White paper

OEE, Continuous Improvement and the Importance of Measurement

Contents

Introduction	3
OEE and the Six Big Losses	4
Calculating OEE	5
Data collection methods and best practices	6
Defining success and growing momentum	8
Visual management tools for success	10
VideojetConnect™	11

Introduction

Inherent in the definition of Continuous Improvement (CI) is the ability to determine whether or not you are truly making forward progress. Successful measurement of CI requires metrics that are in a common format that everyone can use and understand, and that can drive action. Choosing a scoring methodology is the key first step to success. For this reason, many manufacturers select Overall Equipment Effectiveness (OEE) as their key metric.

In his seminal book on Lean Manufacturing, *The Goal*, Eliyahu Goldratt stated, "Since the strength of the chain is determined by the weakest link, then the first step to improve an organization must be to identify the weakest link." This should provide laser focus to your objective...using OEE to identify the primary constraint in your operation and to reduce or eliminate it. Once that is done, something else can be identified as the primary constraint, and the CI cycle repeated.

Terminology: Understanding OEE and the Six Big Losses

The concept of OEE was established by Seiichi Nakajima in the 1960's as part of his work on Total Productive Maintenance (TPM). OEE was defined as "a measure that attempts to reveal hidden costs," and has proven to provide an effective framework due to the direct link between the component metrics of OEE and the TPM 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. As shown below, the TPM Six Big Losses can be mapped to various elements of OEE.

Availability loss is typically thought of as the inverse of downtime. Equipment breakdown is most frequently the biggest contributor to reduced Availability, but other examples include a line starved of raw materials or a QA hold on production. To calculate Availability and to help ensure an OEE measurement is truly reflective of a plant's performance, you must be able to distinguish between Unplanned downtime (when the line goes down unexpectedly) and Planned downtime (when the line is taken down for production change outs or scheduled maintenance, for example).

Performance loss reflects a line that is available and running, but at a rate that is below its maximum speed. The two of the Six Big Losses associated with Performance loss include Slow cycles (continual movement of the line, but at a reduced speed) and Micro-stops (small stops that keep the line from running continuously that over time can add up to larger losses).

Quality loss is associated with production and start-up losses. Production losses include sporadic issues or events that create products that don't meet quality requirements. Start-up losses pertain to materials that are wasted or thrown away at the beginning of production.

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

While not part of the OEE equation, consideration should also be given to how to measure a line that has a capital asset that is sitting idle because it isn't scheduled to run in a given shift. While this schedule loss isn't factored in OEE, it is useful to also measure Total Effective Equipment Performance (TEEP) as a means of utilization (planned production time/all time).

Calculating OEE

To properly calculate OEE, you need to have accurate reference points for each of the three components:

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

Availability

With the total amount of planned run time serving as the denominator in the calculation, it is important to set a strict definition. You could decide that all time is "available production time". In that case, unless you have a true 24/7 operation, you are really measuring Total Equipment Effectiveness Performance. This measurement, however, is more reflective of utilization than efficiency. Typically, your scheduled shift would be the starting point for planned run time, but you will also need to consider planned stops (e.g. time allotted for a break or a meal). Your data and measurement will vary based on whether the entire crew leaves and the line fully stops, or if production continues during that period.

