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True Cost of Unreliability

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Calculate the True Cost of Unreliability

The economic impact on manufacturers that haven't bought into the idea of failure-free operation is easy to determine and, more important, enormous.

Al Poling, CMRP

ALTHOUGH EXPERTS HAVE espoused the virtues of equipment reliability for decades, countless manufacturing operations still suffer significant and unnecessary downtime due to equipment failure. Apparently these manufacturers haven't bought into the benefits of failure-free operation. What will it take to get them to accept the time-proven benefits of reliability? Perhaps they will never be convinced by examples of other manufacturing operations, believing that they are somehow unique. If the benefits derived through reliable operation won't lead them to change, perhaps an examination of the true cost of unreliability will.

The big picture

Businesses operate under the basic equation of: profit = sales minus cost. Although equipment failures affect both sides of the equation, this article focuses on the impact of unreliability on maintenance costs—typically the largest fixed costs in a process-industry manufacturing facility. End users can apply the following calculations from a hypothetical plant to their own business and develop an order-of-magnitude estimate of the impact of unreliability on maintenance costs at their site(s).

For purposes of these calculations, let's assume our hypothetical operation has a plant replacement value (PRV) of US$1 billion and a resident maintenance workforce of 150 craft-level employees.

Maintenance-labor cost

Maintenance costs in a plant include those for skilled craft labor to repair and restore equipment to good operating condition following a failure. The current average U.S. Gulf Coast, fully loaded, maintenance skilled-craft wage rate is approximately $45/hr. Using the U.S. standard of 2,080 hr./man-year, with an estimated overtime rate of 5%, the cost/year/skilled craft worker is approximately $100,000. Consequently, 150 skilled craft workers will cost approximately $15 million/year. In terms of man-hours, including overtime, the number is about 300,000 man-hour/year.

Benchmarking studies have confirmed that best-performing plants average 1% downtime due to unreliability/year, while average performers suffer 7% downtime due to unreliability. These numbers include annualized downtime for turnarounds. To calculate the annualized downtime for turnarounds, simply take the total downtime for your last turnaround and divide it by the number of years between turnarounds. A 30-day turnaround taken every three years equals 10 days of annualized downtime due to the turnaround alone.

Best performers average less than four days of downtime/year due to unreliability, including annualized downtime for turnarounds. Average performers endure more than 25 days of downtime/year due to unreliability.

There is a direct correlation between the number of equipment failures and the number of craft workers required to effect repairs. In theory, the average-performing manufacturer would have seven times more maintenance craft workers than the best performer. That, however, is in theory only. Achieving and sustaining failure-free operation requires truly skilled craft workers and, even they have to focus their efforts on failure avoidance instead of repair.

Work sampling studies have revealed that the efficiency of maintenance-craft workers is extremely high in highly reliable operations, as their work is well defined and scheduled in advance. In comparison to reactive maintenance, schedule interruptions happen on an exception basis in a failure-free environment. Instead of seven-times as many skilled craft workers needed in an average-performing plant, we'll estimate (conservatively) that the number is half that (or three and a half times).

With regard to maintenance labor, the cost of unreliability is the difference between the number and associated cost of skilled craft workers required to support a reliable operation versus an unreliable one. Assuming that the aforementioned 150 such workers, costing $15 million/year, are working in an operation suffering average unreliability, the additional maintenance labor costs are 70% of the total—$10.5 million/year. In this example the true cost of unreliability in skilled craft workers is an additional 105 such workers costing an additional $10.5 million/year, whereas a reliable operation would only need 45 skilled craft workers. This calculation does not factor in the elimination of overtime that would be found in a failure-free environment. While equipment still fails, the impending failure is discerned well in advance so repairs can be made during normal maintenance work hours.

LINE ITEM: $10,500,000 = maintenance-labor cost of unreliability

Maintenance-material cost

Repair material is another major element of maintenance costs. Unfortunately, the ratio of maintenance-material cost to maintenance-labor cost varies by region due to differences in the prevailing wage and the availability (or lack) of repair materials. Equipment's material of construction also factors into material-to-labor ratios.

