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The Lifespan of Burner Management Systems

The Case of PROFIRE 2100

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Introduction

Burner Management Systems (BMS) are electronics-based systems that control and monitor the startup, operation and shut down of the combustion process of industrial burners. It is critical that they are properly maintained and replaced before their life expires to continue smooth industrial operations without prolonged periods of down time.

Numerous product lifetime studies have been done, including many specifically for electronics products, but there is no publicly available information on the lifetime of BMS. BMS products are relatively recent, with a market of about the last 20 years.

In this white paper, we discuss the specific factors that affect BMS lifespan studying Profire's PF2100 system as a specific case. We outline some of the methods that can be used to predict the useful lifetime of BMS, do comparative lifespan analysis for the PF2100 and make specific recommendations on upgrading.

Factors Affecting BMS Lifespan

BMS are special types of control systems. They are used in installations where typically there are great environmental extremes. The fact that, after initial installation, most BMS function for prolonged periods of time without shutting off, means that the electronics generally undergo more severe operational conditions than those of other electronic systems.

A lot of BMS are installed outdoors in industrial settings like remote well sites or processing plants. The fluctuations in the environment place a significant amount of load on the operation of the equipment. Included among the environmental factors are ambient temperature, humidity, mechanical forces, pressure, acoustics and vibration which play a large part in degrading BMS in such locations.

Thus, the type and quality of enclosure that holds the BMS electronics and other protection techniques plays a large part in the lifespan of the system. Enclosures can be selected that are more resilient to the effects of the environment, e.g. using pre-cut foam enclosures protect better against the effect of humidity and water creep. Furthermore, circuit boards and display assemblies can be treated with conformal coating or RTV to protect them from moisture, temperature cycles and corrosion. The UI keypad fixed on the enclosure is also exposed to degradation from environmental factors.

The operational factors that affect BMS electronics are the applied current and voltage loads. Specifically, the load magnitudes, load rates, load range and duration of the loads affect the BMS lifespan.

Factors that affect the reliability of the solder interconnects of the electronics boards that make up the BMS include the interconnect dimensions, attaching methods, soldering methods and stress conditions. In general, having more reliable components and manufacturing methodology drives up the production cost, so BMS manufacturers need to balance the need for reliability with that of acceptable product cost.

The fact that BMS are safety systems means that ongoing smooth operation is critical for safe industrial operations. Maintenance, timely replacement of parts and eventual upgrading the product is essential for continuous accident free operations. Using the precautionary principle for safety, it might be safer for industrial operators to err on the side of caution and replace their BMS before they become completely obsolete.

The lifetime of many of the electronic parts that make up the BMS is significantly smaller than that of the whole product. Parts become obsolete when they are no longer manufactured, either because demand has dropped to low enough levels that it is not practical for manufacturers to continue to make it, or because the material or technologies necessary to produce it are no longer available.

A BMS can be designed for a longer than usual life. An open design architecture and a parts obsolescence strategy helps in extending the BMS life. An open design architecture allows parts to be plugged in based on open standards in the original product ensuring that the product itself lasts a long time. Parts obsolescence strategies includes lifetime buys, substitution, redesign, using aftermarket sources, emulation, reclaim or uprating.

