Project Management Institute® Kingdom of Saudi Arabia

MOTOR PROTECTION FOR CANNED MOTOR PUMPS

Electrical & Instrument Signals

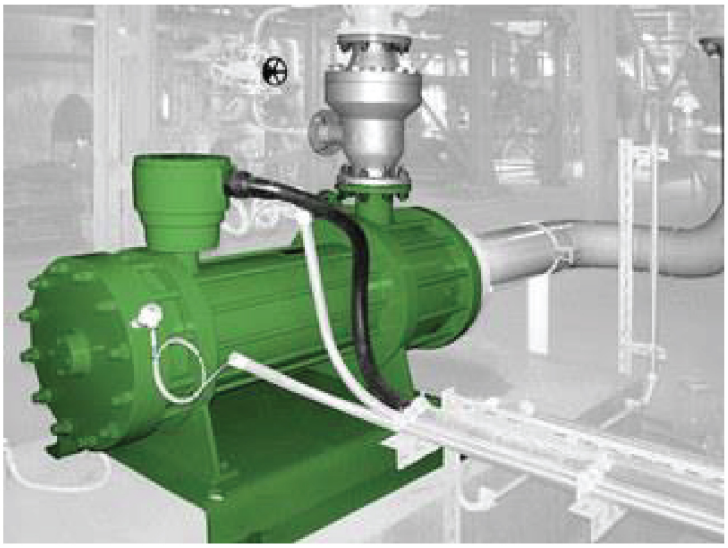
John Keogh

ABSTRACT

An introduction to the mandatory requirements for pump protection for canned motor seal-less pumps and how to connect them.

R&NGLPD/R&YRPD

Canned Motor Pump Protection.



Contents

Introduction

Responses to a survey conducted by CSD in 2021 revealed that Aramco has more than 300 seal-less pumps throughout only eight of its operating facilities. The survey concluded that most installations do not have the minimum mandatory pump protection even when used with processes that have high concentrations of hydrogen sulfide. Also, there should be more awareness of the protection requirements as these are related directly to safe and reliable operations.

There are two sub categories of seal-less pumps:

- o magnetic drive.
- o canned motor.

Both types are included in 31-SAMSS-658 and SAES-G-005. This document gives focus to the latter as two recent projects with R&NGLPD/R&YRPD have received technical queries from their respective EPC contractors regarding motor protection for canned motor pumps.

Note that Tanajib Gas Plant projects Department produced a knowledge asset in June 2021 that provides a very good overview of seal-less pumps and the intention of this publication is to give an in depth understanding of the protection requirements to assist engineers with design preparation.

