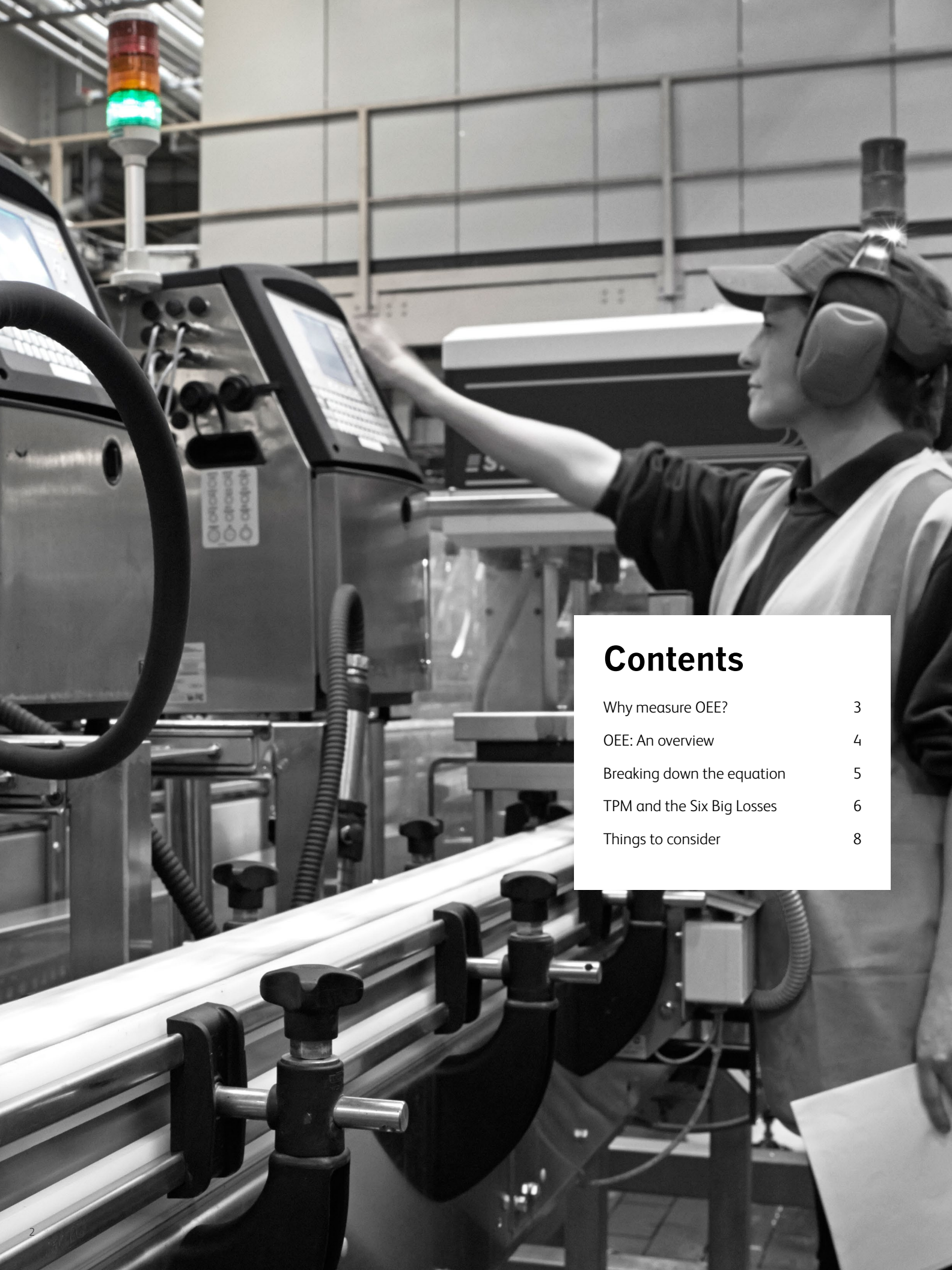**VIDEOJET**

Measuring Overall Equipment Effectiveness (OEE) and the benefits of data automation

OEE provides a model for bringing your entire plant to peak operating performance and keeping it there by focusing on one asset or process at a time, and eliminating factors that reduce performance.

