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Influence of torque flow, pressure on the performance of a fire pump at the gas complex level

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Abstract: In recent years, motor pumps have played an increasingly important role in transferring fluids by increasing pressure, such as in power plants, hydrocarbon complexes and oil companies. Although these companies have advantages, their lack of maintenance can negatively impact their production, resulting in wasted costs and time, as well as putting human lives at risk. Restoration and modernization with improper maintenance or wrong policies can lead to critical and dangerous situations for equipment, the environment and people. And in this sense, we will be interested in the problem of protection against a fire in a gas installation; with the aim of carrying out a performance test of the electric pump which aims to evaluate the performance of the pump of the firefighting network of the gas complex. To achieve our objective according to the NFPA 20 Standard we have the following approach:

- Verification of measuring instruments.
- Installation of an ultrasonic flow meter.
- Application of the performance test on the fire pump.
- Controls flow according to pressure.
- Projection of the results obtained on the manufacturer's performance curve.
- The comparison between the manufacturer's performance curve and the performance curve obtained.
- Analysis of the results obtained.

Finally, to monitor pump performance, we recommend the immediate installation of a permanent flow meter at the pump discharge level and avoid any type of risk.

Keywords: *Fire network, Net height, Performance, Portable flow meter, Pressure.*

1. Introduction

Electric fire fighting pumps, according to the actual situation, there are fire sprinkler pump, fire hydrant pump, fire jockey pump, pressure booster pump [1]. Portable fire fighting pumps can also be divided into vertical and horizontal fire pump. Transmission liquid flow is one of the important performance data of fire fighting pump selection, carrying liquid flow directly affecting the total production capacity of the plant [1]. The fire pump performance test verifies that the pumps are capable of delivering the amount of water and pressure needed to extinguish a fire. Testing typically includes evaluating static pressure and working pressure, as well as pump flow. There are several standards and codes that govern fire pump performance testing, such as NFPA 20 and FM Global. These tests can be performed regularly to ensure that pumps are in good working order and ready for use in an emergency [2]. Firefighting networks are defined as the transport of fire extinguishing agents such as water and

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foam from water storage areas to fire risk areas. This network is characterized by the diversity of its components: cooling equipment, fire extinguishing (water consumers), large tanks, pumps, isolation valves, etc. It is also characterized by the instantaneous availability, on demand, of high flow rates and high pressures [3]. The 71PM05A electric pump is part of the complex's firefighting network. It is powered by sea water to meet fire-fighting needs in parallel with other pumps [4].

2. Pump test 71PM05 A

2.1. Electric Pump Characteristic

Drive Motor	
Builder	ABB
Model	400 RH 04VI
Serial number	954357
Nominal power	630 KW
Rated rotation speed	1475 tr/min
Tension	5500 V
Ambiente temperature	24/47
Pump 71PM05 A	
Builder	ITT
Model	VIT FF SIZE 24 EHC
Serial number	313812
Rated capacity	1400 m^3/h
Total Head	AP=11.2 bar G, soit 111 M

Before Starting	
Pump	**Observation**
Checking the opening of the valves of the sealing water circuit (Stuffing gland)	RAS
Make sure there is a small flow of water at each cable gland	RAS
Check the opening of the suction valve and ensure the positive indication of the suction pressure gauge	RAS
Motor	**Observation**
Checking the Motor-Pump coupling	RAS
Control Panel	**Observation**
Main circuit breaker switch in ON position	RAS
Checking the operating and absence of alarm parameters	RAS

In service	
Pump	**Observation**
Make sure there is a small flow of water at each cable gland	RAS
Check the temperature at the bearings and stuffing glands	RAS
Motor	**Observation**
Check the direction of rotation of the motor	RAS
Make sure the motor is running at rated speed	NA manque indication
Checking the power absorbed by the pump	NA manque indication
Checking the voltages and currents of the 03 phases of the motor	93-101 A /5500V
Control Panel	**Observation**