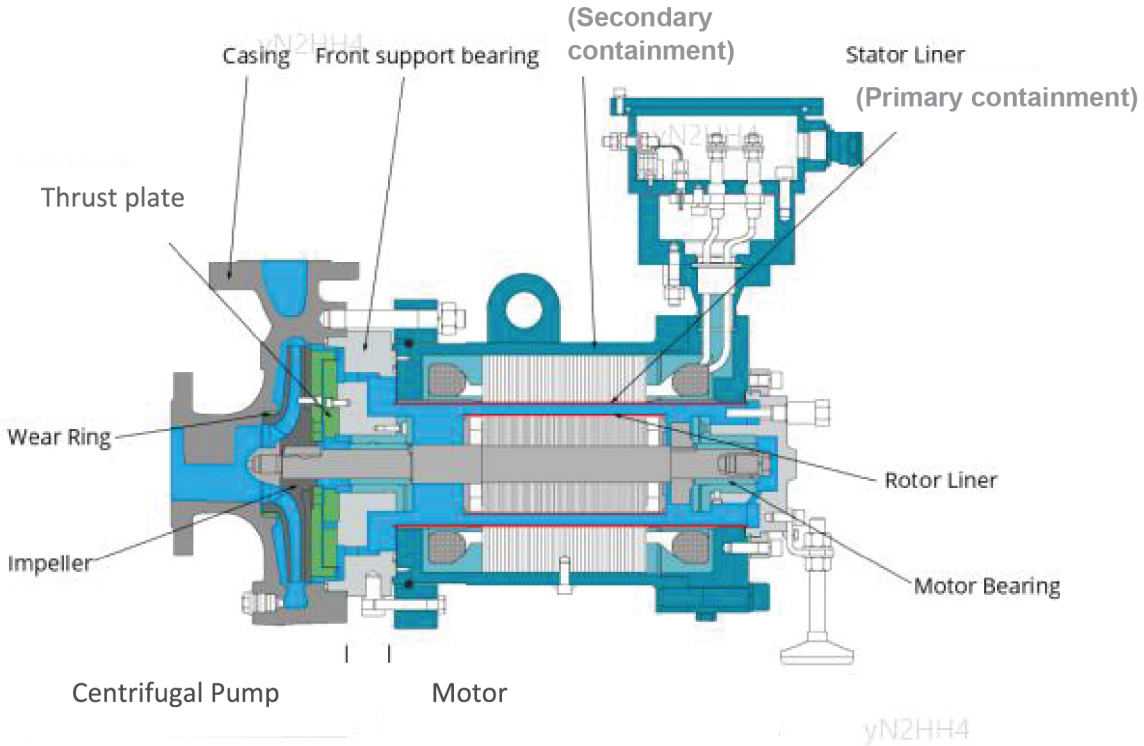
Acronyms

DCS	Distributed Control System
ESD	Emergency Shutdown
f	Frequency (usually measured in Hz)
H2S	Hydrogen Sulfide
Hz	Hertz (electrical supply cycles per second)
MCC	Motor Control Centre
ppm	parts per million
PS	Pressure Switch
RPM	Revolutions Per Second
RTD	Resistance Temperature Detector
SIF	Safety Instrument Function
SIS	Safety Instrument System

Pump design concept

Firstly, we should have a basic understanding of the canned motor pump design and then evaluate the protection strategies. It is significantly important to be aware that this pump design is often selected based on safety requirements due to the process containing high levels of hydrogen sulfide (⍰10,000 ppm) or having low autoignition temperatures. Ref. SAES-G-005 paragraph 4.1.
The diagram below shows a typical arrangement for a canned motor pump. The process fluid flows between the rotor and stator liners to provide cooling. However, for process fluids with normally high operating temperatures an external cooling water heat exchanger can be incorporated in the design.

Typical Horizontal Canned Motor Pump Arrangement



Note that the stator liner and the pump outer casing provide the primary and secondary containment.

Design advantages

This type of centrifugal pump offers a number of performance advantages but they do require some additional consideration with regard to monitoring the running condition parameters and safety interlock and these are identified in SAES-G-005, paragraph 4.1.1.6.1.
Advantages of using canned motor pumps

- The design offers a high level of environmental protection with regard to potential leakage of hazardous or toxic process fluids due to the double containment shell.
- Low sound levels during operation.
- No requirement for mechanical alignment between pump & motor as there is no mechanical coupling.
- Reduced cost of ownership due to high availability and reduced maintenance expenditure.

Appendix A of SAES-G-005 shows the selection process and for pump selection and demonstrates that a process with high concentrations H2S and/ or low autoignition temperatures are key factors in selecting canned motor pump design (due to their double containment shell).

Standard requirements

Aramco Standards Committee for pumps, seals & mixers publishes SAES-G-005 to provide the mandatory requirements for centrifugal pumps. Note that 31-SAMSS-685 also provides specific requirements as well as stating that the vendor and purchaser must have a clear understanding and be in agreement regarding the provisions made for dry run protection.
Table 1 below correlates the mandatory SAMSS & SAES protection requirements for canned motor pumps.

