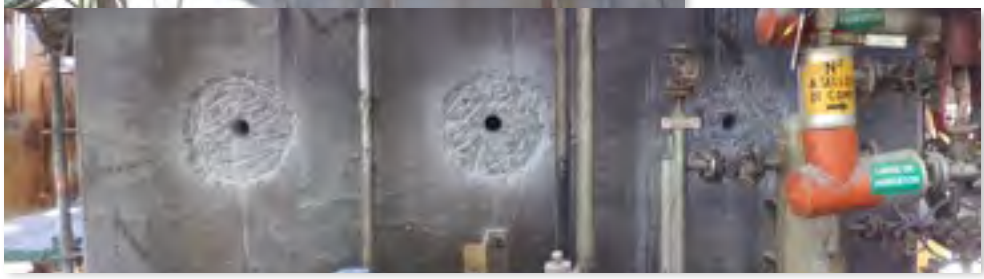
3. REPAIRS CARRIED OUT.

The repairing process was executed with the compressor *in situ,* and the motor removed for proper maintenance proceedings.

3.1. Horizontal and vertical perforations where done, using a ∅ 65mm diamond crown core drill and a ∅ 45mm rotary-percussion drill.

In the horizontal ones the proper surface preparation was carried out to house the steel discs (washers) and the epoxy sealing material.



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3.2. The deteriorated grout was removed around and beneath the crankcase until healthy concrete was encountered. The Alphapad® hydraulic system upheld the equipment in place during all the proceedings.

A layer of approximately 50 mm was also removed from the upper surface of the drive end of the foundation.

The side surfaces where inspected and all mayor cracks found where outlined and deepened, to be covered up afterwards with an Alphatec resin filled with thixotropic aggregates.

3.3. Dywidag bars where prepared with vent and injection tubes, and each one of them measuring the proper length, was inserted in each vertical hole.

In the horizontal holes, grade10.9, fully threaded steel bars where installed along with injection and vent tubes, and sealed with the discs (washers) and the thixotropic epoxy material.

A reasonable amount of resin was poured to act as a blockage or plug to be able to raise the injection pressure inside the vertical holes.

In the horizontal holes, the bars where tightened a bit (10% of the yield), using on one end standard hexagonal nuts, and on the other end Superbolts, which will be tightened to 70% yield just after the injection is finished.

3.4. Once all the surfaces are cleaned and while the motor plates are properly machined, edges smoothened etc, a preliminary pour was done with epoxy resin AT800 to encapsulate the foundation as much as possible, covering all the upper surface and thus improving the pressure injection.

3.5. When the resin poured is cured, the injection procedure is prepared and done in a couple of hours. A total of 340 litres of pure AT342 epoxy resin was injected, distributed as evenly as possible in all the vertical and horizontal holes.

3.6. Immediately after finished injecting, we tightened the Superbolts to the calculated 70% yield, applying 90 N·m to each one of the superbolt nuts, inducing a tension higher than 360kN on each horizontal bar.

3.7. Before installing the motor, formwork for the compressor had to be installed.

3.8.The alignment specialist measured planarity and horizontality of the crankcase and certified that they where within admitted tolerances for the equipment.

3.9. After using epoxy putty to seal all the possible leaks, all nuts where protected and all the surfaces cleaned, the crankcase and the cylinders bases where grouted with AT800, embedding 3/4 of the total hight of the base.

Formwork sealed, nuts and all the adjoining elements protected.

All anchor bolts where isolated from the grout using PE foam.

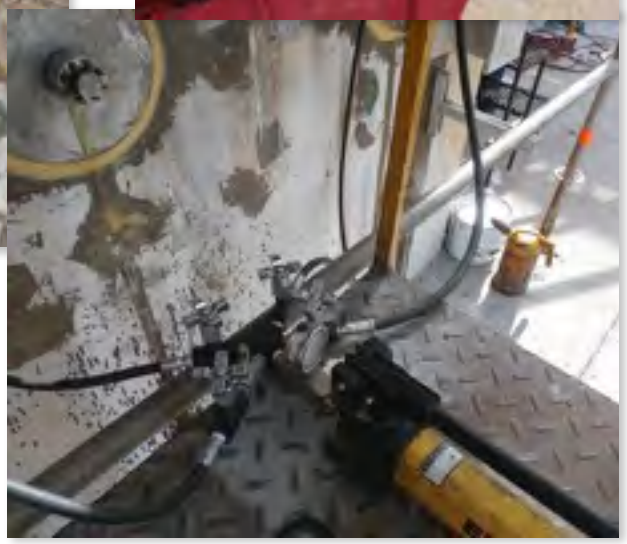
At the same time, a small pour of self levelling AT800 resin was poured on each one of the motor supports, to be able to install 4 Alphapads levelled properly to ease the subsequent aligning process.

3.10. For the motor, before installation the base plates and shims had to be already machined . Before lifting it to its final position, the 2 mm. thick shims and base plates where installed and tightened on the motor.

Immediately after, the crane lifted the motor and left it in position, on top of the four middle-sized Alphapads.

All four Alphapads where connected to a distributor to control individually or jointly the pressure for the alignment of the system.

The alignment was carried out following the instructions of the specialist and the experimented workers and engineers of Shell.



The motor-compressor axis was aligned using first laser equipment for the measurements.

- Firstly measurements of the space between the compressor coupling and the motor where taken with a

dial gauge.

- After, using laser equipment, coaxiality between both compressor and motor axis was determined.

- Once tightened the coupling bolts, we measured the web deflection in the crankcase. The motor was moved accordingly, and adjusted to measure web deflections values of 0,01 mm. The Alphapad system was a great help and made aligning an easy job. Only one 2 mm thick shim per footing was installed between the motor and the baseplate to be able to align the motor when needed.

3.11. The formwork was installed after all aligning measures where correct. AT800 was mixed and poured immediately after, embedding 3/4 of the motor baseplates.

3.12. Before relieving the pressure on the Alphapads, a surface hardness check is necessary to verify to what extent the resin has cured. Approximately, a Shore hardness above 80 guarantees a curing above 90%. cured.

3.13. The whole foundation was painted with epoxy resin as protection method against the elements, all the edges where chamfered and the work area was cleaned.

3.14. The job is finished when all the anchor bolts are tightened. This was carried out by Shell.

En Valencia, a 2 de Abril de 2015