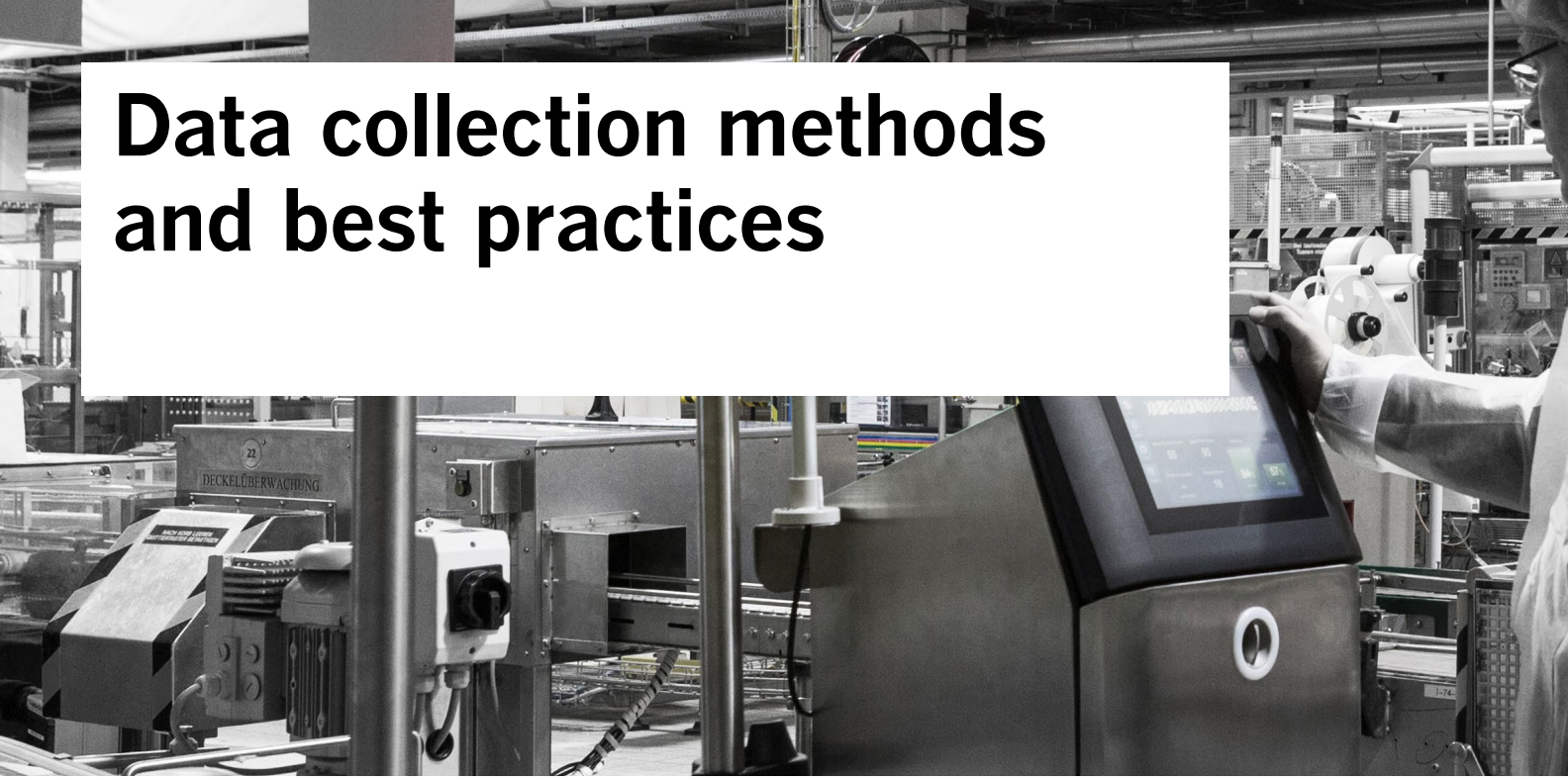
Another key element is changeovers, which occur unless you have dedicated lines for single products. While changeovers are usually planned events, they can represent significant losses, particularly if there is variation in the completion time. It may be best to initially categorize changeovers as unplanned to better capture the related data and have visibility. As your CI programs evolve, and you get a better idea of what appropriate changeover target times might be, you can alter your definition to planned for the targeted time frame, and unplanned for any period that exceeds the target. One more additional consideration is how to handle measurement of lines that aren't scheduled to run for the full shift or not at all. You will likely want to capture "Late stop", "Early Stop" or "Unscheduled" planned downtime events so you are not penalizing yourself for not having enough work to run on that line.

Performance

This value is calculated by comparing the actual throughput speed versus that target speed for the product or line. However, if you are early in your Lean manufacturing journey, it is important to understand 1) if you truly know these numbers, 2) are they accurate, and 3) are you clear on what they represent? To get started, you will need to enter something as your set point, but it is highly advisable to review and understand the actual data to get a sense for what is reality versus your best guess. Otherwise, you may end up exerting effort against an unrealistic goal or conversely, you may get a false indication that a line is running well when in fact there is significant room for improvement. Additionally, you will want to get clarity on whether your target represents the theoretical maximum you could get from that line or equipment or whether it reflects a more "typical" run rate with some inefficiency built in. It is preferable to measure yourself against the theoretical max, and depending on the scope of you CI program, it could be useful to understand and track against both numbers.

