






BOS Processing Brochure

# The Homogenisation Applications Handbook

A practical processing guide to high-pressure homogenisation across the dairy, food & beverage, pharmaceutical, life-science and chemical industries with recommended pressures, process routes and BOS MG-series machine selection for more than twenty-five applications.

## BOS Homogenisers

Rebuilt and technically validated from decades of homogenisation field experience, updated to current practice, metric pressures and today's application landscape.



## Why processors choose BOS

- 75 years of homogenisation know-how and field experience.
- A complete MG-series range, manufactured in the EU.
- Over 15,000 spare parts on stock, worldwide supply.
- Service & parts for APV, SPX and Gaulin fleets.
- Customer Service Laboratory for feasibility trials.
- Worldwide distribution & local service network.

since 1950 BOS homogenisers

# About This Manual

High-pressure homogenisation is one of the most versatile unit operations in modern processing. The same machine that gives fresh milk its stable, creamy body can build a pharmaceutical nanoemulsion, rupture yeast cells to release a recombinant protein, or disperse a pigment for a high-performance coating. This handbook brings those applications together in one place.

The original process reports behind this manual were compiled over many years of laboratory and plant trials on the Gaulin and Manton-Gaulin homogenisers, the very machines BOS has serviced, refurbished and supplied parts for since 1950. That heritage know-how remains remarkably sound: the physics of droplet break-up and particle dispersion has not changed. What has changed is the language (pressures are now stated in bar, particle sizes in nanometres), the achievable performance, and above all the range of products the technology now serves.

For this 2026 edition we have re-written every process note in current terms and cross-checked the fundamentals against recent literature. All figures have been converted to metric, and each application has been mapped to the BOS MG-series. We have also added application families that did not exist when the first reports were written. These include plant-based beverages, pharmaceutical nano-carriers, injectable lipid emulsions and advanced material dispersions.

## How to use this handbook

- Start with The Science of Homogenisation for the shared principles behind every application.
- Use Selecting the Right Process to translate a product into pressure, stages and passes.
- Jump to the Application section for your industry — each entry is self-contained.
- Cross-check the MG-series data and quick-reference table for machine selection.
- Pressures and passes are starting points — final settings are confirmed by trial.
- The BOS Customer Service Laboratory can run product-specific feasibility trials.

“We are eager to share our knowledge, so that you can enjoy a trouble-free homogenisation process.”

**Jeroen van Douveren, CEO BOS Homogenisers**

# The Science of Homogenisation

A high-pressure homogeniser is a positive-displacement pump that forces product through an adjustable restriction, the homogenising valve, at very high pressure. As the fluid accelerates through the narrow gap it experiences intense shear, turbulence, cavitation and a sudden pressure drop. In microseconds these forces tear droplets and particle clusters apart and distribute them evenly through the continuous phase.

### Emulsions

An emulsion is a system of two immiscible liquids in which one is dispersed in the other as fine droplets, most often oil-in-water. An emulsifier is needed to stabilise the new surface and prevent the droplets from coalescing again. The homogeniser creates enormous new surface area; the finer and more uniform the droplets, the slower the system creams or separates (Stokes' law), and the longer the shelf life.

### Dispersions

A dispersion is a finely divided solid suspended in a liquid. Homogenisation de-agglomerates particle clusters and distributes them uniformly, while a dispersing agent prevents them re-clustering. The same machine, valve and principles apply only the formulation chemistry differs.

### Trading mechanical energy for chemistry

One of the most valuable, and still entirely current, insights from the original field work is that mechanical energy can be traded for emulsifier. A spontaneous, un-homogenised emulsion may need 25–50 % emulsifier to stay stable. High-shear mixing brings that down to 5–10 %; a colloid mill to 2–5 %; and a high-pressure homogeniser to as little as a few tenths of a percent. Because mechanical energy is far cheaper than emulsifier, the homogeniser often pays for itself in formulation cost alone while delivering a finer, more stable product.