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Checking for absence of alarm	RAS
Off	
Pump	**Observation**
Make sure there is a small flow of water at each cable gland	RAS
Control Panel	Observation
Stop the pump by pressing the STOP push button	RAS

Testing start & stop modes

Item	Fashion	Result	Observation
01	Local boot	Concluding	RAS
02	Remote start from the control room	Concluding	RAS
03	Start in Auto mode by drop in network pressure	Not Operational	To be made reliable
04	Remote shutdown of the control room	Concluding	RAS
05	Local manual stop (STOP push button)	Concluding	RAS

Testing local measuring instruments

Instruments	Observation
Pressure gauge, discharge	RAS
Flow meter	Not installed

3. Performance Test

3.1. Checking the Valves Before Testing

State of Valves	Observation
All valves in the test line are open	RAS
All By-pass valves are closed	The two manual discharge valves are strapped
The main valves connected to the network are closed	RAS

3.2. Motor Pump Performance Test of 71PM05 A

Fire pumps are usually approved by a certification body and are powered by an electric or diesel engine or sometimes a steam turbine. In a firefighting installation, one or more fire pumps can operate as service pumps (50%) and the others are emergency pumps.

The fire pump routes water to the sprinklers to extinguish the fire. The number of fire pumps installed depends on the occupancy risk (high, medium or low) and the specific standard.

Due to the unavailability of a flow meter at the pump discharge, the flow readings were taken by a portable ultrasonic flow meter from the brand: GE, reference: PT878.

For reasons related to the operation of the ultrasonic flow meter, it was very easy to exactly set the percentage of the pump flow rate to all the values predefined in the procedure. The leakage flow rate through the two manual discharge valves which are strapped is estimated at 10%, it will be added to the measured flow rate values.

For safety reasons linked to the installation, the test was stopped at approximately 72% of the nominal flow rate (presence of water leaks proportional to the discharge pressure, at the level of the pump cooling line) [5].

NB: The pump discharge valve is located upstream of the two manual discharge valves.

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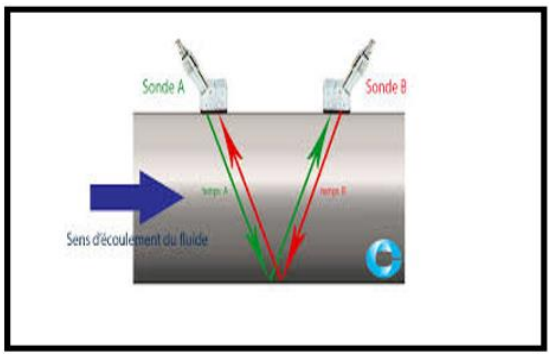

Figure 1.
Portable ultrasonic flow meter [6].

Table 1.
Flow rate readings based on pressure.

Flow (%)	Flow (m^3/h)	Flow +10% (m^3/h)	P.suc (Bar)	P. disc (Bar)	P.Diff (Bar)	Height Net realized (m)	Height Net constructor (m)	Gap (m)	% height net Realized/height nominal (111m)
0.00	0.00	NR	/	NR	NR	NR	148	NA	NA
38.85(*)	544 (*)	NR	/	NR	NR	NR	140	NA	NA
72.85	880	1020	/	11.5	11.5	113.81	122	-8.19	102.53
79.64	975	1115	/	11	11	108.86	119	-10.14	98.07
87.14	1080	1220	/	10	10	98.97	115	-16.03	88.35
99.28 (**)	1250	1390	/	9	9	89.07	110	-20.93	80.24
107.14	1360	1500	/	8	8	79.17	108	-28.83	71.32
128.57	1660	1800	/	6.2	6.2	61.36	95	-33.64	55.28
150	NA	NA	/	NA	NA	NA	78	NA	NA

Note:: NA : Not applicable; (*) : Min flow; NR : Unrealized; (**) : Considered nominal flow
P.suc : Suction pressure; P.disc : Discharge pressure; P.Diff : pressure difference.