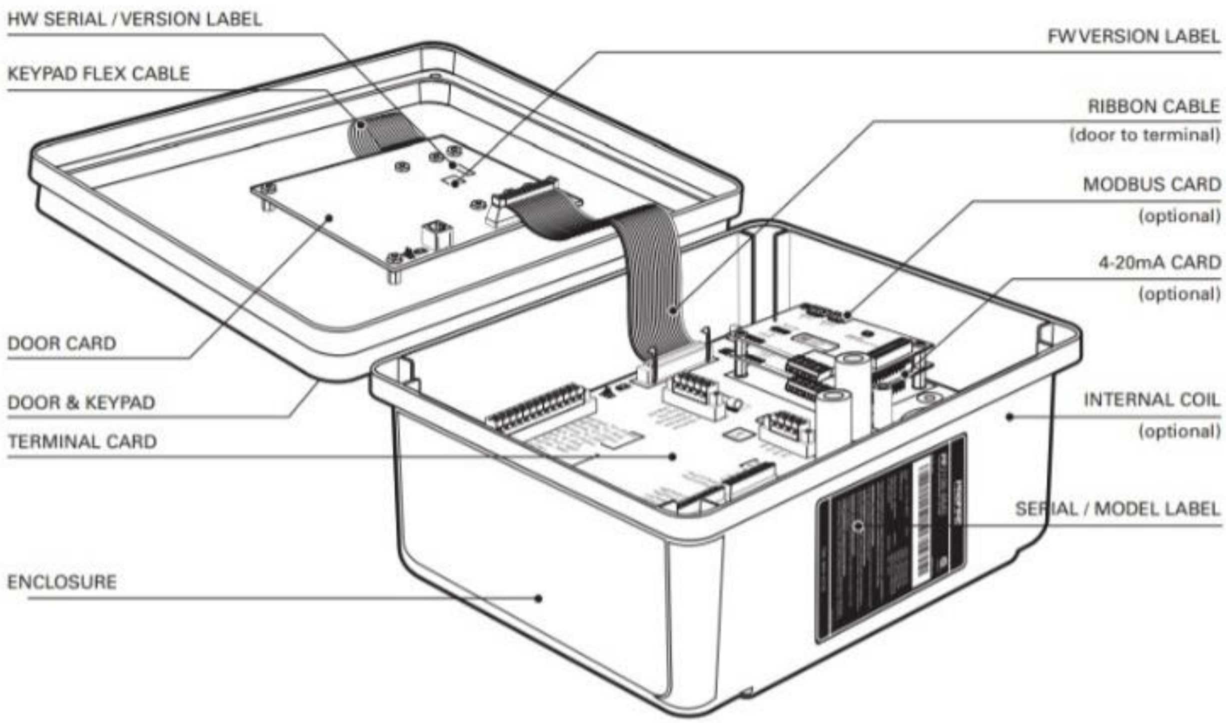
BMS manufacturers can buy and store enough parts to meet the system's forecasted lifetime requirements. In part substitution, manufacturers use a different part with identical or similar form fit and function. When it comes to part redesign, the BMS may be upgraded to make use of newer parts. Parts may be sourced from aftermarket sources, as third parties continue to provide the part after the BMS manufacturer has obsoleted it. Manufacturers may go for parts emulation by using parts with identical form fit and function that are fabricated using newer technologies. They might reclaim the parts by salvaging them from other products. Finally, uprating is a parts mitigation strategy where parts outside their manufacturer specified environmental range (usually higher temperatures) substitutes the original.

The Profire PF2100 System

The PF2100 BMS is an electronic control and monitoring system designed for use on a wide array of natural draft burner industrial applications. It provides electronic pilot ignition, flame detection, temperature control, and remote monitoring. In addition to being an extremely useful tool, it improves safety by preventing the flame from being lit under unsafe conditions.

The PF2100 was released in 2010 to help meet emerging standards that were developing in the industry and that would provide a user-friendly and reliable system. Quick and easy installation, application flexibility, proven reliability, and an easy to use interface that provides clear feedback made the PF2100 a good solution for single burner natural draft applications.

The main problems that occur in the PF2100 are due to human factors. Our product service records indicate that operator error and misuse of the system is the primary reason for premature degradation of the product. Problems intrinsic to the product may be tracked down to the electronics, the enclosure that houses the electronics and the keypad that is installed on the enclosure and is exposed to the elements.