A reasonable hypothesis is to use a one-to-one ratio of maintenance material to maintenance labor. Applying this ratio to our hypothetical plant with 150 maintenance craft workers at a cost of $10.5 million/year means the site spends another $15 million on maintenance-repair material annually. Using the same approximation as we used with maintenance labor, 70% of these material costs would be avoidable if the plant were operating in a failure-free mode. In monetary terms, this represents yet another $10.5 million attributable to unreliability.

LINE ITEM: $10,500,000 = maintenance-materials cost of unreliability

Equipment-replacement cost

In consequential failures, equipment cannot be repaired and, thus, must be replaced. Benchmarking studies have shown that manufacturing operations running their equipment to failure spend exponentially more than best performers spend on maintenance capital, *i.e.,* equipment replacement.

Manufacturers that take care of their equipment and embrace failure-free operation derive extraordinary service-life from that equipment. Conversely, those who operate in a run-to-failure mode wear out equipment quickly.

Run-to-failure is a particularly costly maintenance strategy. Best performers will spend 1% or less of their PRV each year to replace equipment that has reached the end of its useful life. In contrast, average performers will spend 3% to 5% annually on replacement equipment. Determining the true cost of unreliability, therefore, requires factoring in the price tag for equipment replacement.

A reasonable assumption is that best performers spend 0.5% of PRV and average performers spend 4% of PRV on annual equipment replacement. That means, based on our hypothetical plant, with a PRV of US$1 billion, a best performer would be spending approximately $5 million annually on equipment replacement due to unreliability, and an average performer would be spending approximately $40 million annually. Thus, in our hypothetical example, the true cost of unreliability reflects an additional $35 million/year for equipment replacement.

LINE ITEM: $35,000,000 = equipment-replacement cost of unreliability

Additional costs

Another significant maintenance cost involves maintenance administration and staff. Granted, there is not a direct correlation between the number of maintenance salaried personnel and maintenance wage personnel. Still, there are common ratios of salaried to hourly wage personnel—and they differ dramatically between better and poorer performers. Merely reducing numbers of skilled craft workers, though, doesn't translate to an equal percentage reduction in staff. For example, in average-performing operations, there may be more maintenance supervisors, but the ratio of craft to supervisor positions is higher. In best-performing operations, the ratio of maintenance supervisors to craft personnel is lower. This situation results from recognition of the value of maintenance supervisors as facilitators who can greatly enhance the efficiency of a maintenance workforce.

A similar condition exists with maintenance planners. Poor performers have larger numbers of skilled craft workers/maintenance planners—with some of the worst performers in the range of 60:1. An individual maintenance planner can't effectively serve such a large number of skilled craft workers—and is likely operating in a reactive mode, expediting materials or performing other duties required to support reactive maintenance.

In contrast, the ratio of skilled craft workers to planners at a best-performing site is more apt to be in the 20:1 range. With this type of ratio, a planner can prepare detailed job plans, procure materials, and efficiently perform other planning functions. The net result is that there will be no appreciable administration and staff cost savings in moving from a run-to-failure to failure-free environment. This is due to changes in ratios of craft to staff positions and the redeployment of some personnel from reactive work to proactive functions that are needed to support failure-free operations.

Additional maintenance costs affected by unreliability involve facilities, including offices, shops, break rooms, restrooms, and related infrastructure costs. Rolling-stock requirements can also be

Unreliability: A Very Expensive Proposition

The three largest maintenance-cost categories affected by unreliability are maintenance labor, maintenance material, and maintenance capital, *i.e.,* equipment replacement. In our hypothetical manufacturing operation with a plant replacement value (PRV) of US$1 billion and resident workforce of 150 skilled craft workers, we can calculate the cost of unreliability individually and collectively as follows to the right:

$10,500,000 = *maintenance-labor cost of unreliability*

$10,500,000 = *maintenance-materials cost of unreliability*

$35,000,000 = *equipment-replacement cost of unreliability*

$56,000,000
TOTAL MAINTENANCE COST OF UNRELIABILITY

$70,000,000 = Total current annual maintenance cost for labor, material, and maintenance capital, i.e., *equipment replacement.*

80% = Percentage of the total maintenance labor, maintenance material, and maintenance capital spent unnecessarily due to unreliability.