For mechanical behavior, measurements were taken by the structure concerned following the procedure.

Table 2.
Thermal parameters.

Flow (%)	Pump temperature reading (°C)				Temperature readings of motor		Observation
	Cable Gland		Bearing				
	DE	NDE	DE	NDE	DE	NDE	
0.00	NR	NR	NR	NR	NR	NR	
38.85(*)	NR	NR	NR	NR	NR	NR	
72.85	NR	NR	NR	NR	NR	NR	
79.64	NR	NA	NR	NR	NR	NR	
87.14	NR	NA	NR	NR	NR	NR	
99.28 (**)	NR	NA	NR	NR	NR	NR	
107.14	NR	NA	NR	NR	NR	NR	
128.57	NR	NR	NR	NR	NR	NR	
150	NA	NA	NA	NA	NA	NA	

Note: NA : Not applicable; (*) : Min Flow; NR : Unrealized; (**) : Considered nominal flow

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Table 3.
Vibration parameters.

Flow (%)	Side	Pump			Motor			Observation
		Vertical (mm/s)	Horizontal (mm/s)	Axial (mm/s)	Vertical (mm/s)	Horizontal (mm/s)	Axial (mm/s)	
100	DE	3.23	3.17	2.81	2.69	2.15	NR	RAS
	NDE	NA	NA	NA	2.36	2.51	2.54	

Table 4.
Electrical parameters.

Flow	Flow	Voltage displayed (V)			Current displayed (A)			Observation
(%)	(m^3/h)	U12	U23	U31	I1	I2	I3	
0.00	NR	NR	NR	NR	NR	NR	NR	
38.85(*)	NR	NR	NR	NR	NR	NR	NR	
72.85	1020	5500	5500	5500	67	67	67	
79.64	1115	5500	5500	5500	67	67	67	
87.14	1220	5500	5500	5500	71	71	71	
99.28 (**)	1390	5500	5500	5500	71	71	71	
107.14	1500	5500	5500	5500	71	71	71	
128.57	1800	5500	5500	5500	67	67	67	
150	NA	NA	NA	NA	NA	NA	NA	

Note: NA: Not applicable; (*) : Min flow; NR : Unrealized; (**) : Considered nominal flow

Table 5.
Sound level.

Sound level readings at 1 m in (Db)							
A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
80	81	88	87.2	88.2	88.4	87	88.5

The sound level of the noise reaches values exceeding the tolerated threshold, therefore wearing a noise protection earmuff is recommended.

4. Evolution of the H.M.T of the Pump 71PM05 A Depending on the Flow Rate

By definition, the total manometric head (T.M.T) of the pump is the difference between the delivery head and the suction head of the pump (this can be calculated in pressure).

According to the results of the test carried out, the new performance curve is as follows:

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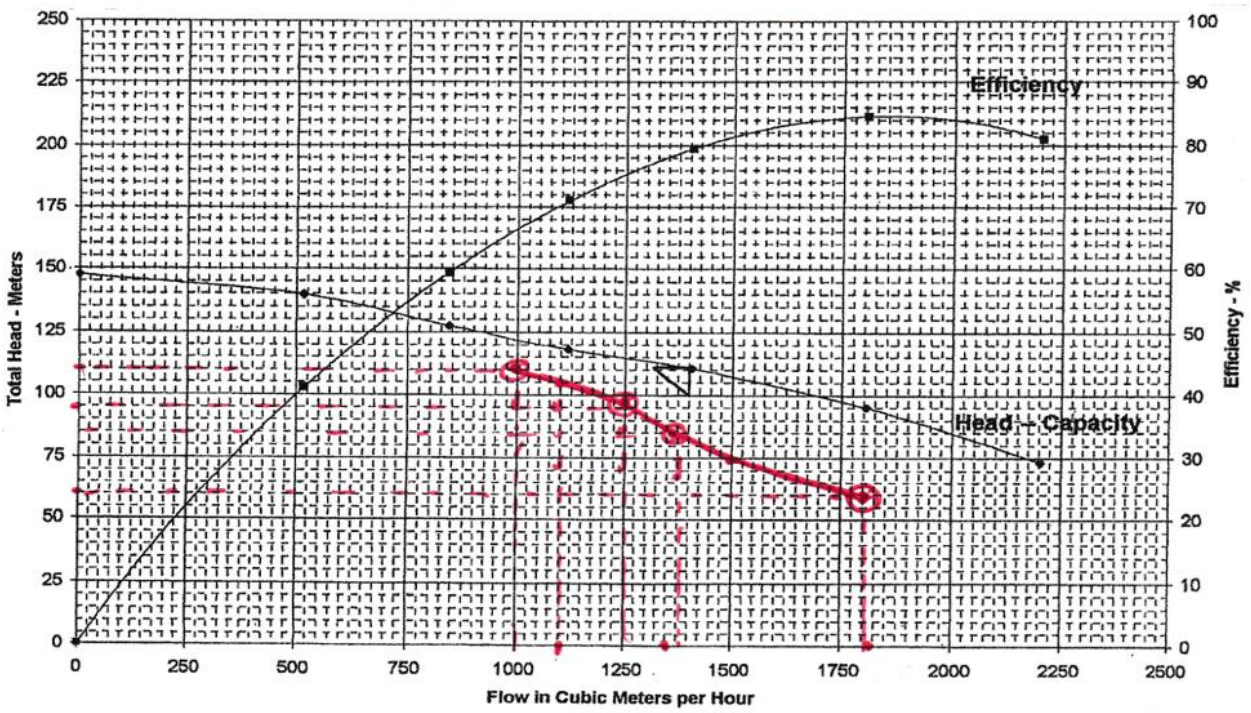

Figure 2.
Pump 71PM05 A performance curve.

The constructor curve.
The new test curve.

4.1. Performance Judging of the Pump 71PM05 A

According to the test procedure and in accordance with NFPA 20, the evaluation of the pump performance is based on three essential points [7]:

1- At 0% of the nominal flow rate (discharge valve closed), the H.M.T supplied by the pump must be within the range of 100 to 140% of the nominal head.
2- At 100% of the nominal flow rate, the H.M.T supplied by the pump must not be below the nominal head.
3- At 150% Of the nominal flow rate, the H.M.T supplied by the pump must be at least 65% of the nominal head.

Table 6.
Pump performance factor summaries & comparisons.

Flow (%)	HMT of Constructor (m)	HMT Carried out (m)	Gap (m)	Tolerance (NFPA)	(%) HMT carried out/HMT nominal (111m)	Comments
0.00 %	148	NR	NR	The net height achieved must be in the range of	NR	For safety reasons linked to the installation, water

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Flow (%)	HMT of Constructor (m)	HMT Carried out (m)	Gap (m)	Tolerance (NFPA)	(%) HMT carried out/HMT nominal (111m)	Comments
				100 to 140% of the nominal height		leaks proportional to the discharge pressure at the level of the pump cooling line prevented the test at 0% flow
100%	111	73	-38	The net height achieved must not be below the nominal height	80.24 Less than 100	Value of HMT realized is Inconclusive
150%	78	NR	NR	The net height achieved must be less 65% of the nominal height	NR	Pump performance limit at 128.57% of rated flow with discharge valve fully open

The results obtained show that the net head developed by the pump, which represents its performance, is below the nominal net head for a flow rate of 100%, in accordance with the standard in force. The pump must be urgently made reliable in order to bring its performance within the tolerance interval [8].

5. Recommandations

- Carry out a general overhaul of the motor pump.
- Clean the pump suction and clean the pool.
- Make the piping and cooling lines relating to the motor pump more reliable.
- Provide for the installation of a flow meter at the pump outlet.
- Make the two manual discharge valves more reliable.