As the adage goes, you can only improve what you can measure. This white paper will explain OEE in practical terms and provide examples of how it can be used to drive productivity improvements in your production.
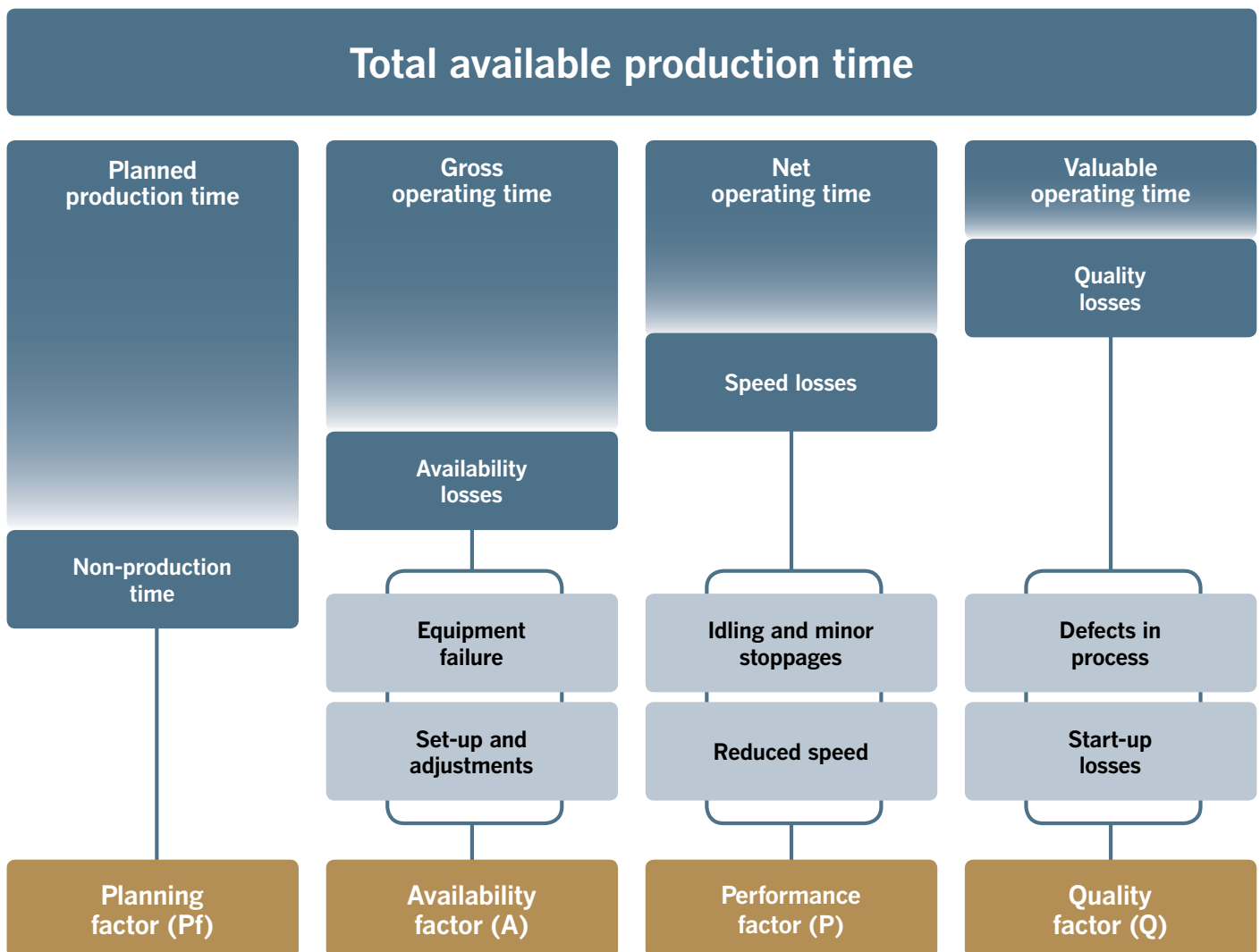
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Why measure OEE?