## Key principles - unchanged since the first process reports

- Finer, more uniform droplets > slower separation > longer shelf life.
- Particle size falls with rising pressure and additional passes.
- A good pre-mix (narrow droplet distribution) makes homogenisation far more effective.
- Two-stage valves add back-pressure to break droplet clusters and reduce "ringing".
- Over-working an emulsion can exceed the emulsifier's capacity and cause flocculation.
- Temperature rise is modest — roughly 2 °C per 100 bar for water-based products.

# Selecting the Right Process

Four questions turn almost any product into a homogenisation recipe: what is the target particle or droplet size, what is the pre-mix viscosity, how many passes are practical, and what pressure is needed to reach the required fineness? As a rule of thumb, droplet size falls roughly in proportion to the logarithm of homogenising pressure.

| Typical operating windows by product class | | | |
|---|---|---|---|
| **Product class** | **Pressure (bar)** | **Passes** | **Typical target** |
| Dairy — milk, cream, recombined | 150–250 | 1 (two-stage) | 0.5–1 $\mu$m fat globules, no cream line |
| Plant-based & protein beverages | 150–300 · UHPH to 1,000+ | 1–2 | Stable suspension, no sedimentation |
| Food emulsions & sauces | 100–350 | 1–2 | Viscosity, gloss, stability |
| Flavour / essential-oil cloud emulsions | 200–350 | 2–3 | < 2 $\mu$m, no oil ringing |
| Pharma nanoemulsions & lipid carriers | 500–1,500 | 3–6 | 100–200 nm, low polydispersity |
| Injectable / parenteral lipid emulsions | up to 1,000+ | multiple | USP particle-size limits (patient safety) |
| Cell disruption (biotech) | 600–1,500 | 1–3 | Cell lysis, product release |
| Pigment / nano-oxide / material dispersions | 300–1,500 | 1–4 | De-agglomeration, uniformity |

### One stage or two?

A single-stage valve is enough for straightforward size reduction. A two-stage valve applies a second, lower back-pressure (typically 10–15 % of total) that breaks up droplet clusters formed in the first stage essential for dairy, flavour emulsions and any product prone to clustering or “ringing”.

### Viscosity guides equipment choice

Homogenisers work best on pre-mixes up to roughly 1,000 cP (internal-phase viscosity); above this, efficiency gradually falls. Very high-viscosity, high-oil products such as mayonnaise are the classic exception and have historically been the domain of the colloid mill. Note too that higher pressure is not always better: over-working can break an emulsion, and multiple gentle passes often beat one aggressive pass.



# The BOS MG-Series

A complete range of eleven high-pressure pumps and homogenisers, manufactured in the Netherlands and tailored to capacity and pressure. Every application in this manual can be matched to an MG model from a compact lab unit to a 45,000 litre/hour production line.










| Machine Specifications Overview | | | | |
|---|---|---|---|---|
| **Type** | **Litres / hour** | **Pressure (bar)** | **Power (kW)** | **Typical fit** |
| MG2 | 1.300 l/h | 100 – 1.400 bar | 5,5 kW | Lab, R&D, small pharma |
| MG3 | 3.500 l/h | 100 – 1.400 bar | 15 kW | Pilot / small production, nano |
| MG4 | 5.000 l/h | 100 – 1.400 bar | 22 kW | Small food & dairy |
| MG12 | 8.500 l/h | 100 – 1.400 bar | 30 kW | Mid dairy & food |
| MG14 | 9.500 l/h | 100 – 1.400 bar | 37 kW | High-pressure / nano at scale |
| MG18 | 13.000 l/h | 100 – 1.400 bar | 75 kW | Pharma & fine chemicals |
| MG30 (5-piston) | 20.000 l/h | 100 – 1.400 bar | 90 kW | Large dairy & beverage |
| MG45 | 25.000 l/h | 100 – 1.400 bar | 132 kW | Large food & beverage |
| MG120 (5-piston) | 40.000 l/h | 100 – 1.400 bar | 160 kW | Very large dairy |
| MG124 (5-piston) | 45.000 l/h | 100 – 1.400 bar | 200 kW | High-volume production |
| MG140 (6-piston) | 50.000 l/h | 100 – 1.400 bar | 250 kW | High pressure at high volume |