At first glance, these figures may appear unrealistic. They're not. The harsh reality is that unreliable operation is very expensive for any manufacturer, regardless of size.

affected, as can various support staff outside of the maintenance function, such as human resources, training, and safety. Generally speaking, though, there is no substantive reduction in administration, staffing, and related cost categories as a result of reducing and/or eliminating unreliability.

The bottom line

As discussed here (and shown in the accompanying sidebar), the true cost of unreliability is enormous. By adding up the previously noted line-item maintenance costs for our hypothetical plant, we can see that unreliability amounted to a staggering $56 million (or 80%) of unnecessary spending for maintenance labor, materials, and equipment replacement costs.

Given this type of economic impact of unreliability, why don't all manufacturing operations transition from failure-prone to failure-free environments? Unfortunately, there's no single root cause. Many factors contribute to the situation. Among them:

- The constant distraction of equipment failures is akin to putting out fires. Consequently, everyone is so focused on reacting that they believe they can't take the time to implement measures to avoid the failure. A fairly simple solution here would be to devote a small number of employees to developing and implementing plans to avoid equipment failures. For this approach to be effective, however, those proactive resources can't be dragged back into firefighting mode. Otherwise, nothing will improve.
- Poorer-performing operations rarely have a strategic plan or, if they do, it's typically mere window-dressing written to satisfy corporate management. Without a well-thought-out vision or mission, plant personnel will naturally accept the status quo as the normal mode of operation.
- There is a lack of leadership in poorer-performing manufacturing operations. Either the current management lacks the requisite leadership skills or there are no incentives positive or negative to change the status quo. Humans respond to stimulus. If there are no consequences for being unreliable, nothing will change. Conversely, if there are no rewards for becoming reliable, or if the existing reward system somehow perversely rewards unreliable behavior, nothing will change.

Better-performing manufacturing operations typically share the benefits of failure-free operation with all employees. As a result, everybody has a stake in improved reliability.

While this discussion used a hypothetical manufacturing site to illustrate the true cost of unreliability, the same ratios can be applied to obtain an order-of-magnitude estimate of the cost of unreliability for your operations. Remember, though, that someone needs to take the initiative before improvement can begin. **MT**

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Calculate the Impact of Unreliability On Sales

While most acknowledge that unreliable operation is costly at the plant level, the impact, when projected to sales, is enormous.

Al Poling, CMRP

GENERALLY SPEAKING, MANUFACTURING personnel understand the effect unreliability has on maintenance. Unreliability requires more maintenance resources and materials to repair failed equipment as well as increased maintenance capital spending caused by the need to replace equipment that has reached the end of its useful life. Running equipment to failure causes equipment to reach the end of its useful life prematurely. What many manufacturing personnel do not understand is the effect unreliability has on sales.

Maintenance professionals find it difficult to garner support of corporate executives who do not understand maintenance. However, these same executives have a very clear understanding of profit and loss. If they understand the effect unreliability has on sales and, therefore, profit, they will be much more inclined to support a comprehensive reliability initiative. It might surprise many maintenance professionals to learn that there is a mutual benefit to be derived from reliability: reduced maintenance costs and increased sales and revenue.

To understand this relationship, we must examine the basic business model. All for-profit businesses operate under the same equation: PROFIT = SALES – COST. Equipment failures affect both sides of this equation.

"Calculate the True Cost of Unreliability," an article published in the February issue of *Maintenance Technology* (p. 13 and at maintenancetechnology.com) examined the impact unreliability has on maintenance costs. In this article we will examine the effect unreliability has on sales.

A hypothetical plant will be used for purposes of calculations. You can apply these calculations to your own operations to develop an order-of-magnitude estimate of the impact unreliability has on sales and profitability.

For the calculation purposes, we will use a hypothetical plant that has a plant-replacement value (PRV) of $1 billion US, with a targeted return on capital employed (ROCE) of 30%. In other words, business stakeholders expect to realize $300 million in earnings before interest and taxes on their $1 billion investment. We will also assume that this plant operates at 70% capacity due to lack of sales.