Quality

On the surface, this reference point is straightforward as it represents the total number of products produced. However, it is essential to ensure you are tracking quality in a manner that is compatible with your QA workflow. For example, do rejected products get re-worked? If so, you might not want to count the products that do eventually make it through quality, but you will need to guard against double counting them as production. Moreover, if first pass yield measurement is in scope for your initiative, you may want to assign them as a QA reject for the time being and recount them when they go through the line again. The timing of how final disposition of rejected product occurs will also have to be factored into your tracking system. If a disposition is reached quickly, it shouldn't be much of an issue, but putting products on hold for later disposition is a relatively common QA workflow. If that is the case, consider whether you will create your tracking system so that the rejects can be properly allocated to a shift, potentially even down to the hour they occurred. Or you may determine if just entering it at the time of resolution will be sufficient as a starting point for measurement.



Data collection methods and best practices

Data collection: Manual versus automated

At its most basic level, you will need to choose between manual and automated data collection prior to implementation of a CI program. To best make that decision you will want to first determine what data you need, who intends to use it, and then balance these against what data may be readily available versus challenging to obtain. You will also need to create standard work around collecting the data and provide additional inputs that give the data context. It is equally important to ensure there is standard work with owners clearly defined for the viewing, analyzing and acting on the data. An example of why this is important is that a team on the line might view a limited set of the data on a daily basis to better understand what went right and wrong on the previous day so that they can take necessary short-term corrective actions, while a management team may look at broader set of data, but on a less frequent cadence.

Pros and Cons of Data Collection Methods

Automated Data Collection (using sensors and software)	Manual Data Collection
⊕ Minimal labor	⊖ Labor intensive
⊕ Highly accurate, consistent	⊖ Varying accuracy, inconsistent, especially around event duration
⊕ Real-time data	⊖ Significant lag in data availability
⊕ Easy to standardize VM boards, accessible via many digital devices	⊕ VM boards can be customized
	⊖ Stationary
⊖ Requires networked data collection devices	⊕ Simple to get started, connectivity not required
⊖ Moderate capital investment	⊕ Little to no capital investment

Automated data collection best practices

Automated data collection with a CI program requires careful consideration and planning to make sure that you capture data that is granular enough to be meaningful and that is actionable. This usually begins with the selection of a productivity tracking software that best meets your needs and is scalable to your CI requirements both as you begin, and as you grow into a sustainable program. With implementation of a productivity tracking software it is important to remember that data is your foundation. To evaluate OEE Availability you will need to create and assign meaningful downtime codes and you will need to give thought to how the data will be best captured. Best practices for this include:

1. **Terminology must be easily understandable and identifiable. This clarifies ambiguity on which downtime code "fits" best and prevents two operators from reporting the same event differently.**

2. **Captured data must lead you in an actionable direction, even if not directly pinpointing a root cause.**

3. **Codes should be related to how personnel might organize their work and undertake corrective actions. For example, if you have different staff to address mechanical versus electrical issues, you will want to make sure your codes correlate to the appropriate area of responsibility.**

4. **Factors other than just machine breakdowns, such as raw materials flow, QA related issues, staffing constraints, and other variables should be considered.**

5. **Strike a balance between obtaining detailed data and creating an overload of codes. Too many can confuse operators and also lead to data that is so microscopic that nothing stands out as a big problem to be addressed.**

While some later-model production equipment may have the intelligence to output very specific fault codes, while informative, directly accessing that data is likely not advisable for a new CI program. Integrating that information usually entails significant effort from specialized personnel. Codes are very specific to each machine, which could end up masking an issue specific to your operation. Furthermore, if you start incorporating multiple machines with this capability, you run the risk of violating best practices 1 and 5 above.