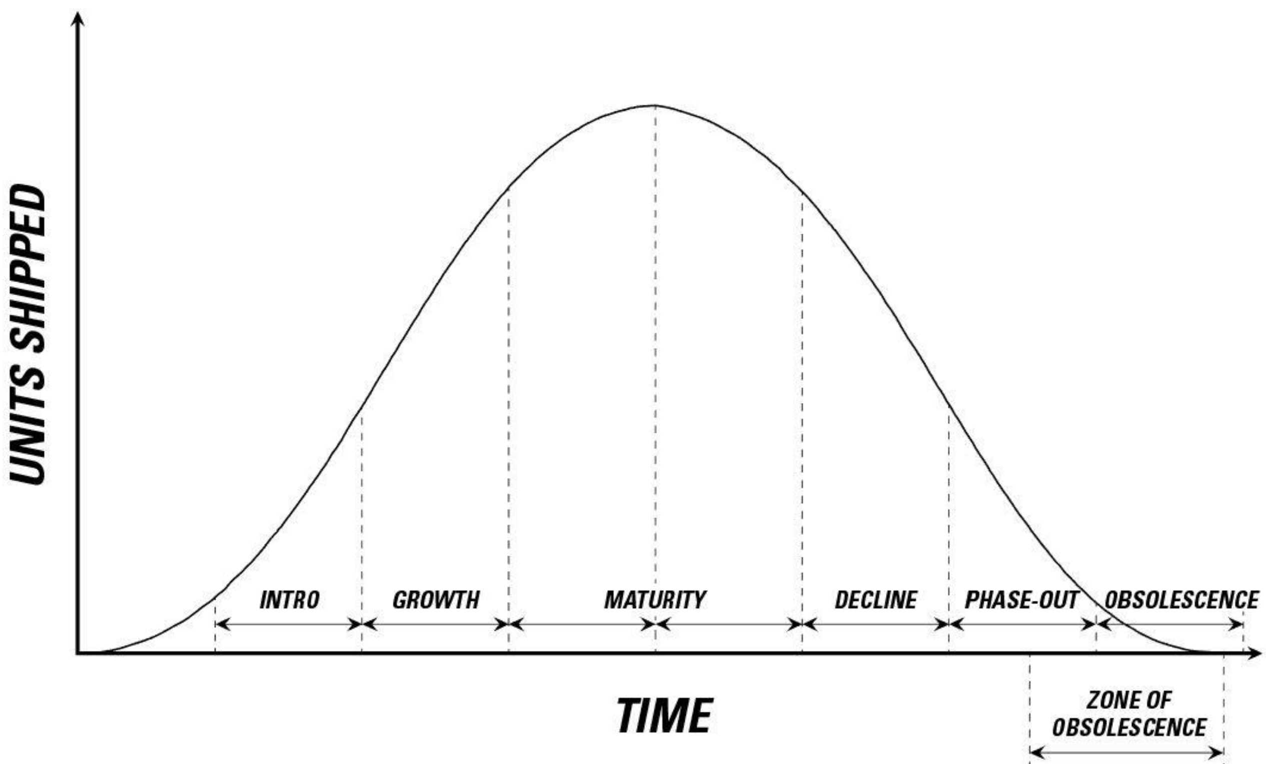
The PF2100 was designed for a product life of 10 years with some over protection margin built-in. The electronics components and parts were sourced from manufacturers with 10-year reliability criteria. Also, the availability of parts was forecasted for 10 years. Improper grounding has been the main cause of premature electronic component failures.

The PF2100 uses a type 4X polyester enclosure that is designed to withstand harsh chemicals, weather extremes, and corrosive environments. The material of the enclosure is tough and lightweight. It also provides ultraviolet protection and a tight environmental seal. This enclosure has performed decently in protecting the system from environmental damage in North American installations till now although it is not recommended for harsh climates like that of the Middle East.

The weakest part of the PF2100 BMS has been its keypad. It seems to be the critical factor that might cause the product to be replaced or upgraded prematurely. Heat and ultraviolet radiation causes the keypad to delaminate and become brittle. This, in addition to the pressure exerted by the keypad flex cable from within the enclosure to the keypad surface, causes keypad cracking. When this happens, the keypad becomes dysfunctional and cannot be replaced. Thus, units that are installed near equipment with high temperatures or in direct sunlight South facing in the northern hemisphere are more prone to early replacement.

BMS Lifecycle Stages

Most BMS pass through several lifecycle stages corresponding to the changes in their sales. The figure below shows a representative lifecycle bell curve based on typical BMS sales history data. It shows six common life cycle stages: introduction, growth, maturity, decline, phase-out and obsolescence.



The introduction stage is usually characterized by high production costs driven by recently incurred deign costs and low yield, frequent modification, low or unpredictable production volumes, and lack of specialized production equipment. Making costs, at this stage, may also be high. Early adopter customers who buy the product in its introductory stage tend to value performance over price.