## The MG-Series at a glance

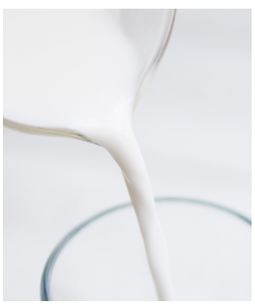
- Easy access for maintenance, low downtime.
- All product-contact parts corrosion resistant.
- Spare parts available worldwide — over 15,000 in stock.
- Compatible service & parts for APV, SPX and Gaulin fleets.
- EHEDG-compliant and aseptic executions available.
- Unbeatable reliability, backed by 24-month warranty.

# 01 - Dairy & Beverage

The original home of homogenisation, and still its largest market. From standardised milk to the fast-growing world of plant-based drinks, the goal is the same: a stable, uniform, appetising liquid that will not separate on the shelf.



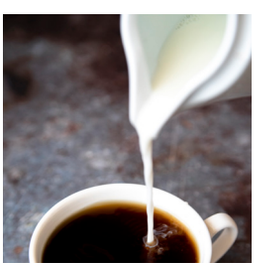
| **Milk, Cream & Recombined Dairy** [Dairy] | |
|---|---|
| **Application** | Fresh, UHT, condensed and recombined milk and cream; standardised fat products. |
| **Why homogenise** | Breaks fat globules to ~0.5–1 $\mu$m so cream cannot rise; improves whiteness, mouthfeel and stability, and prevents fat separation in UHT products. |
| **Process** | Two-stage, 150–250 bar, single pass, typically at 60–70 °C. |



| **Plant-Based & Protein Beverages** [New · Growth] | |
|---|---|
| **Application** | Oat, almond, soy, pea, hazelnut and blended plant “milks” and high-protein drinks. |
| **Why homogenise** | Reduces and unifies particle size, unfolds protein and coats oil droplets — cutting sedimentation and creaming. Ultra-high-pressure (UHPH) can also cut microbial load without heat damage. |
| **Process** | 150–300 bar conventional; UHPH up to ~1,000+ bar for stability plus cold-chain-free shelf life. |



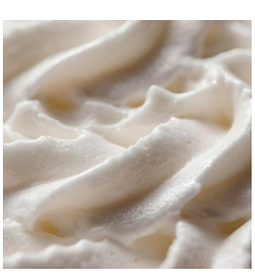
| **Soya Beverage** [Dairy alt.] | |
|---|---|
| **Application** | Single-strength and spray-dried soy drinks; a milk replacement where lactose tolerance or cost matter. |
| **Why homogenise** | Ruptures bean cell structure to release protein and oil (up to ~99 % protein recovery), disperses fibre, and produces a fine oil emulsion that will not separate on storage. |
| **Process** | after pressure-cooking, homogenise at 280–550 bar; fill hot or sterilise for long shelf life. |



| **Coffee Whitener & Creamers** [Beverage] | |
|---|---|
| **Application** | Liquid and spray-dried non-dairy creamers and coffee whiteners. |
| **Why homogenise** | Emulsifies vegetable fat into the protein/carbohydrate phase for whitening power, feathering resistance in hot coffee, and a stable emulsion before drying. |
| **Process** | two-stage, 150–300 bar, at emulsion temperature. |



| **Flavour & Essential-Oil Cloud Emulsions** [Beverage] | |
|---|---|
| **Application** | Orange-oil and citrus concentrates, weighted flavour oils and cloud emulsions for soft drinks. |
| **Why homogenise** | Drives oil droplets below ~2 $\mu$m for a stable cloud and true flavour delivery — while avoiding over-working, which causes flocculation and neck “ringing” on dilution. |
| **Process** | two-stage, 200–350 bar, 2–3 passes; second stage 10–15 % of total. |



| **Whipped & Frozen Toppings** [Beverage] | |
|---|---|
| **Application** | Aerosol and frozen whipped toppings, dessert emulsions. |
| **Why homogenise** | Creates the fine, uniform fat emulsion that gives good overrun, whip stability and a smooth set after freezing. |
| **Process** | two-stage, 150–250 bar, tuned to fat system. |