Raise sales price

Sales revenue is driven by two key levers, price and volume. The higher the sales price per unit the higher the margin, the higher the sales revenue, and the greater the profit. Additionally, the more product you sell (sales volume), the higher the sales revenue and the greater the profit. So both sales price and sales volume determine the revenue garnered by the business. Unreliability has a very profound effect on those two factors. To understand the relationship between asset reliability and sales revenue in this equation we need to examine each component in more detail.

The price of a product is largely set by whatever price the market will bear. However, the market places a premium on quality. The highest sustainable product quality can only be produced through uninterrupted manufacturing. As assets become more reliable, manufacturers are able to produce consistently higher quality product, something customers value. This isn't new. W. Edwards Deming espoused the virtues of product consistency more than a half century ago.

If a 5% price premium can be garnered from customer willingness to pay more for higher quality product, then the subsequent increase in sales revenue is calculable. Assuming the hypothetical plant had $500 million in sales during the reporting period, the increased revenue from a higher price enabled by higher-quality product would be an additional $25 million in sales revenue.

This increase in sales revenue was made simply by reducing and/or eliminating unplanned equipment failures. No additional capital was required, resulting in a direct increase in the return on capital employed and, more importantly, on profitability.

LINE ITEM: $25 million = The increase in revenue due to higher sales price for higher quality product derived from reducing and/or eliminating unreliability.

Increase capacity

A second sales-revenue benefit derived from the elimination and/or reduction of unreliability is garnered through a lower cost per unit (CPU) of production. By operating in a failure-free mode, manufacturers are able to increase throughput. When there are fewer production interruptions caused by equipment failures, more product is made over the same period of time.

For example, if the average production rate was 80 tons per day, including time lost to equipment failures, then a natural benefit derived by reducing and/or eliminating equipment failures would be an automatic increase in capacity. If one additional hour per day of production was gained, the subsequent increase in capacity would be 4%.

A 4% increase on $525 million in annual sales revenue would be worth an additional $21 million in sales revenue. As was the case with improved product quality, this increase in capacity was derived without any additional capital investment. Companies are always striving for increased sales by whatever means, but they inevitably expect to have to invest significant capital in a new production unit or to expand an existing production unit.

LINE ITEM: $21 million = The incremental sales gained through the incremental increase in production capacity derived from reducing and/or eliminating unreliability.

Increase sales margin

Additionally, a 5% reduction in the cost per unit derived by spreading costs, *e.g.*, operational and energy costs, over a larger volume of product could be significant. This is effectively an increase in the sales margin of the product being sold. Using the aforementioned $500 million in annual sales, the benefit would be 5% of $500 million, or an additional $25 million in profit.

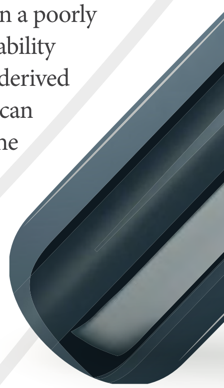
LINE ITEM: $25 million = The increase in profit caused by an increased sales margin gained by reducing the cost per unit derived from reducing and/or eliminating unreliability.

Admittedly, an argument against the aforementioned gain could be made. Just because you produce more product doesn't mean that you can sell it. But let's examine the primary means of competition in a capitalistic environment. Companies generally compete on price and/or on quality. By reducing and/or eliminating equipment failures, both of these factors are enhanced. If you have a higher quality product to offer, your competitive position is automatically strengthened. You can increase price to increase sales revenue and/or maintain the same price and increase sales volume by offering a higher quality product for the same price.

The gains illustrated above appear to be reasonable, so we'll assume that we could potentially increase sales price and sales volume, thereby deriving a dual benefit from the reduction and/or elimination of unreliability.

Reduce maintenance

We must also consider that, with a reduction in unreliability, maintenance costs, typically the highest fixed cost in manufacturing, are substantially lowered. Maintenance costs are distributed across all production in the form of maintenance cost per unit of production. The net result of lower maintenance cost is therefore lower cost per unit of production. In a poorly performing operation, characterized by high unreliability and subsequent high maintenance cost, the benefit derived from reducing the maintenance cost per unit alone can be profound. Benchmark studies have shown that the difference between a best performer and a worst performer, relative to maintenance cost, can be exponential. In other words, a worst performer will spend exponentially more on maintenance per unit of production than a best performer.