The growth stage is characterized by the BMS's market acceptance. Increased sales during this stage may justify the development and use of specialized equipment for production, which in turn improves economies of scale of production. Mass production, mass distribution, and mass marketing often bring about price reductions. This stage often consists of the largest number of competitors, as opportunity-seeking firms are attracted by the product's profit potential and, strategic acquisitions and mergers have not yet taken place.

The maturity stage of the BMS lifecycle is characterized by high-volume sales. Competitors with lower cost of production may enter the market.

The decline stage is characterized by decreasing demand and generally decreasing profit margin. Towards the end of the decline stage, only a few specialized manufacturers remain in the market.

Phase-out occurs when the manufacturer sets a date when production of the BMS will stop. Generally, the manufacturer issues a discontinuance notice to customers and provides a last-time buy date.

Discontinuance occurs when the manufacturer stops production of the BMS. The product may still be available in the market if the production line or product stocks were bought by an aftermarket source.

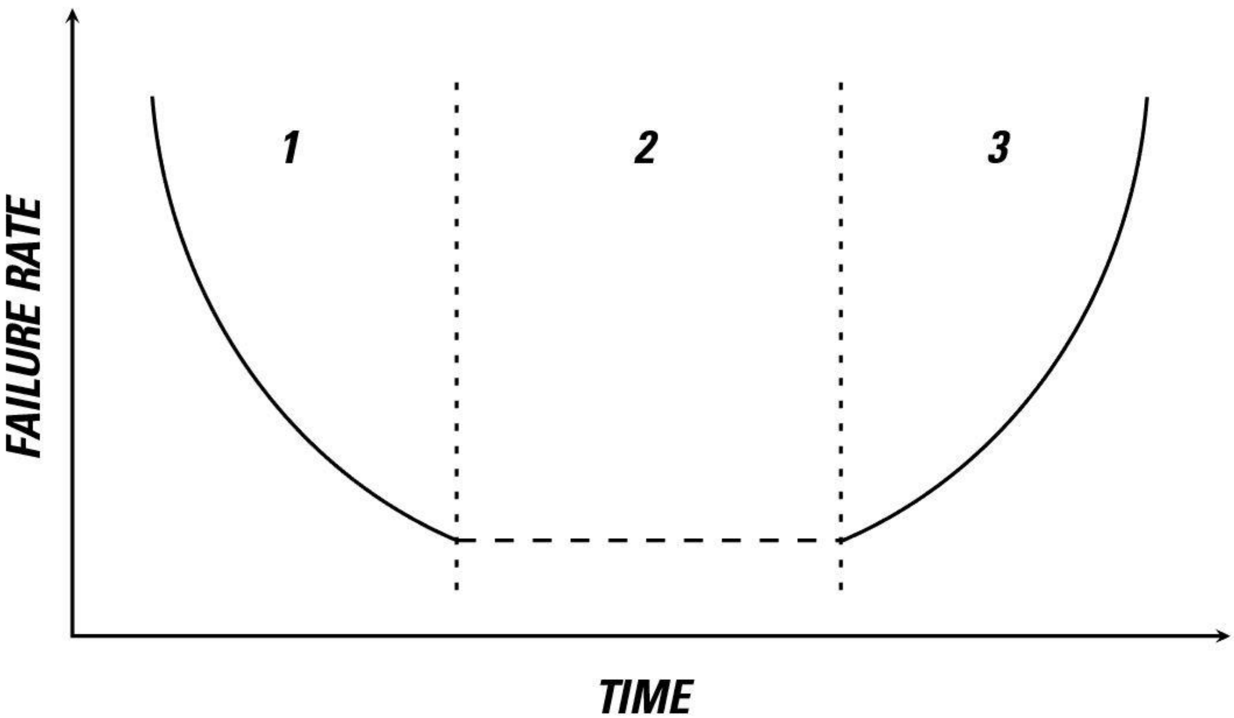
The table below summarizes typical BMS lifecycle characteristics for these stages.

