	نگهداشت و افزایش تولید میدان نفتی بینک	
NISOC	سطح الارض	HIRGAN ENERGY
	احداث ردیف تراکم گاز در ایستگاه جمع آوری بینک	

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طرح نگهداشت و افزایش تولید ۲۷ مخزن

CALCULATION NOTE FOR CAPACITOR BANKS

نگهداشت و افزایش تولید میدان نفتی بینک

D03	Aug. 2023	AFD	H.Shakiba	M.Fakharian	A.M.Mohseni	
D02	Jul. 2022	IFA	H.Shakiba	M.Fakharian	M.Mehrshad	
D01	Feb. 2022	IFA	H.Shakiba	M.Fakharian	M.Mehrshad	
D00	Nov. 2021	IFC	H.Shakiba	M.Fakharian	M.Mehrshad	
Rev.	**Date**	**Purpose of Issue/Status**	**Prepared by:**	**Checked by:**	**Approved by:**	**Client Approval**

Class:2	**Client Doc. Number: F0Z-709017**

Status:

IDC: Inter-Discipline Check

IFC: Issued For Comment

IFA: Issued For Approval

AFD: Approved For Design

AFC: Approved For Construction

AFP: Approved For Purchase

AFQ: Approved For Quotation

IFI: Issued For Information

AB-R: As-Built for Client Review

AB-A: As-Built –Approved

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5	X						55					
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1.0   INTRODUCTION

Binak oilfield in Bushehr province is a part of the southern oilfields of Iran, is located 20 km northwest of Genaveh city.

With the aim of increasing production of oil from Binak oilfield, an EPC/EPD Project has been defined by NIOC/NISOC and awarded to Petro Iran Development Company (PEDCO). Also PEDCO (as General Contractor) has assigned the EPC-packages of the Project to "Hirgan Energy - Design and Inspection" JV.

As a part of the Project, a New Gas Compressor Station (adjacent to existing Binak GCS) shall be constructed to gather of 15 MMSCFD (approx.) associated gases and compress & transfer them to Siahmakan GIS.

GENERAL DEFINITION

The following terms shall be used in this document.

CLIENT:	National Iranian South Oilfields CLIENT (NISOC)
PROJECT:	Binak Oilfield Development – Surface Fcilities; New Gas Compressor Station
EPD/EPC CONTRACTOR (GC):	Petro Iran Development Company (PEDCO)
EPC CONTRACTOR:	Joint Venture of : Hirgan Energy – Design & Inspection (D&I) Companies
VENDOR:	The firm or person who will fabricate the equipment or material.
EXECUTOR:	Executor is the party which carries out all or part of construction and/or commissioning for the project.
THIRD PARTY INSPECTOR (TPI):	The firm appointed by EPD/EPC CONTRACTOR (GC) and approved by CLIENT (in writing) for the inspection of goods.
SHALL:	Is used where a provision is mandatory.
SHOULD:	Is used where a provision is advisory only.
WILL:	Is normally used in connection with the action by CLIENT rather than by an EPC/EPD CONTRACTOR, supplier or VENDOR.
MAY:	Is used where a provision is completely discretionary.

2.0   SCOPE

This document covers minimum necessary requirements for the design, selection, manufacture, inspection, testing and delivery of Capacitor bank.

It shall be used in conjunction with data/requisition sheets for present document subject.

3.0   NORMATIVE REFERENCES

3.1   Local Codes & Standards

- IPS-E-EL-100 (1)   Engineering Standard for Electrical System Design
- IPS-M-EL-181 (2)   Material & Equipment Standard for Power Factor Improvement Capacitor

3.2   The Project Documents

- BK-GCS-PEDCO-120-EL-LI-0001-D04   Electrical Load List

3.3   Environmental Data

Refer to "Process Basis of Design; Doc. No. BK-GNRAL-PEDCO-000-PR-DB-0001"

3.4   Order of Precedence

In case of conflict between requirements specified herein & the requirements of any other referenced document, the most approved stringent requirements of below listed items shall be considered based on the approval given by the owner's representative:

- Purchase order
- Material Requisition
- MTO & Data Sheet
- This Specification
- Drawing & Other Specification
- Reference Project Specification
- Iranian Petroleum Standard (IPS)
- Reference international Code & Standards

When the term "Authorized", Authorization", "Approval", or "Approved" are used in this specification, it shall mean authorization or Approval from OWNER.

In case of any conflict between the project documents, the most stringent one shall be considered.

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4.0 CALCULATION

4.1 Calculation for LV Capacitor Bank

According to load list (BK-GCS-PEDCO-120-EL-LI-0001-D04):

Total Active Peak Load Power for LV switchgear is = 242.97+217.93+343.49=804.39 Kw

Total Reactive Peak Load Power for LV switchgear is = 137.83+118.78+213.61=470.23 Kvar

Therefore:

$\text{Tan}\,(\Psi_1) = \frac{Q}{P} = \frac{470.23}{804.39} = 0.58$ while $\text{Cos}\,(\Psi_1) = 0.863$

According to IPS-M-EL-181 power factor shall improve to 0.95

So $\text{Cos}\,(\Psi_2) = 0.95$ then $\text{Tan}\,(\Psi_2) = 0.33$

$$Q = P \times (\text{Tan}\,(\Psi_1) - \text{Tan}\,(\Psi_2)) \quad \textbf{formula(1)}$$

According to formula (1) we calculate:

$Q_L = 804.39 \times (0.58 - 0.33) \sim 201.09 \, Kvar$

According to basic document a coefficient 0.6 is required. So the capacitor will be 201.09x0.6
=120.654

According to above calculation, We choose two sets of 120 KVAR capacitor bank.