In the process industry, the range of performance in maintenance cost as a percent of plant-replacement value (PRV) is from less than 1% for best performers to more than 15% for worst performers. For illustration purposes we will assume a 1% reduction in maintenance cost as a percent of PRV. We will assume maintenance costs were 3% of PRV, but have been reduced to 2% of PRV by implementing a robust condition-monitoring program that facilitates corrective action prior to catastrophic failure. The net increase in profit through reduced maintenance costs based on a PRV of $1 billion would be $10 million.

LINE ITEM: $10 million = The increase in profit gained by a reduction in maintenance cost derived from reducing and/or eliminating unreliability.

Extend turnaround frequency

Although it is not universally recognized, maintenance turnarounds are caused largely by unreliability. The primary driver for turnarounds is typically pressure-equipment inspection. But what if you used non-intrusive condition monitoring such that you eliminated the need to open equipment for visual inspection?

Far too many process plants still take annual turnarounds. In

Unreliability Puts a Dent in Sales

$25 million = *Increased sales price for a quality premium product*

$21 million = *Increased sales from additional capacity through reliable operation*

$25 million = *Increased profit from increased sales margin gained by reducing the cost per unit*

$10 million = *Increased sales margin from reduced maintenance costs*

$18 million = *Increased sales volume from 12 additional production days*

$215 million = *Increased sales revenue from continuous operation*

$314 million
Total increase in sales revenue enabled by reliable operation

$814 million = The total annual sales revenue enabled by reliable operation
30% = The current return on capital employed
60% = The new return on capital employed enabled by the reduction and/or elimination of unreliability

At first glance these numbers may appear to be unrealistic, but the harsh reality is that unreliable operation is very expensive on the cost and sales sides of the business equation.

this era of advanced inspection technologies, that is inexcusable. Better-performing process plants have extended the frequency of their turnarounds out to 5 to 7 yr. Let us assume that the hypothetical plant still takes annual turnarounds that cause 21 days of lost production. If the turnaround frequency was extended out to 3 yr., with only a 7-hr. increase in duration, a net annualized increase in production of approximately 12 days would be realized.

If we conservatively calculated the value of each day of production, based on current production rates and sales prices, twelve additional days of production would net an additional $18 million in sales revenue.

LINE ITEM: $18 million = The increased sales revenue gained from 12 additional days of production derived from reducing and/or eliminating unreliability caused by annual turnarounds.

Increase production

The final potential gain we will examine is the 30% of production capacity that is not currently utilized, auspiciously because of a lack of sales. Claiming that no sales were lost due to unreliability is a self-fulfilling prophecy. As long as the manufacturer is not a sole source producer, additional sales were lost to competitors. If we go back to the benefits of the highest sustainable product quality and lowest sustainable unit cost of production, there would be no valid reason for not selling every unit of production. That additional 30% of production and subsequent sales is a game changer for the business. Using the original assumption of $500 million in annual sales, adding in the additional sales revenue from continuous production, and ignoring the quality premium, the net gain in sales revenue is an astounding $215 million.

LINE ITEM: $215 million = The increased sales revenue gained by running continuously, derived directly and indirectly through the reduction and/or elimination of unreliability.

There are arguably additional sales and revenue gains that can be derived through the reduction and/or elimination of unreliability. However, using the examples above we can see that a significant increase in sales and related revenue can be gained through reliable operation.

This is not an insignificant amount of sales revenue for any size organization. The business case for reliability is compelling! Although a hypothetical manufacturing site was used to illustrate the effect of unreliability on sales, the same calculations can be used to obtain an order-of-magnitude estimate of the value of lost sales due to unreliability for any plant. Plant management and corporate leaders need to understand the high cost of unreliability. All it takes is for someone to take the initiative and calculate the value for your operation. Once the true cost of unreliability has been exposed, garnering support for improved reliability should be easy! **MT**

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