BMS Characteristic	Introduction	Growth	Maturity	Decline	Phase-Out	Obsolescence
Sales	Slow but increasing	Increasing rapidly	High	Decreasing	Lifetime buys may be offered	Sales only from aftermarket sources, if at all
Price	Highest	Declining	Low	Lowest	Low	N/A
Usage	Low	Increasing	High	Decreasing	Decreasing	Low
Modification in the BMS	Frequent	Periodic	Periodic	Few or none	None	None
Profits	Low	Increasing	High	Decreasing	Decreasing	Decreasing

If data from these BMS characteristics is plotted over time, we can obtain an estimate of the stage in the BMS lifecycle we are at. Thus, we can predict when obsolescence is likely to occur. For example, when it comes to BMS sales data analysis over time, we can predict it to be after 2.5 standard deviation of the preceding graph from the mean.

BMS Reliability

The failure rate, λ, for a BMS is defined as the percentage of components failing per unit time. This varies throughout the BMS life. If λ is plotted versus time, we get the characteristic "bathtub" curve shown below.



The curve has three regions:

1 - Infant Mortality - When the product is initially launched, it faces a lot of failures.

2 – Useful Life - The product stabilizes and faces constantly low failure rates.

3 – Wear Out - The product starts facing a lot of failures due to reaching its useful lifespan.

The Mean Time Between Failures, MTBF, is the inverse of the failure rate.

$$MTBF = 1/ \lambda$$

Reliability, R(t), is often defined as the probability that a piece of equipment operating under specified operating conditions shall perform satisfactorily for a given period of time.

It can be calculated using the following equation:

$$R(t) = e^{-\lambda t} = e^{-t/MTBF}$$

The useful life of a BMS can be estimated using Weibull analysis. It informs us where the BMS is on the bathtub curve, and thus how much time before wear out is to occur.

The two-parameter Weibull analysis involves fitting the lifetime data of individual BMS units to the following cumulative distribution function:

$$F(x) = 1 - e^{-(x/\alpha)^\beta}, \text{ for } x > 0$$

where α represents the characteristic life of the BMS and β indicates where on the "bathtub" curve the BMS is.

PF2100 Comparative Lifespan Analysis

Profire's PF2100 BMS is a special type of industrial control system which operates in harsh environments and in which safety is critical. For this reason, it is important to analyze its useful lifespan. In such applications, the higher the risk of a component failure, the higher the risk of a safety incident. This is true, even if the individual electronic components that make up the PF2100 are expected to exceed the product's own lifespan.

In general, the lifespan of electronics in various industries is estimated according to the following table.

Parameter	Consumer	Industrial	Automotive
Temperature	0 to 40 C	-10 to 70 C	-40 to 85/155 C
Operation Time	1 to 3 years	5 to 10 years	Up to 15 years
Humidity	Low	Environment	0 to 100 %
Tolerated Field Failure Rates	< 10 %	<< 1 %	Target: zero failure
Supply	None	Up to 5 years	Up to 30 years

Consumer electronics are designed to operate only 1-3 years cumulatively and their lifespans are getting shorter. They work best in indoor environments and some extent of failure is tolerated. Industrial electronics, operate cumulatively about 5-10 years and are designed for a broader range of environmental conditions. Their parts may be available up to 5 years after production has stopped. Very little failure is tolerated in industrial electronic products. Automotive electronics are designed for the harshest range of environmental and operational conditions. They operate cumulatively for up to 15 years. Virtually no failures are tolerated in critical control components of automotive electronics.

BMS electronics are designed to operate somewhere between the characteristics for industrial electronics and automotive electronics, as BMS are safety critical devices in that their target failure rates are close to zero during their useful lifespan.

The following table has some sample electronics products and their lifespans. BMS like PF2100 are at about the mid-range in terms of product life in this table.