In order for manufacturing companies to succeed in today's globally competitive environment, they must find ways to continuously improve productivity. A proven and highly effective method of generating such improvements involves measuring OEE and using it to identify root causes of inefficiency and to prioritize and validate productivity improvement efforts. Automating the OEE data collection process offers the highest possible level of accuracy and immediacy. OEE productivity software can help streamline the process for driving operational improvements, and some newer options provide a lower cost and ease of setup that make it more attractive than ever before.

$$\boxed{\text{OEE \%}} = \boxed{\text{Availability factor (A)}} \times \boxed{\text{Performance factor (P)}} \times \boxed{\text{Quality factor (Q)}} = \frac{\text{Valuable operating time}}{\text{Planned production time}}$$

OEE: An overview

When the concept of OEE was originally introduced, it was designed to measure the effectiveness of a piece of equipment. But over the years, it has come to mean more. Overall Equipment Effectiveness is a generally accepted Lean Manufacturing principle that provides a percentage measurement of how truly productive things like a plant, line, piece of equipment, or shift is over a given time frame. In the world of packaging, this question can be "How efficient are your packaging lines?" To answer this question, you may measure your OEE on your packaging line, on your filler, your carton erector and on your printer. While they are all pieces of equipment on the line, often times above and beyond the sum of the pieces, you're more interested in what's going on with your line in general.

What does this look like?

Total available production time			
Planned production time	Gross operating time	Net operating time	Valuable operating time
			Quality losses
		Speed losses	
	Availability losses		
Non-production time			
	Equipment failure	Idling and minor stoppages	Defects in process
	Set-up and adjustments	Reduced speed	Start-up losses
Planning factor (Pf)	Availability factor (A)	Performance factor (P)	Quality factor (Q)

Breaking down the equation

Availability

Availability is the percentage of time that a machine or other physical asset is expected to be available for production, in other words, the % of time you were running when you expected to be running. It factors out time periods where the equipment wasn't scheduled to be producing, such as scheduled planned maintenance or a planned break. Equipment breakdowns, unavailable materials or other unplanned downtime reduce availability.

Example: If packaging line 1 was scheduled to be running for 14 hours on a given day, but was only actually producing for 12, the Availability for that line would by 85.7%.

Performance

Performance measures actual machine output versus the established maximum (the ideal rate) for that piece of equipment/process. Brief interruptions (several minutes or less) are factored into this metric, as opposed to ongoing downtime events which are part of the Availability calculation. The calculation is:

$$\text{Performance} = \frac{\text{Total/ideal cycle time} \times \text{Output (actual)}}{\text{Available operating time}}$$

(Available operating time = Planned operating time − downtime and changeover time)

So what does that look like in practice?

Example: If packaging line 1 was running for 12 hours, with an ideal rate of 2,500 pieces per hour, with an actual output of 23,250 in that period, Performance for that line would be 77.5%.

Quality

Quality reflects the number of manufactured parts that are deemed acceptable per defined quality standards versus the total amount produced. The important thing to remember is that this measurement is based on first pass yield.

Example: If packaging line 1 was producing a total of 23,250 pieces, of which 22,650 of which were considered good parts, the Quality for that line would be 97.4%.

Based on the above component calculations, the OEE for the line in the defined time frame would be 85.7% x 77.5% x 97.4% = 67.4%.

This score would be considered "Typical," whereas an 80% OEE score would be considered "Ideal" and classified as world-class performance. (Figure 1)
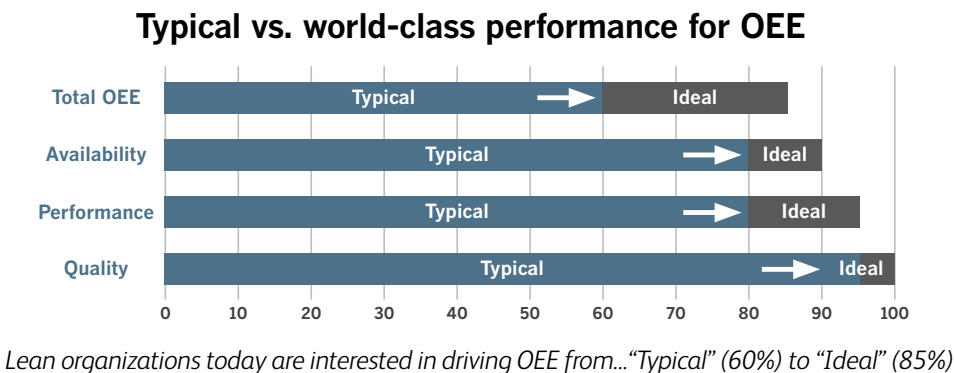
Typical vs. world-class performance for OEE

Lean organizations today are interested in driving OEE from..."Typical" (60%) to "Ideal" (85%)

Figure 1

TPM and the Six Big Losses

TPM stands for total productive maintenance. This is a philosophy regarding how you should be evaluating, monitoring, and eliminating the six big losses in your production. The six big losses can be mapped to various elements of OEE.