6. General Pump 71PM05 a Overhauls

It is the set of examination actions, controls and interventions carried out with a view to ensuring the property against any major or critical failure for a period of time or for a given number of units of use. It is customary to distinguish, depending on the extent of this operation, between general overhauls and the change of parts such as:

- Angular contact bearings.
- The pads.
- The wheels.
- Wear rings (Wheel and diffusers).
- Pump shafts.
- Gaskets and liners.

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Figure 3.
Condition of the wheel very degraded [9].

Figure 4.
Pump components [10].

After purifying the recommendations, a second performance test is strongly recommended for regulatory compliance of the motor pump.

7. Evolution of the Net Head Developed by the Pump as a Function of the Flow Rate

By definition, the net head developed by the pump is the difference between the total head calculated

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at discharge minus the total head calculated at suction of the pump [11].

Table 7.
Flow rate readings based on pressure (2nd test).

Realized values								
Flow (%)	**Flow (m^3/h)**	**P. suc (Bar)**	**P. disc (Bar)**	**Height Net realized (bar)**	**Height Net realized (m)**	**Height Net constructor (m)**	**Gap (m)**	**% height net realized/height nominal (111m)**
0.00	0	0	NR	NR	/	/	/	/
57.14	800	0	12.40	12.40	124.87	128.00	-3.13	112.49
100	1400	0.00	11.10	11.10	111.78	111.00	0.78	100.70
140	1875	0.00	8.80	8.80	88.62	92.50	-3.88	79.83
150	2100	0.00	7.20	7.20	72.50	73.00	-0.50	65.32

According to the results of the test carried out the new performance curve is as follows:

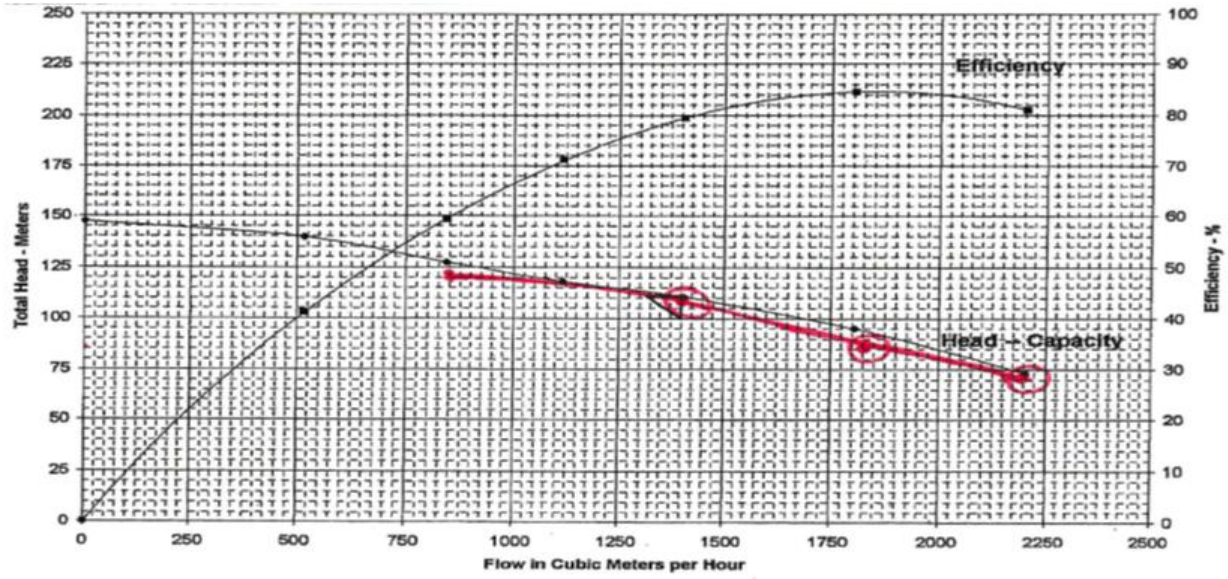

Figure 5.
Pump 71PM05 A performance curve.
The constructor curve.
The new test curve.