Also current of capacitor bank will be calculated from following formula:

$$I = Q/(\sqrt{3} \times 0.4) \quad \textbf{formula (2)}$$

According to formula (2):

$I = \frac{120}{\sqrt{3} \times 0.4} \cong 173.20 \, A$

We consider upstream breaker bigger that 1.5 I:

$I_b = 1.5 \times 173.20 = 259.8$

Then we select 315A MCCB circuit breaker.

4.2 Calculation for MV Capacitor Bank

Gas Compressor Power Factor Compensation

According to basic design, each gas compressor shall have separate capacitor bank. Based on Load

List, (BK-GCS-PEDCO-120-EL-LI-0001-D04):

Total Active Peak Load Power for C-2101A is 981.05 Kw.

Total Reactive Peak Load Power for C-2101A is 812.928 Kvar

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Therefore:

$$\text{Tan}(\Psi_1) = \frac{Q}{P} = \frac{812.928}{981.05} = 0.828 \text{ while } \text{Cos}(\Psi_1) = 0.77$$

According to IPS-M-EL-181 power factor shall improve to 0.95

So $\text{Cos}(\Psi_2) = 0.95$ then $\text{Tan}(\Psi_2) = 0.33$

According to formula (1) we calculate:

$$Q_L = 981.05 \times (0.828 - 0.33) \sim 488.56 = 500 \, Kvar$$

Therefore each capacitor bank shall be 500 KVAR for each Compressor.

According to ABB Manual Handbook (Attachment), Single Power Factor Correction is as follow:

Single or individual power factor connection is carried out by connecting a capacitor of the correct value directly to the terminals of the device which absorbs reactive power. This type of power factor correction is advisable in the case of large users with constant load & power factor & long connection times.

Individual PFC is usually applied to motors. The capacitor unit capacitors are connected directly to loads.

The usual connection diagrams are shown in the following figure:

Diagram 1   Diagram 2   Diagram 3
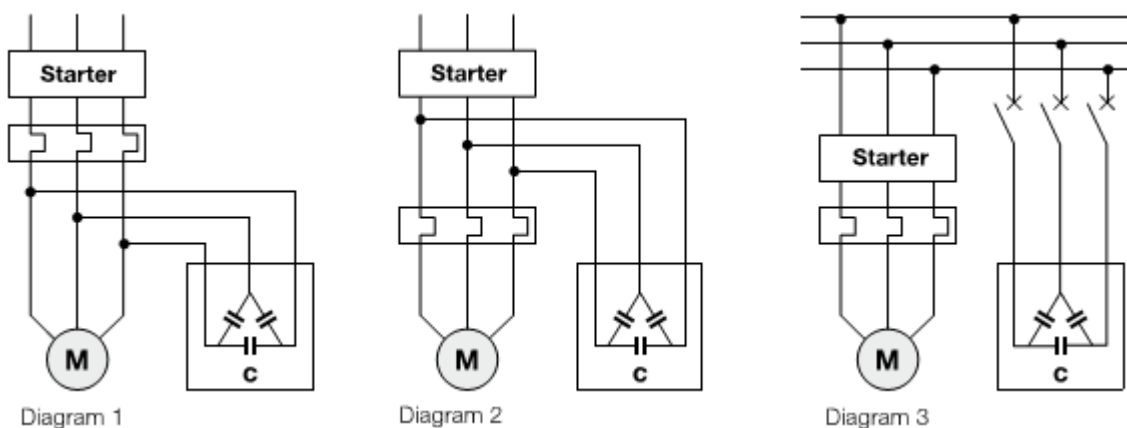
In the case of direct connection (diagrams 1 & 2), there is a risk of that after disconnection of the supply, the motor will continue to rotate (residual kinetic energy) & self-excite with the reactive energy supplied by the capacitor bank, acting as an asynchronous generator. In this case, the voltage is maintained on the load side of switching & control device, with the risk of dangerous overvoltage of up to twice the rated voltage value. Therefore total capacity should not be more

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than reactive power of motors at no load condition, because this may cause over voltages in the system.

However in the case of diagram 3, to avoid the risk detailed above, the normal procedure is to connect the PFC bank to the motor only when it is running & to disconnect it before the disconnection of the motor supply.

As a general rule, for a motor with power P, it is advisable to use a PFC with reactive power Q below 90% of the reactive power absorbed by the no load motor Q, at rated voltage U to avoid a leading power factor.

Considering that under no load condition, the current absorbed I_0 is solely reactive, if the voltage is expressed in volts, it results

$$Q_L = 0.9 \times Q = 0.9 \times \frac{\sqrt{3} \times U \times I_0}{1000} \ [Kvar] \quad \textbf{formula(3)}$$

Generally, no load current of motor is about 30% of full current & accordingly,

$$I_{Full\ Load} = \frac{P}{\sqrt{3} \times V \times Cos(\emptyset) \times \eta} = \frac{981}{\sqrt{3} \times 11 \times 0.77 \times 0.95} = 70.4$$

Based on

$$Q_L = 0.9 \times Q = 0.9 \times \frac{\sqrt{3} \times 11000 \times 0.3 \times 70.4}{1000} = 362\ [Kvar]$$

3 Sets of 360KVAR capacitor banks shall be designed for C2101A/B/C.

According to above calculation:

$Q_1 = 812.9$ Kvar

$Q_L = 360$ Kvar

Therefore $Q_2 = 812.9 - 360 = 453$ KVAR

After Power Factor Correction of Compressor, the active power is 981 Kw while reactive power is 451 Kvar, then power factor is Cos(Atan (453/981))=0.9

Power factor will improve from 0.77 to 0.9 .