SAES-G-005 4.1.1.6.1.(d)		Bearing wear detection or shaft position sensor (unless ceramic bearings are used)
SAES-G-005 4.1.1.6.1 (e)	31-SAMSS-685 7.4.2.1	Description
i-	a)	Leak detection into pump stator
ii-	b)	Pump power monitoring of low flow monitoring
	c)	Temperature of liquid in motor section
iii-	d)	Motor winding temperature

Table 1

Note that the pump vendor may often require additional considerations such as:

i. Reverse rotation protection.
ii. Axial position monitoring
iii. Multiple sensors for winding temperature.
iv. Vibration monitoring.

It is recommended to incorporate all of the vendor protection requirements into the project design in order to retain the manufacturers warranty.

Protection signals

One of the concerns raised during the project detailed design relates to the connectivity of the protection signals; should they be connected to the process automation system or connected to the motor control center in the substation.

	Description	Alarm/ Shutdown
1	Leak detection into pump stator	S
2	Pump power monitoring or low flow monitoring	A
3	Temperature of liquid in motor section	A and/or S
4	Motor winding temperature	A and/or S

31-SAMMS-685 paragraph 7.4.2.1 (February 2022) stipulates the following mandatory warning and critical alarm requirements.

	Description	Alarm/ Shutdown
1	Leak detection into pump stator	S
2	Pump power monitoring or low flow monitoring	A
3	Temperature of liquid in motor section	A and/or S
4	Motor winding temperature	A and/or S

Table 2

Table 2 gives some guidance regarding where these signals should be connected.

Item 1, leak detection into the pump stator occurs when the primary containment has failed. This is detected by a pressure increase in the stator chamber and a pressure instrument will send this signal to the Safety Instrument System (SIS), typically and ESD system. One question that is often asked concerns why the leak detection does not have any pre-alarm or warning setpoint. The answer relates to the fact that the pressure entering the stator chamber will be around the same value as the pump suction pressure, (usually quite a low value) and it will happen at one time, (at the moment of failure) effectively a small and sudden increment.

SAES-J-601 (Emergency Shutdown and Isolation Systems) paragraph 6.1.2 discourages the use of process activated switches and so the specification in the material requisition to the pump vendor should specify a pressure transmitter. The default selection for most vendors is a pressure switch because it is less expensive.

SAES-J-601 [Reference]
Paragraph 6.1.2.
Process actuated switches shall only be used when ESD digital or analog transmitters are not suitable for the intended process service or measurement application. Process actuated switches shall be selected to be closed during normal process operation and shall open when the shutdown condition is reached.

