EFRC Training Workshop

Foundation design for reciprocating compressors

Anchor Bolts Design considerations

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Anchor Bolt Design Considerations

1. Static Load on grouting and concrete
2. Anchor bolt type and selection
3. Friction coefficient, edge distance and spacing
4. Anchor bolt, installation and execution
5. Fatigue and thermal expansion considerations
6. Frame anchor bolt fatigue

1. Static Loads

a. Anchor bolt preload
b. Compressor deadweight
c. Limits of compressive loads on grout material and concrete

Static Loads

Anchor bolt preload required for

- Generating friction between frame and foundation
- Limiting the fatigue stress in the bolts
- Limitation of frame vibrations

Standard UNC thread series for bolt size up to and including 1", above 1" series 8 UN.

Static Loads

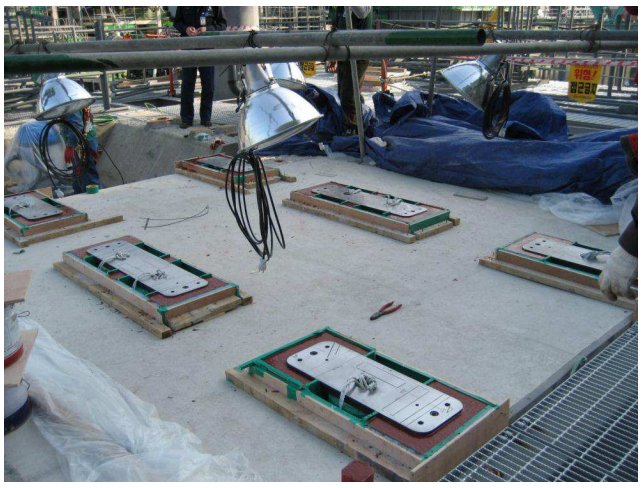
- Compressor deadweight

Static loads;

- Limits

Epoxy compressive strength and creep is very temperature dependent (oil sump temperature!!)

Epoxy chocks design pressure maximum 7.0 MPa.
(Marine industry 3.5 MPa, sometimes approval for 5MPa)



Static loads

- Limits

Concrete compressive strength minimum 28 MPa (API 618 5th edition refers to the API RP 686).

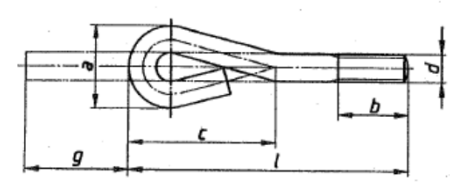
2. Anchor bolt type and selection

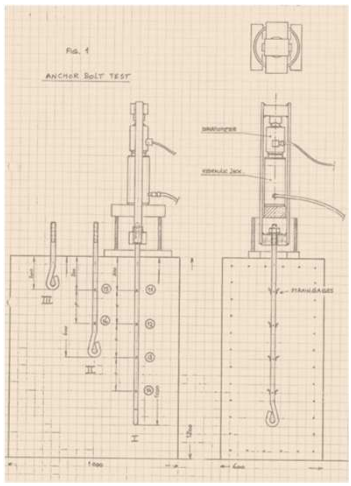
a. Summary of bolt types with advantages & disadvantages

