Semi-critical pump monitoring

Protection and condition monitoring in hazardous areas using the SKF Multilog On-line System DMx

By Chris James and Marcel de Boer • SKF

Introduction

Among the many thousands of pieces of rotating equipment found in a typical oil and gas refinery or chemical plant, only a few are instrumented with vibration monitoring systems for machine protection or condition monitoring purposes. The vast majority of machines – most commonly electric motor driven pumps - carry either no such instrumentation, or very simplistic devices of limited use to a plant asset management program.

Walk-around routes

A standard approach to monitoring the many semi-critical and non-critical pumps (and fans) in a plant is to include them in manual, walk-around data collection routes. Such Predictive Maintenance programs use sophisticated data collection devices, carried by skilled technicians, to capture both static and dynamic vibration data on a periodic basis, with bi-weekly or monthly measurement intervals around the plant.

The constant industry drive to improve machine availability through condition monitoring is also accompanied by a similar emphasis on manpower efficiency and reduction. For walk-around programs, these are conflicting economic drivers (i.e., take more data with fewer people). Many plant operators look to resolve this problem with the use of permanently installed, automated monitoring systems.

Plant automation

An obvious solution to automating vibration monitoring is to expand and use the Plant Automation System (PAS) or Distributed Control System (DCS). However, DCS systems can only manage static value data provided by simple transmitters, and cannot deal with complex, dynamic vibration data required for effective predictive maintenance. Installation of dedicated vibration on-line "surveillance" systems provide this complex data, at measurement intervals of minutes and hours instead of weeks and months. Many plants may have a combination of dedicated surveillance systems and simple transmitters.

Installation costs

High installation costs associated with on-line vibration surveillance systems have been a barrier to their widespread deployment. The principal costs come from new wiring (vibration signals measured in millivolts need high quality field cable) and engineering and labor rates.

Emerging technologies

Two relatively new technologies are beginning to overcome these installation cost hurdles, and make the return-on-investment of expanding vibration monitoring instrumentation a practical reality:

Wireless systems

Vibration monitoring devices, such as the SKF Multilog On-line System WMx, that have radio (WiFi) connections back to the control or instrument room are becoming increasingly available, and for minimum installation costs as the devices are battery powered. The drawback of using batteries is battery life, so to prolong battery life these devices do not run continuously. Instead, they are "woken up" to take one or two measurements daily. For monitoring of non-critical machines previously covered monthly or quarterly, this is perfectly adequate.

The SKF Multilog On-line System WMx.

Field bus systems

Instead of wireless, field bus systems use the approach of less-wire. Field bus systems use "smart" monitoring devices located in the field, instead of in the control or instrument room. These devices are inter-connected by a small number of "bus" wires, instead of large volumes of analog instrument cable leading back to the control room. This greatly reduces the installation costs, while at the same time providing measurement data almost continuously. For semi-critical machines, where a wireless daily measurement is inadequate, this is an ideal solution.

Hazardous areas

A further barrier to installation of vibration surveillance systems in the oil and gas, and Hydrocarbon Processing Industries (HPI) is that the field environment is a potentially explosive one. Hence instruments need to comply with strict safety regimes defined by European and North American regulatory bodies:

- **ATEX Directive:** Zone 0, Zone 1, or Zone 2 areas
- **NEC:** Class 1 Division 1, Class 1 Division 2 areas

Compliance to these regimes certainly increases the cost of devices, and frequently limits functionality of any device.

SKF Multilog On-line System DMx

SKF has developed a new concept in vibration monitoring: provide machine protection and condition monitoring in a distributed, modular device that is instrinsically safe for hazardous area use.

The SKF Multilog On-line System DMx module.

The system is known as the SKF Multilog On-line System DMx. This system has great advantages above conventional 19" based systems, where installation costs often exceed half of the budget.

Field bus system

The SKF Multilog DMx takes the field bus approach discussed above to reduce installation cost barriers to expanding vibration monitoring coverage.

Imagine a semi-critical asset, like a pump, installed a couple of hundred meters away from a control room (where conventional monitoring systems would be installed). To install such a pump with a couple of accelerometers would lead to enormous installations costs, as each channel has to be wired with expensive multi-core cables from the pump to the control room.