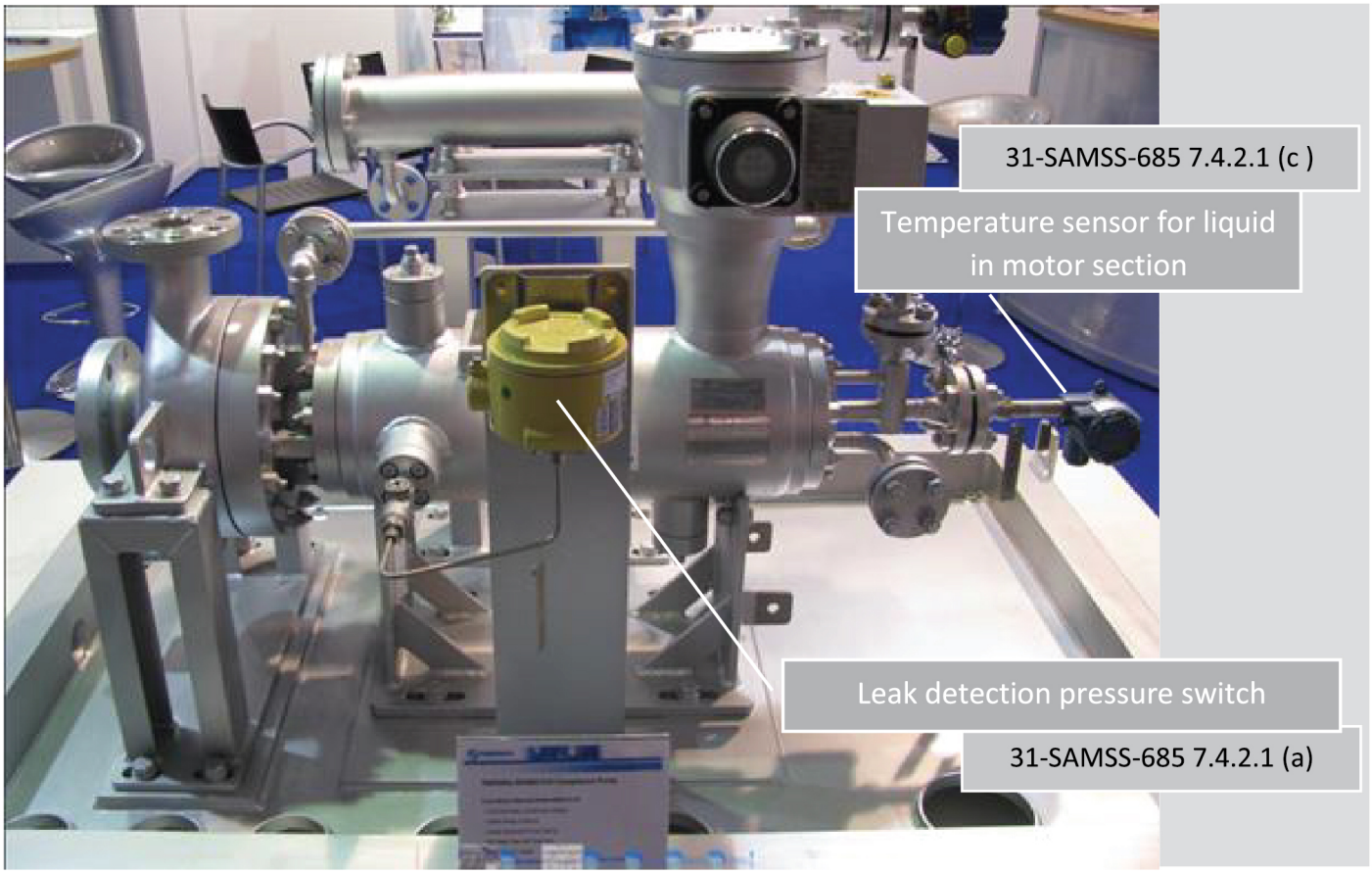
The other three signals will usually have a measurable rate of increase so that the control operator will receive an alarm and have time to make operational decisions as to whether to monitor the trend or to select another pump to take over. If a study such as a HAZOP identifies that a safety shutdown function is required then the signals will be connected as inputs to the SIS otherwise these can be connected to the process control system such as the DCS.
With regard to the second item in table 2, pump power monitoring or low flow monitoring, the designer has the option to use the functionality of a motor load control relay installed at the cubicle in the substation motor control center (MCC) to monitor the power.

This type of relay is installed on the front door of the cubicle and can be programmed to monitor current and power parameters and initiate a motor trip as the 37 relay function. Although this is a very cost-effective option, all aspects need to be considered.

i. It can connect to any process automation system to provide an analogue signal for the purposes of power monitoring and creating an alarm condition. if it initiates a motor stop then the control operator only receives an indication that the motor has stopped (and in local mode) because the breaker has tripped in the substation. The sequence of events recorder (SoE) will only time stamp the event as “pump stopped”.
ii. The control room operator can only monitor the power if the analogue monitoring signal is connected, otherwise there is no warning to the operator that the pump is running with abnormal current or power readings.

The alternative is to monitor the pump discharge flow with an electronic flow transmitter that provides a signal connect to the DCS with warning and critical alarm setpoints.

The image below shows a typical arrangement for a horizontal canned motor pump.



Pump speed.
SAES-G-005 paragraph 4.1.1.6.1 states:

b) The operating speed of canned motor pumps shall not exceed 3,600 RPM.