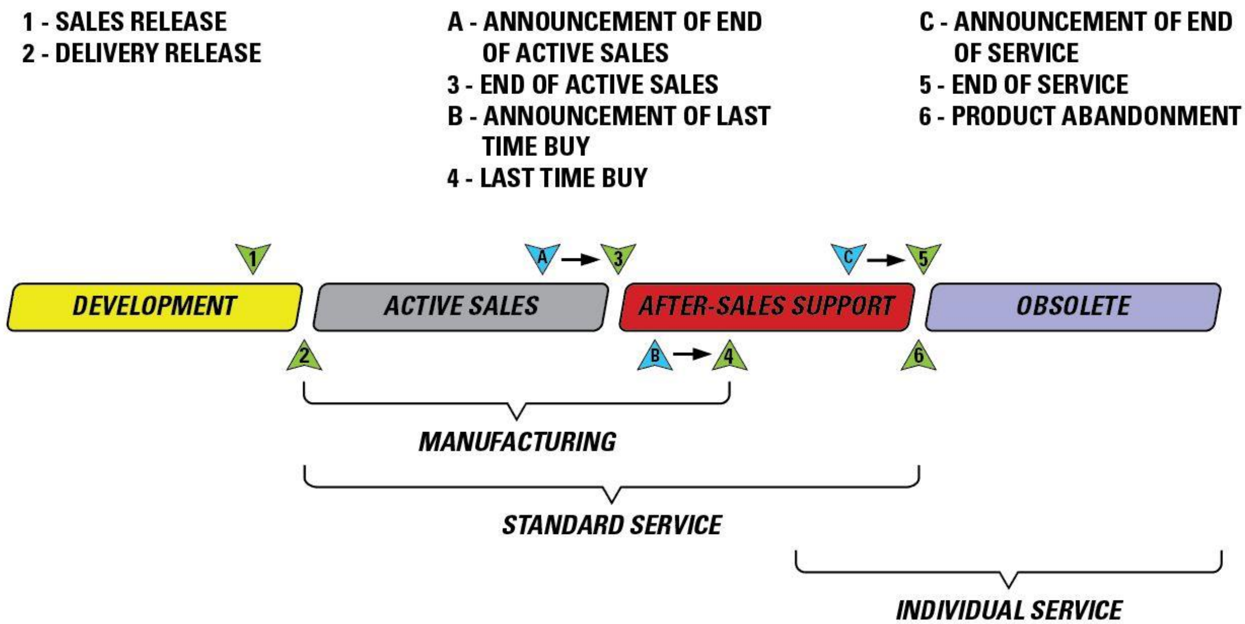
Product	Product Type	Product Lifespan
Smart Phone	Consumer Electronics	4.6 years
Laptop	Consumer Electronics	5.5 years
TV	Consumer Electronics	7 years
Honeywell 7800 BMS	Industrial Electronics	10 years
Texas Instruments AM335x Processor	Industrial Electronics	11.4 years
HVAC Electronic Controls	Industrial Electronics	15 years
Elevator Controller	Industrial Electronics	20 years

PF2100 was designed for an expected lifetime of 10 years. The lifespan of the electronic components used and their availability estimates were about 10 years. It is a product which is very close to the Honeywell 7800 BMS in the table above in functionality, installation environment, quality of electronics, and safety requirements. Profire designed the PF2100 for a 10-year operational life. As such, customers should begin planning to replace the PF2100 after about 8 years of operation in the field to allow adequate time for a replacement plan to be developed and implemented.

If the PF2100 is made to operate beyond its lifespan, the risk of failures and hence safety incidents rise sharply, as the product reaches the far end of the “bathtub” curve (the wear out region). Having to deal with increasingly costly and catastrophic failures at an accelerated rate that operating in this region entails is an unacceptable safety risk that operators should avoid.

Conclusion

BMS lifecycle that was discussed earlier can also be represented in terms of four phases: development, active sales, after-sales support and obsolescence shown below.



The active sales phase starts following the BMS development phase. The BMS sells during this phase until the manufacturer announces the end of active sales with a time period after which they would stop selling the BMS in the market. Following the end of sales, the manufacturer announces last time buy period in which customers will have the chance to purchase and store the abandoned BMS spare parts.

Service will continue in the after-sales phase of the BMS lifecycle. The manufacturer will announce the end of service before finally ending all support to the product. At that stage, the product will be considered abandoned and obsolete.

Our analysis indicates that the PF2100 is reaching the end of active sales stage. Profire Energy will soon be announcing end of active sales for this product. If you currently use a PF2100, now may be a good time to contact the Profire service team to plan its upgrade to ensure any discontinuities in operations.

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