Defining success and growing momentum

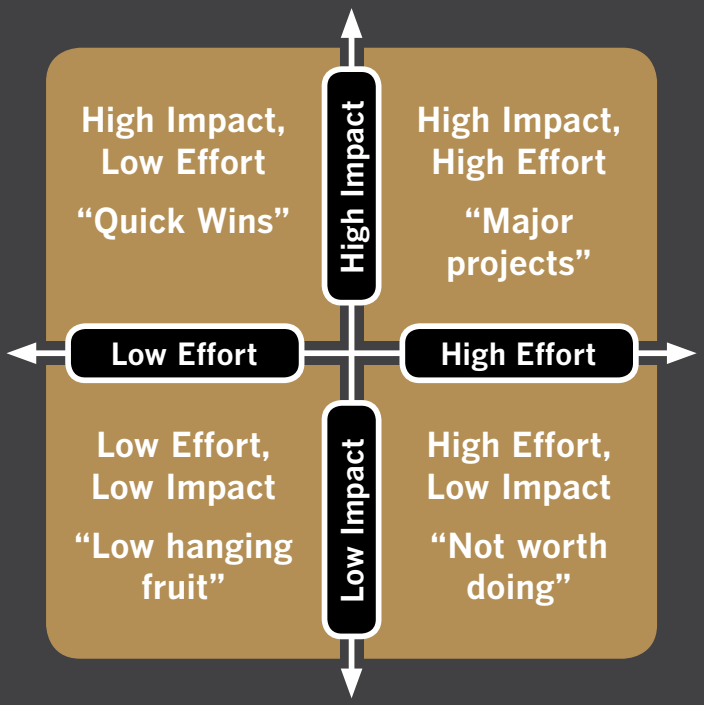
Defining success: What is a good improvement target?

At the onset of your CI journey, determining your target for improvement should be a topic of discussion for the team. While suggested total OEE score target percentages exist (a 60% improvement score is considered "typical" and 85% is considered "world class") and are seemingly helpful, it is advisable not to get caught up in these figures as you launch a CI program. There are too many variables that can affect your metric and therefore, your results. These can include variances based on your industry, the unique workflows of your operation, and in particular, the nuances of the implementation of your measurement system. Using these improvement targets as absolutes can lead to a false sense of security with a high score or an unnecessary sense of emergency with a low score. Your success is best determined by the establishment of a consistent measurement system that can indicate if you are improving, and can help you assess the impact of your assigned countermeasures. Attainment of a specific target is best left to a later stage in your program after your CI processes are optimized and your targets individualized to your operation.

Grow momentum with low hanging fruit

Searching your entire operation for its number-one constraint is not likely the best way to get started with an OEE-based CI program. Instead, getting quick traction on an item you can clearly identify and affect is often the better route as it generates momentum and mobilizes organizational buy-in. Most operations managers have a sense for where their problem areas might be, so it advisable for them to help identify a manageable area of the operation to use as a starting point.

While going after the biggest loss first seems logical, it might not always be the best course of action. A best practice is to plot the impact of attacking a specific item versus the effort that will need to be undertaken, looking for the best combination of high impact with low effort (see chart on page 9). It is helpful to think broadly when defining effort. Aside from the direct efforts of those involved, be sure to include dollars required, the efforts of non-direct personnel who may need to supervise or support the team members, and the opportunity costs related to the team members. (Note that it is advisable to have at least some resources who are fully dedicated to the CI initiative and won't have opportunity costs related to items not on the chart). You should also factor into the equation whether or not you really think you can do something to address the issue.



Navigating Impact Versus Effort

Getting started

To grow momentum with the team and to build a culture of CI, it may be advisable to start with something in the low effort category, even if it only has a moderate to low impact (see chart above). With growing success, over time you will want to be more rigorous in choosing items with increasing levels of impact. When selecting your initiatives, you will need to mindfully apply knowledge of your operation along with the Theory of Constraints to ensure you aren't selecting an item that can't be improved until another item is acted upon first. This advanced mindset usually comes at a more mature stage in the CI cycle and is handled by an optimized design of your data collection process.

In some cases, the data may lead you directly to an answer. For example, the outfeed conveyor motor on Line 3 is causing frequent and extended downtime. Or data could lead you to further observation (e.g. you investigate the significant number of line stops on line 2 and find that the operator for that shift requires additional training to properly feed product.