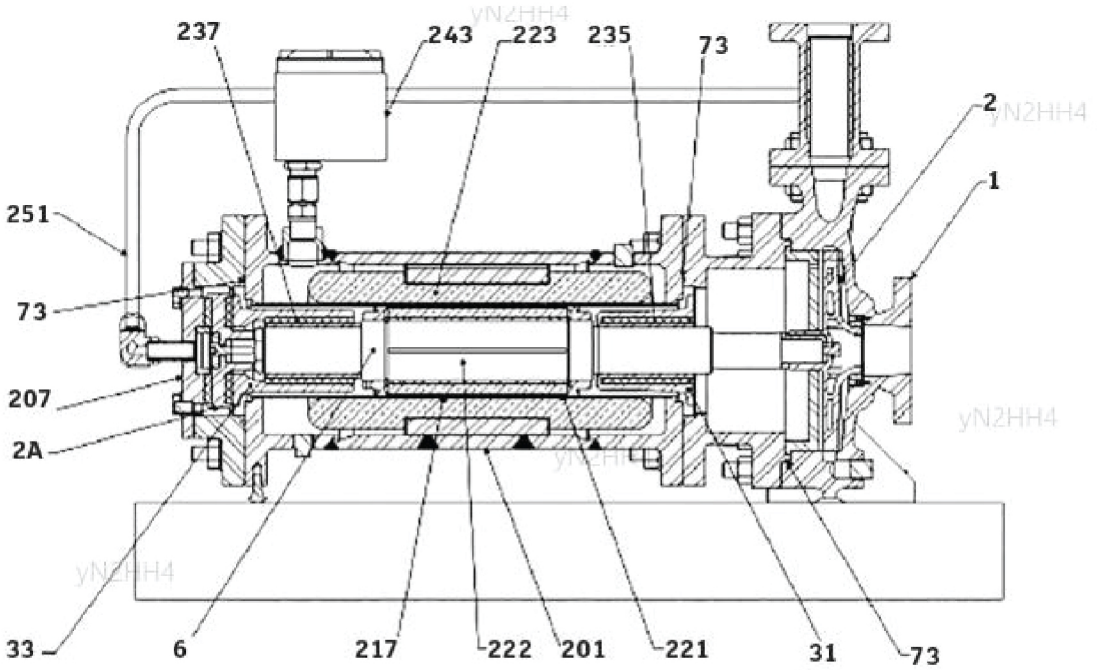
The operating speed of the pump is fixed by the frequency (f) of the main electricity supply and within Saudi Aramco facilities this is 60Hz and this equates to a maximum speed in revolutions per minute (RPM).