Availability loss

Availability is typically thought of as the inverse of downtime, and while that's a reasonable generalization, there is additional nuance that is important to understand in order to make a useful connection to TPM and the Six Big Losses. Equipment breakdown is usually the biggest contributor to reduced Availability, and it is easy to conceptualize a conveyor breaking or a cartoner being down as an event that falls into this category. However, there are other events that deduct from planned operating time that really aren't related to a machinery malfunction, yet still fall into this category. Examples would be that the line is starved of raw materials or a QA hold has stopped the line. Conversely, there are events such as an in-feed jam, which while related to the equipment, are best categorized as a performance loss, which will be discussed later.

Duration is the most common criteria for determining which bucket different event types should fall into. Typically, cessations in production between one to five minutes are considered micro-stops and fall under performance loss, while those over five minutes are classified as downtime, and cause a hit to Availability. In most Lean systems, downtime events are tracked with an assigned reason code. However, the duration threshold will vary from manufacturer to manufacturer based upon how granular the required data set is versus the amount of effort line personnel can afford to put into the act of on-going measurement.

To help ensure an OEE measurement is truly reflective of your plant's performance, you'll need to distinguish between **Unplanned downtime** and **Planned downtime**, as events that fall under the latter would not be considered an **Availability loss**. Most planned downtime events are obvious and easy to categorize such as a lunch break or planned maintenance event or sanitation period. However, for an event such as a changeover, it might be a matter of what you want your metrics to indicate. Changeovers are typically a fact of life on a packaging line, but they deduct from production time, so there is value in tracking changeovers and measuring against a target time to calculate your **Set-up and adjustments loss**.

You'll also need to give thought to how to measure a line that isn't scheduled to run on a given shift. Schedule loss is factored out of the OEE calculation, but if a capital asset sitting idle is also a concern, it is useful to also measure Total Effective Equipment Performance (TEEP), which adds the fourth element of utilization (planned production time/all time) to the calculation.

Performance loss

This category reflects a line that is available and running, but at a rate that is below its maximum speed, and can be correlated to two of the TPM six big losses. The first loss is a **Slow cycle** where the line is running continuously, but at a reduced speed. This kind of loss can be indicative of poorly-tuned equipment, materials issues, extended start-up periods, or operator inefficiency.
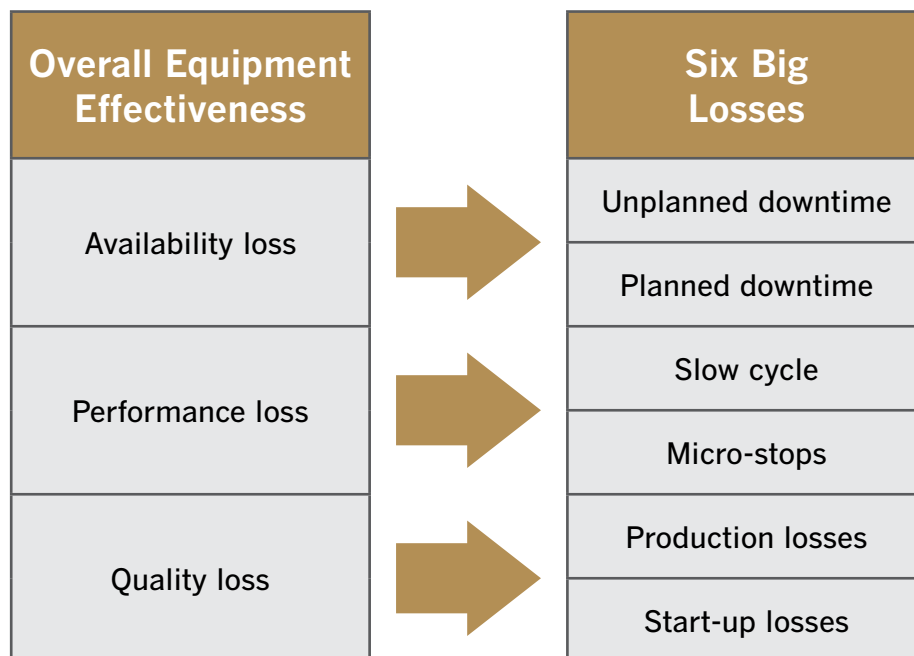
The second category, as previously described, is **Micro-stops**. These are events that stop production for a short duration and reflect an inability to keep the line continuously flowing. By definition, an individual event doesn't translate to a significant loss, but over the course of a shift, multiple occurrences can add up to a significant leakage in throughput. Therefore, capturing this loss is essential. Micro-stops can be caused by a variety of reasons, but because they are not categorized, it's necessary to understand which lines are significantly affected. After identifying these lines, you can then dig deeper via observation to help find the root cause of the problem. One example might be finding frequent line stops due to carton jams where the operator was quick to clear the jam, but upon observation, you identify that he/she failed to readjust the in-feed. This missed adjustment then caused the issue to continually repeat itself. With training, this is an issue that could then be quickly rectified.