With the SKF Multilog DMx, SKF has chosen a new approach. The monitoring and/or protection, and sensor power is provided locally at the machine, and a single communication line is used to create a connection to the control room. This communication line is much less expensive than the high quality multi-core signal cable set.

Machine protection or machine surveillance, or both?

As previously discussed, the principal driver for expanding vibration monitoring system coverage is to perform Predictive Maintenance through condition monitoring. However, in the event of excessive vibration, an automatic machine shut down can prevent catastrophic failures from rapidly developing faults. This is known as "machine protection."

The most critical machines in HPI have historically been heavily instrumented for both protection and condition monitoring. The type of protection instrumentation on these machine classes is defined in detail in the API 670 Standard. The API 670 Standard details sensor, vibration processing, and logic solving features necessary to protect machines where a fast developing fault may need a reaction time measured in milliseconds. The process criticality of these machines also means that the automatic shut down signal from the API 670 device must be used by a specialized Emergency Shut Down (ESD) system to bring the process down safely.

The DCS is used with API 670 systems for operator information only. With a semi-critical pump, where the fastest failure mode may be measured in minutes or more, and an ESD system is not necessary, then the DCS can be used to provide a shut down control command to the machine.

This is where the functionality of the SKF Multilog DMx offers an ideal solution:

- Provide API 670 standard protection functions in a small device that can be connected to the DCS by a field bus
- Provide dynamic vibration data for condition monitoring
- With hazardous area certification

This document now describes installation details of a real life example.

Semi-critical pump monitoring – oil refinery

The above mentioned benefits were key reasons why a refinery in Western Europe selected the SKF Multilog DMx for monitoring a number of semi-critical, un-instrumented pumps manufactured by Ingersoll Rand. The pumps were part of an entire class monitored with weekly portable data collector routes using the SKF Microlog and SKF @ptitude Analyst condition monitoring system. However, failures had been missed, and the refinery decided to invest in a permanently installed system in order to:

- Decrease the measurement interval
- Provide some machine protection using the DCS
- Release walk-around manpower for other tasks.

The pumps were located in pairs in an ATEX Zone 1 hazardous area.

Sensors

Each pump was equipped with four intrinsically safe rated industrial accelerometers.

CMSS786A-IS Industrial Accelerometer.

Three sensors were placed in the radial direction (on the motor and pump) to detect vibration caused by faults such as unbalance, looseness, cavitation, and bearing wear. One sensor was placed in the axial direction (on the motor) to detect vibration caused by shaft misalignment.

CMSS 786A-IS Industrial Accelerometers – radial direction, stud mounted.

SKF Multilog DMx monitor modules

Each pump required a single SKF Multilog DMx module, so modules were mounted in pairs in a weatherproof enclosure located between the two pumps.

CMMA 9920 Monitor Modules (field mounted).

The SKF Multilog DMx modules were powered by a CMMA 9120- ATEX intrinsically safe power supply mounted next to the enclosure. This power supply received a +24 V DC feed for a local power distribution panel.

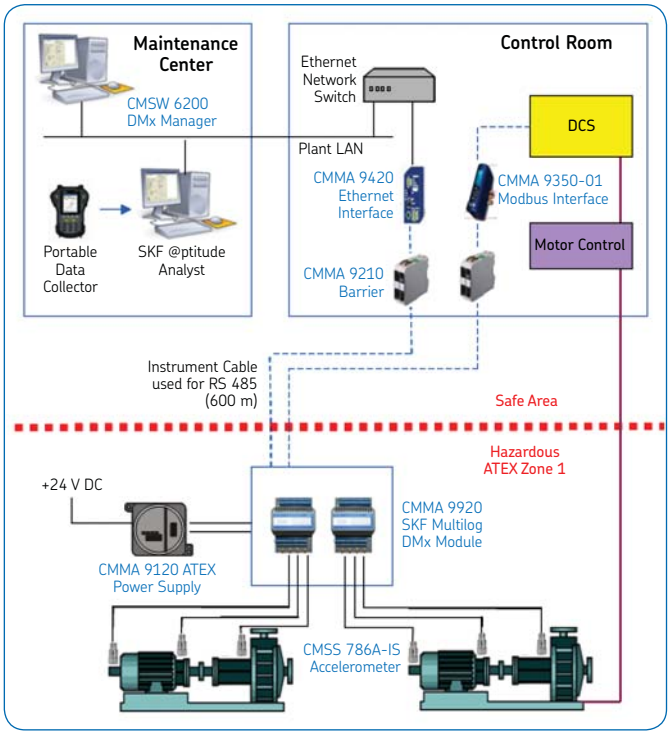
CMMA 9120-ATEX Power Supply.