S = f x 60 = 3,600 RPM

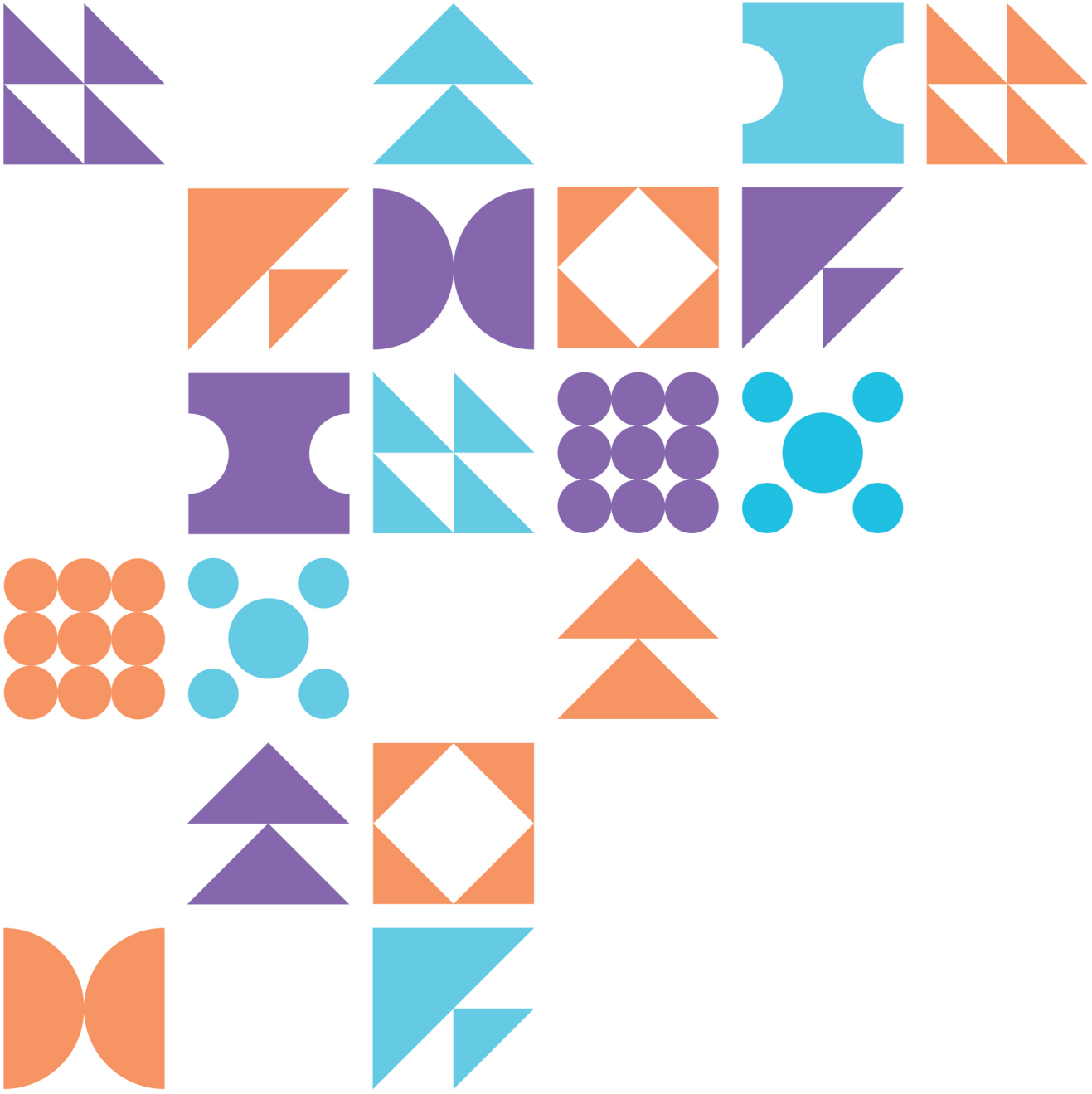
Accordingly, if the pump is correctly specified for connection to a 60Hz electrical supply then by default there is compliance with item (b) of SAES-G-005, paragraph 4.1.1.6.1. However, in the event of the motor being connected to a speed controller such as a variable frequency drive then limitations must be in place to prevent the speed exceeding 3,600 RPM.

Contractual reference.

Any vendor specific requirements that are additional to mandated by Aramco will most likely be unknown during the Project Proposal development and therefore it is important that the Scope of Work that is issued to EPC or LSTK bidders contains the statement: "Contractor shall consider all of the vendor and manufacturers recommendations for monitoring and protection of canned motor pumps that may be additional to those specified in SAES-G-005 and 31-SAMSS-685".



1	Casing	73	Gasket	223	Assembly, stator
2	Impeller	201	Housing, stator	235	Bushing, bearing, inboard
2A	Impeller, auxiliary	207	Cover, motor end	237	Bushing, bearing, outboard
6	Shaft, Pump	217	Shell, containment		
31	Housing, Inboard bearing	221	Can, rotor	243	Box, electrical connection
33	Housing, Outboard bearing	222	Assembly, rotor	251	Tube, circulation



Project Management Institute®
Kingdom of Saudi Arabia

pmi_ksa_chapter PmiKsaChapter pmi_ksa_chapter pmiksa.sa