For **Performance loss** to be measured, accurate throughput targets need to be established for each line or segment. In setting these targets, you should take into account who will be using the resultant performance data and for what purpose. Those tasked with continuous improvement, such as plant engineers, want to view performance against what is theoretically possible with current equipment. For this use case, it makes sense to set targets equal to the specification from the equipment supplier. However, operations personnel would rarely create a production schedule based on the theoretical max run rate. If you intend for this user group to be able to access the data in real-time to assess performance and adjust schedules, you may want to set a second set of targets that includes expected inefficiencies (typically 15% vs. max run rate).

Quality loss

There are two big losses that occur in regard to Quality. **Production losses** are fairly obvious to define — you're in production and sporadically a few of the items you are producing are of poor quality. Another loss sometimes forgotten about would be the materials that are thrown away during **Start-up**. For example, on a continuous flow wrapper, you would likely expect some scrap while production is ramping up to speed, and while the whole line is stabilizing. This is a quality loss, because you've made materials that are not sellable. Unfortunately, this loss of time is part of doing business, but you want to understand it and figure out how to minimize it.

You will also need to align your data collection practices for **Quality loss** within quality assurance workflows. If much of the workflow is automated, the reject data may be extractable from equipment such as check-weighers and vision systems. However, when the process is based on human visual inspection, there may be no other alternative than manual input. It certainly wouldn't be uncommon for elements of both to exist within your packaging operation, so the ability for the QA and efficiency reporting systems to interact (or be one in the same) is beneficial.

Overall Equipment Effectiveness	Six Big Losses
Availability loss	Unplanned downtime
	Planned downtime
Performance loss	Slow cycle
	Micro-stops
Quality loss	Production losses
	Start-up losses

Things to consider

Pitfalls: The data challenge

While the six big losses represent a systemic approach to identify waste and inefficiency, in a way that it can be broken down into individual categories with specific countermeasures, getting there is not always easy. To identify losses, it is essential that you are working with good, reliable data that can be organized in a manner that aligns with OEE and TPM principles, and ultimately yields actionable insight. While the means of data collection will vary based on where you are in your Lean manufacturing journey, many manufacturers are collecting data manually, for lack of a better means of doing it. While it is a good place to start, this approach is laborious, often inaccurate, and difficult to standardize. It is for these reasons that a manual approach to data collection can be a significant barrier to long-term success. And varying stakeholders with different processes can create a wide range of data that isn't likely to support identical conclusions.

Recommendations: Automation of data collection

With advances in the IIoT, data collection can now be automated using equipment already on the packaging line. With the development and integration of equipment sensors and efficiency software technology, data collection can be streamlined, far improving data accuracy and consistency. And in time, collected data can generate a storehouse of trusted and meaningful information that can be used across the organization for improvement initiatives.