Determining impact: Frequency versus time

In ranking the impact of items, the most common way to look at it is in terms of total production time or throughput loss. Often this view will give you a solid and objective ranking, but early-on in development of your CI process, when you have a smaller data set, frequency of occurrence should not be ignored. If you have a high-ranking loss, for example, but it stems from a single incident, you may need to gain some understanding of to what degree that item was an anomaly or may have been fully addressed during the recovery process. In that case, effort might better be spent on items where you can observe a high frequency, indicating a systemic issue that is almost sure to reoccur.

Measuring effectiveness and sustainment

The ultimate goal of a CI program is for the OEE in the targeted area to increase, but new and additional factors might be contributing to the change and masking the effect of a countermeasure. While the best case scenario is near immediate elimination of the targeted loss, that isn't always possible. That is why it is advisable for team members to align, and commit to in advance, improvement goals in terms of loss reduction and time period (e.g. achieve a 60% reduction in loss over 30 days) and for activities to be tracked on a regular cadence via visual management tools.

Implementation of a sustainable CI program is achievable with the right tools and thoughtful planning. Using data and OEE methodology as your guide, you can set baseline metrics and improvement targets, establish standard work, and track progress using Visual Management tools. With consistency and ongoing measurement, you can watch your success grow over time, better your production and establish a culture of continuous improvement.

Using visual management tools for success

Visual management best practices

Making sure data is formatted and accessible in a manner that is consistent with good Visual Management practices is essential. An advantage to using production tracking software is that it's typically set-up to easily organize a series of fairly standard visual indicators and can be accessible to multiple personnel in a number of ways, whether that be large monitor on the production floor, or a PC/Tablet/Phone viewing the data remotely. However, a hand-written board can also be effective and of course is fully customizable to measure and display the data in a manner that fits your needs.

Good Visual Management Practices

- 3 Second rule – winning/losing in 3 seconds
- Visible at a distance
- Directed toward a group, not individuals
- Shows a standard and performance to that standard
- Spells out all acronyms and abbreviations
- Involves all associates in the visual management process
- Focuses team on the critical few
- Used to drive problem solving in a blameless environment

But above all else, a commitment and a consistent process of reviewing and acting on the displayed metrics is crucial to success. The best organized board in the world will still be nothing more than decoration unless the key stakeholders continually review the data, align on its implications and execute follow-up actions on a regular basis. It is advisable to provide detail, in writing, about the constituencies that will use the data, what they will use it for, how often they will review it, how actions will be agreed upon and assigned and expected outcomes. But even once agreed upon, follow-through is the key element (see chart example below).

Implementation of a sustainable CI program is achievable with the right tools and thoughtful planning. Using data and OEE methodology as your guide, you can set baseline metrics and improvement targets, establish standard work, and track progress using Visual Management tools. With consistency and ongoing measurement, you can watch your success grow over time, better your production and establish a culture of continuous improvement.

VideojetConnect™ Configuration and Assignments Guide/Template				
Category	**Task**	**Group/Person Responsible**	**Status/Comments**	VideojetConnect™
Configuration	User set-up	Operations - "Bob Jones"	Complete; "Bob" will add new users as necessary	
	Line set-up	Operations - "Bob Jones"	Complete	
	Shift set-up	Operations - "Bob Jones"	Complete	
	Downtime code creation	Maintenance - "John Smith"	Complete; "John" will add new codes as necessary	
	Product set-up	Scheduling - "Sally Miller"	To be updated weekly	
Category	**Task**	**Group/Person Responsible**	**Mechanism**	**Status/Comments**
Data Entry	Product	Line 1 - Shift operator Line 2 - Shift operator Line 3 - Shift operator	Line 1 - Tablet #7 Line 2 - Line-side PC Line 3 - Tablet #8	SOP Written. Shift 2 Operators still need to be trained.
	Downtime	All lines - Maintenance leader	Either the line side mechanism or their own PC	Maintenance leaders will have rights for retroactive DT assignment
	QA rejects	All lines - QA	Their own PC	Entered as needed on an hourly basis
Category	**Data**	**Reviewers**	**How/Frequency**	**Status/Comments**
Data Review	Previous day - Plant level performance	Ops - "Bob Jones"; Maintenance - "John Smith"	Morning management meeting	Use shift summary report
	Previous day - Line level performance	Line leaders and their team(s)	Morning stand-up meeting	Use shift summary report
	Weekly downtime review	"John Smith" and maintenance team	Weekly maintenance meeting	Use downtime report dashboard in meeting to see overall and by line/shift
	Packaging ops performance	Senior management team	Monthly ops review	Use OEE downtime report dashboard in meeting to see overall and by line/shift

Using a template similar to this one can help create consistency and accountability with key stakeholders.