b. Anchor bolt termination

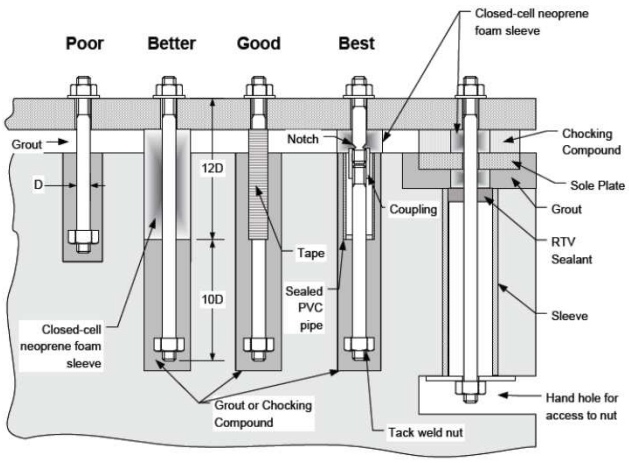
Anchor bolt type

More than 50 years HTC experience in gasengines and compressors





Anchor bolt type



Source ITW Technical Bulletin # 660A

2. Anchor bolt type and selection

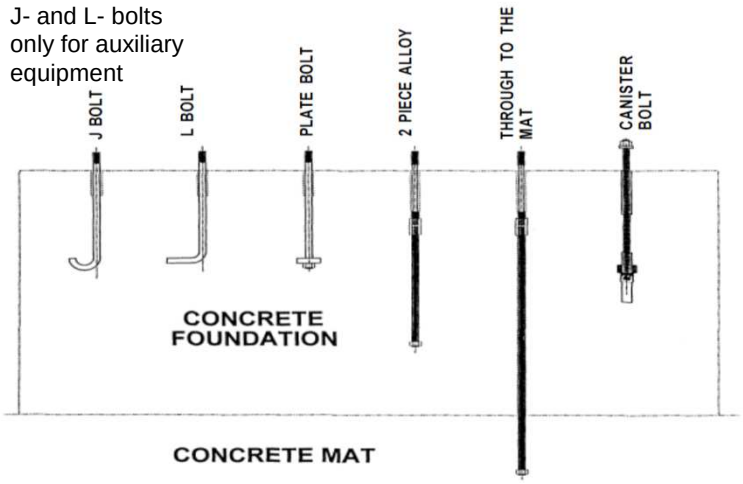
a. Summary of bolt types with advantages & disadvantages

b. Anchor bolt termination point

The simplest design would be a nut termination and calculations have been performed for both nut and plate termination.

Anchor bolt termination point

J- and L- bolts only for auxiliary equipment



Source GMRC report TR-97-2

Termination requirements

- A termination having a diameter of 3 times the bolt diameter or more meets the bearing load requirements
- GMRC SWRI Report No. TR 97-6 a termination plate diameter of three to four bolt diameters
- GMRC: the recommended termination thickness is 1.35 to 1.5 times the bolt diameter.

3. Friction, edge and spacing

a. Friction between footings and soleplates
b. Friction between footings/ soleplates and grout/concrete
c. Edge distance and bolt spacing

Friction, edge and spacing

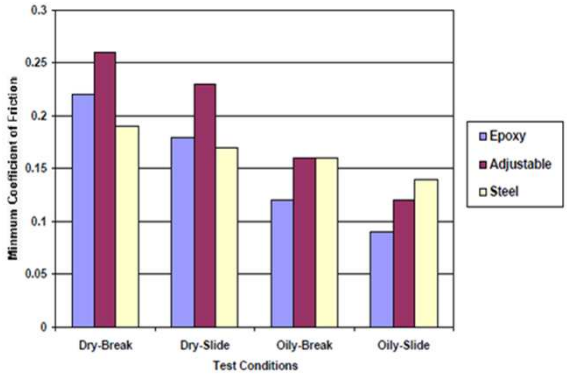


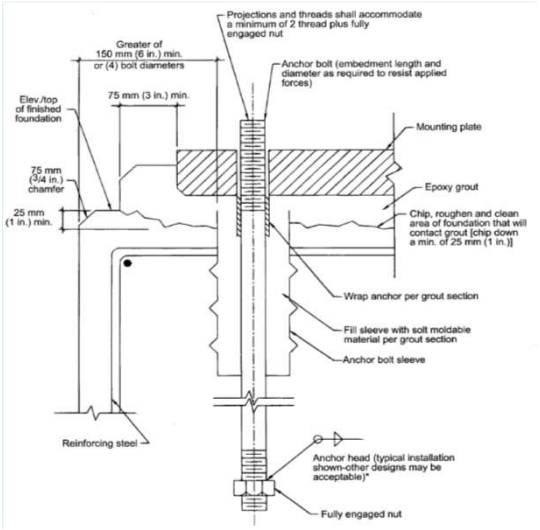
Figure 2-56. Minimum Friction Coefficient for Cast-Iron on Various Other Materials, from GMRC Technical Report TR97-3 [2]

Friction, edge and spacing

- Friction, based on clamping force and deadweight must be sufficient to restrain the Free Forces and Moments.
- Bolt design and load to meet a safety factor of 2 on the friction force

Friction, edge and spacing

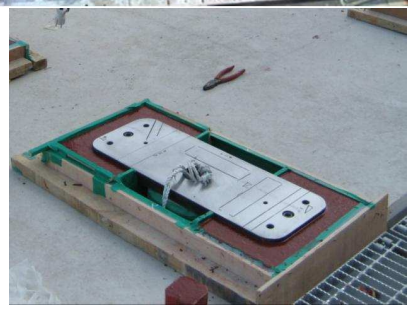
- API 686 2nd edition



4. Anchor Bolts installation

a. Pre-installed or post-installed
b. Thread and nut (design and lubrication)
c. Tightening
d. Bolt material and preload
e. Anchor bolt length: free, embedment
f. Bolt pockets (size and bond strength)