Needs assessment

Navigating the value propositions of the available efficiency software solutions can be challenging. When evaluating a solution, a thoughtful understanding of your needs, both now and over the long term is necessary. Scalability and complexity are big things to consider. Some offerings may be complex to implement and are more robust in functionality than needed (i.e. you may not need a solution that will control the chillers in your production operation). Other offerings may be highly-specialized and geared toward a specific user, perpetuating a data silo issue. And still others might be overly simplistic, giving you high-level data that leaves you multiple steps away from a root cause of a problem. With software solutions available at a wide range of prices, you'll also want to find something you can get up and operating quickly at a cost that fits your budget. Finding a perfect balance of all of these elements can be tricky, so finding a trusted partner with knowledge of your production, as well as your needs and processes, is also important.

VideojetConnect™

Through thoughtful research, we've identified the need for a scalable, affordable and easily implemented productivity and efficiency solution that can help manufacturers to quickly start actualizing and benefiting from their own packaging line data. Our The VideojetConnect™ productivity tool leverages the printing equipment already on the line, and with simple set-up and minimal investment, you can add a new level of transparency into your packaging line operation. This visibility empowers you to maximize production throughput, reduce your operating costs, and drive process improvements. Highlights include:

Minimized investment and simple set-up

- Offered as a cloud-based SaaS (Software as a Service) on a factory-level basis
- Available as a yearly subscription with low monthly payments
- No installation or ongoing maintenance required
- Simple self-configuration to get up and running

Manage your daily production

- At-a-glance understanding of whether your packaging lines are on track to meet your production targets
- Provides visibility to projected shortfalls, allowing for quicker adjustments

Identify areas for improvement

- Review performance data over multiple packaging lines
- Track metrics over time to spot lines that are underperforming
- Deep dive into details related to dips in productivity

Engage your workforce

- Places easy-to-use efficiency tools in the hands of front-line operators
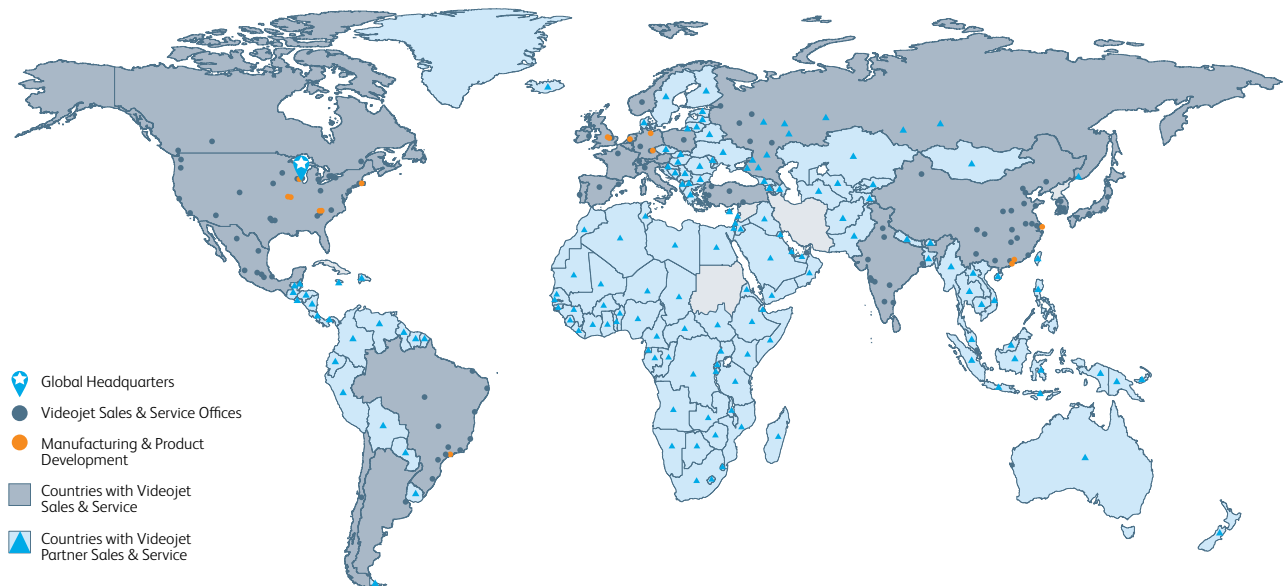- Helps users to achieve daily goals and lead the charge for continuous improvement

For more information on this, or any other Videojet product, contact your Videojet representative.

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