Connection to control room

The pumps were located some 600 meters (2 000 ft.) by wire run from the control room. The only means of communication with the SKF Multilog DMx is by either of two RS 485 connections.

Fortunately, the plant wiring was over-dimensioned in the past with instrument cable. It is common practice during plant constructions to include at least 20 % spare capacity for future use. As the RS 485 method is carrying digital data streams ("0101110"), it is more tolerant of cable quality than the millivolts-level analog voltage signals used in conventional vibration monitoring systems. Hence, it was possible to connect to two spare twisted-pair cables found near the SKF Multilog DMx enclosure, which lead to the control room.

Transmitting the RS 485 over existing instrument cable saved both cost and time. The complete process of installing sensors, mounting and connecting the SKF Multilog DMx system, and providing the link to the DCS system in the control room was done in one day!



Schematic.

RS 485 link 1

One RS 485 link was used to provide a Modbus communication to the DCS, via a CMMA 9350-01 protocol interface. This link carried overall vibration level data (static value) for display in the DCS, and alarm status information for the DCS to relay to the motor control panel. The alarm status is generated by the API 670 standard voting logic within the SKF Multilog DMx. With this method, an excessive vibration level could be flagged within seconds, and the motor shut down to avoid a catastrophic failure.

RS 485 Link 2

The second RS 485 link was used to provide an ethernet connection to the plant network, via a CMMA 9420 terminal server. This link carried vibration time waveforms (dynamic data) for analysis in SKF @ptitude Analyst, thus uniting with data collected by the portable walk-around program.

SKF @ptitude Analyst

The connection of the system to the plant's SKF @ptitude Analyst platform allowed the following data collection enhancements over the portable data collection system's weekly data:

Continuous data collection

A "live" display of both overall and FFT data can be used by plant technicians to view "what's going on" with the pump without having to physically visit the machine.

Alarm event capture

Alarms are reported almost immediately, and a "pre-event" buffer is populated by the SKF Multilog DMx, such that in the event of an alarm or shutdown in the middle of the night, data immediately prior to the event can be analyzed.