Anchor bolts
Pre-installed or post-installed



Thread and nut (design and lubrication)

- At least 2½ threads above the fully engaged nuts (API RP 686).
- Threads and nut bearing faces adequately oiled/greased (no molykote etc)

Bolt material and preload

Materials	standard	Grade 8.8	A193 B7
Minimum specified Yield strength (Mpa)	300	640	724

Bolt preload

is defined as a % of the minimum specified yield strength
Factors to be considered:

- Calculations are based on the tensile stress only.
- The applied tools determine the total stress (torque, shear and tensile)
- The fatigue stress range is determined by the prestress.
- The local stresses in concrete chocks and plates
- Bolt sizes.
- Stress intensification and corrosion.

The suggested allowable preload is between 50 and 70% YS
Higher strength materials than B7 should not be used

Bolt material

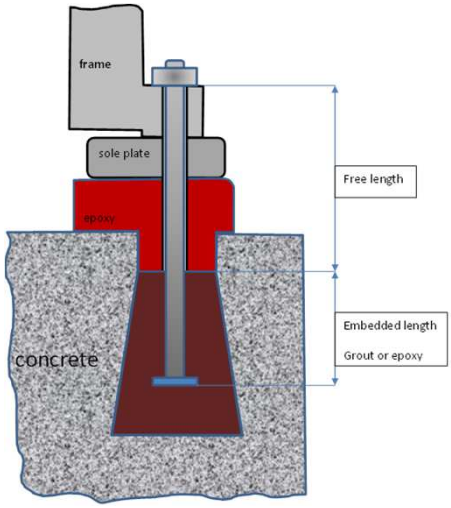
Low % yield strenght:

- Moderate stress level
- Design margin
- Less susceptable to corrosion and over torque

Tightening (torque-tension)

- calibrated manual torque wrench or hydraulic torque wrench
- hydraulic jack or the use of special nuts (preferred)
  - no torsional load on and torsional deformation of the anchor bolt during tightening

Length: free, embedment



Bolt pockets (size and bond strength)

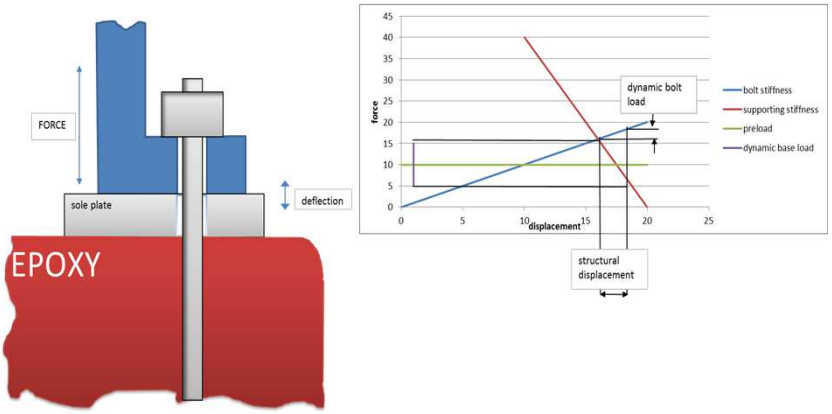
Pocket size and depth must be large enough to accommodate the tension and the shear force.

5. Fatigue and thermal expansion

a. Frame anchor bolts fatigue

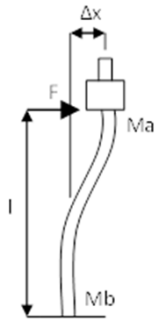
b. Effect of thermal expansion

Frame anchor bolts fatigue



Frame anchor bolts fatigue

Effect of thermal expansion



summary

- Anchorbolts to be designed to obtain a firm contact load on the foundation under all operational conditions
- Enough friction is required to stop the horizontal vibration
- Maintain sufficient edge distances
- The embedded and free length must be large enough to either ensure good long term integrity and to have sufficient elasticity for the horizontal thermal expansion
- Maximum compressive load on epoxy and concrete to be taken into account
- Do not use very high tensile strength steels to avoid stress corrosion effects
- Larger bolts and high strength steel bolt preferably tensioned by hydraulic jacks or special nuts
- Grout supplier instructions must be followed, eg. mixing quantities and mixing speed, temperature, layer thickness, time etc

Anchor Bolt Design considerations

End of Presentation