In accordance with article 6.2 "Factory and Field Performance" of NFPA 20, the evaluation of pump performance is based on two essential points:

1- At 0% of the nominal flow rate (discharge valve closed), the net head provided by the pump must be within the range of 100 to 140% of the nominal head.
2- A 150% of the nominal flow, the net head provided by the pump must be at least 65% of the nominal head.

From the performance curve produced on the pump, the table below summarizes the evolution of the pump performance factor.

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Table 8. Pump performance factor

Flow (%)	Performance constructor (m)	Performance Current (m)	Gap in %	Tolerance (NFPA)	Result. (% compared to H nominal)
0.00%	147	NN	-	De 100 à 140%	NN
100%	111	111.78	+ 0.78	≥ 100%	100.70 Acceptable
150%	73.0	72.5	-0.5	≥ 65% (For 150%)	65.32 Acceptable

Note: NN: Not noted.

At 100% of the nominal flow rate, the 71PM05 A pump preserves its performance (the net head provided by the pump is always equal to the nominal head) [11].

The results obtained showing that the net head developed by the pump, which represents its performance, is within the tolerated range, in accordance with the standard in force.

To monitor pump performance, we recommend installing a permanent flow meter at the pump outlet.

Figure 6.
Permanent Flow meter [12].

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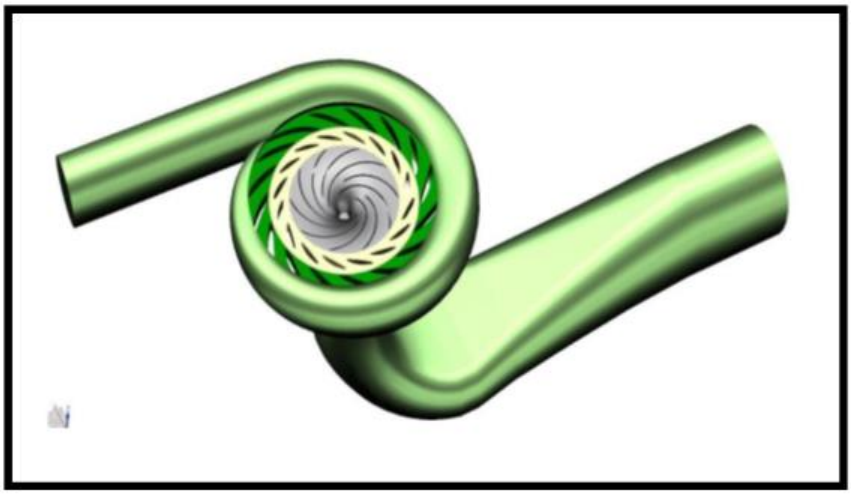

Figure 7.
Full flow geometric [13].

8. Conclusion

This work is considered as a starting point for several studies on fire networks by tackling different issues such as the study of danger and the estimation of the quantities of water necessary for fire extinguishing.

And also, plan the installation of a permanent flow meter at the pump outlet to allow monitoring of pump performance.

Fire pumps are used in industry due to the diversity of their applications, their special capacity and they are characterized by their ease of use and the frequent need for routine maintenance, and its advantages include high productivity, low costs and average efficiency in addition to energy efficiency, corrosion resistance and reliability.

The performance of a pump will be a function of pressure losses in the system, with pumps producing differential flow and pressure, given inlet conditions. A pump curve is a graphical representation of the differential flow rates and pressures that can be produced by a pump. 90% of pump-related problems arise from the system in which they are installed and therefore it is important to note that pump selection is only part of the process of selecting a suitable pump for the process [14].

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