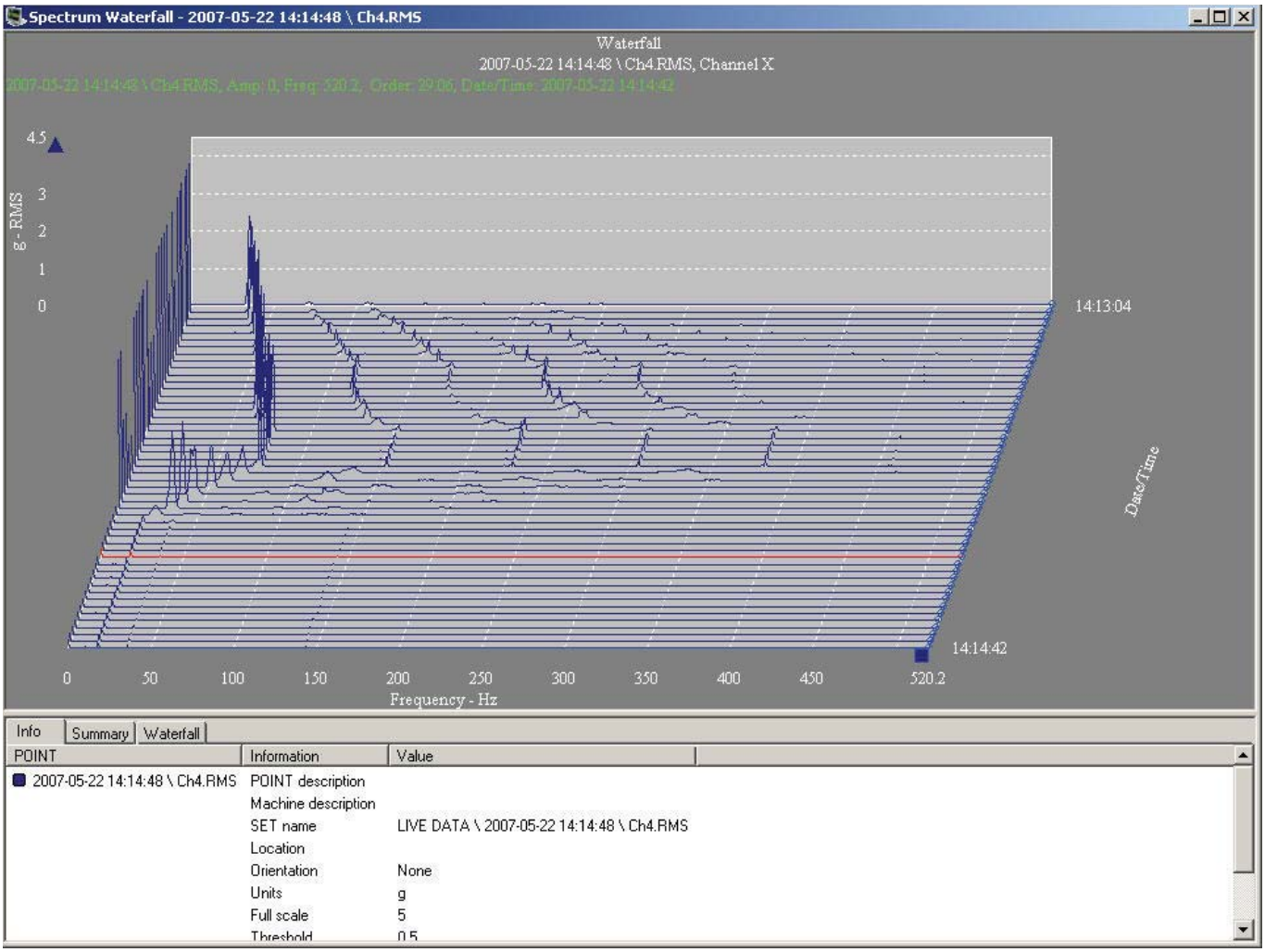
Scheduled storage

Scheduled storage every few hours, providing trends with good resolution, versus weekly data points.

Better pump condition visibility is gained. If high vibration occurs, immediate action can be taken to prevent damage and safety related issues.

Typical Bill of Material

Item	Quantity	Model number	Description
For two (2) pumps			
1	8	CMSS 786A-IS	Accelerometer, 100 mV/g, Ex ia
2	8	CMSS R6QI-9100-16	Accelerometer cable assembly, isolated, IP 68 connector, 5 m length
3	2	CMMA 9920	SKF Multilog DMx, 4 channel with transducer power, ATEX certified Ex ib [ia]
4	1	CMCP150-08	Enclosure, NEMA 4X, stainless steel
5	1	CMMA 9120-ATEX	Power supply for SKF Multilog DMx. Input +24 V DC, ATEX certified Ex
Control room – for all pumps			
6	2	CMMA 9210	Barrier, RS-485, GM INT, for SKF Multilog DMx
7	1	CMMA 9350-01	Interface module/protocol converter, Modbus RTU output
8	1	CMMA 9420	Interface module/terminal server, Ethernet output
9	1	CMMA 9170	Power supply for SKF Multilog DMx interface modules, 110/220 V AC input, +24 V DC output
10	1	CMSW 6200	SKF Multilog DMx Manager configuration software



SKF @ptitude Analyst – spectrum waterfall plot.

Summary

Economic pressures are continuously driving companies to increase their efficiency in order to remain competitive. For Predictive Maintenance programs in the upstream and downstream oil and gas business, this means collecting more data with fewer people. This requires a strategy to expand automated machine surveillance for condition monitoring purposes, and semi-critical pumps are prime candidates. In addition, the nature of the environment in these industries requires compliance with strict hazardous area regulations. The SKF Multilog DMx provides a cost-effective, field bus based, intrinsically-safe means of implementing this strategy.

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