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. The VideojetConnect™ productivity tool leverages the Videojet 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 under-performing
- 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

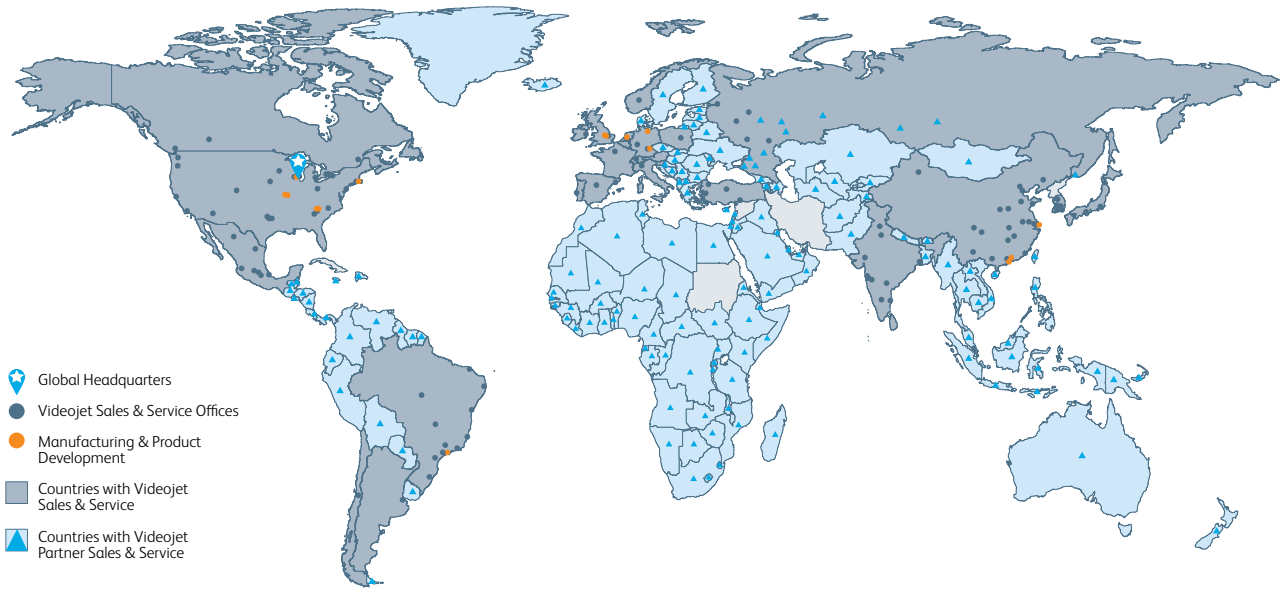
For more information on this, or any other Videojet product, contact your Videojet representative.

Peace of mind comes as standard

Videojet Technologies is a world-leader in the product identification market, providing in-line printing, coding, and marking products, application specific fluids, and product life cycle services.

Our goal is to partner with our customers in the consumer packaged goods, pharmaceutical, and industrial goods industries to improve their productivity, to protect and grow their brands, and to stay ahead of industry trends and regulations. With our customer application experts and technology leadership in Continuous Inkjet (CIJ), Thermal Inkjet (TIJ), Laser Marking, Thermal Transfer Overprinting (TTO), case coding and labeling, and wide array printing, Videojet has more than 345,000 printers installed worldwide.

Our customers rely on Videojet products to print on over ten billion products daily. Customer sales, application, service, and training support is provided by direct operations with over 4,000 team members in 26 countries worldwide. In addition, the Videojet distribution network includes more than 400 distributors and OEMs, serving 135 countries.



Order supplies **shop.videojet.com**
Call **800-843-3610**
Email **info@videojet.com**
or visit **www.videojet.com**

Videojet Technologies Inc.
1500 Mittel Blvd. Wood Dale IL 60191 / USA

VIDEOJET