# 02 - Food & Culinairy

Sauces, dressings, purées and prepared foods rely on homogenisation for the three qualities the shopper notices first: body, gloss and a product that stays mixed from opening to last spoonful.



| **Mayonnaise** [Emulsion] | |
|---|---|
| **Application** | High-oil (65–80 %) oil-in-water emulsion stabilised by egg. |
| **Why homogenise** | Maximises oil surface area for high viscosity and long stability. A classic high-viscosity exception: the colloid mill is traditional here, as a homogeniser can over-extend the emulsifier and break the emulsion. |
| **Process** | colloid mill at controlled gap/throughput; homogenise only for lighter, lower-oil dressings |



| **Salad & French Dressings** [Emulsion] | |
|---|---|
| **Application** | Pourable and spoonable dressings, lower oil than mayonnaise. |
| **Why homogenise** | Produces a stable, uniform emulsion with the target viscosity and cling, resisting oil separation on the shelf. |
| **Process** | colloid mill at controlled gap/throughput; homogenise only for lighter, lower-oil dressings |



| **Tomato Ketchup & Purées** [Sauce] | |
|---|---|
| **Application** | Ketchup, tomato paste-based sauces, fruit and vegetable purées. |
| **Why homogenise** | Refines pulp and disperses solids for a smooth, glossy, thick body with excellent cling and no serum separation. |
| **Process** | 100–200 bar, single pass; hard-faced valve for pulp |



| **Cream Soups & Cheese Sauces** [Food·Safety] | |
|---|---|
| **Application** | Cream soup bases, cheese sauces for canned vegetables and ready meals. |
| **Why homogenise** | Builds viscosity and a creamy, stable emulsion — often allowing far more water and fewer solids, with better colour, flavour release and post-retort stability. |
| **Process** | 100–150 bar; large viscosity and stability gains vs. shear mixing |



| **Baby & Infant Food** [Food·Safety] | |
|---|---|
| **Application** | Strained fruit, vegetable and meat baby foods. |
| **Why homogenise** | Delivers a smooth product free of fibre, fat or muscle particles, and a uniform texture safe and easy to swallow. |
| **Process** | 100–250 bar; meat products at the higher end for full particle refinement |



| **Egg & Dairy Proteins** [Ingredrient] | |
|---|---|
| **Application** | Reconstituted whole-egg, sodium caseinate manufacture and protein ingredient systems. |
| **Why homogenise** | Fully hydrates and disperses dried or precipitated protein into a smooth, lump-free, uniform fluid ready for further processing or drying. |
| **Process** | 100–200 bar, single pass, warm |

# 03 - Pharmaceutical & Life Sciences

The fastest-growing frontier for high-pressure homogenisation. Modern valves reach the pressures needed to build nanometre-scale carriers, meet injectable-grade particle limits, and release products from inside living cells.



| **Pharmaceutical Nanoemulsions** [New] | |
|---|---|
| **Application** | Oil-in-water carriers for poorly soluble APIs — oral, topical and injectable drug delivery. |
| **Why homogenise** | Reaches 100–200 nm droplets that raise bioavailability, improve stability and enable controlled release. HPH is regarded as the gold-standard route for pharmaceutical nanoemulsions. |
| **Process** | 500–1,500 bar, 3–6 passes, temperature-controlled |

| **Liposomes, SLN & NLC** [New] | |
|---|---|
| **Application** | Liposomes, solid lipid nanoparticles and nanostructured lipid carriers for drug and nutraceutical delivery. |
| **Why homogenise** | Hot high-pressure homogenisation of a molten-lipid pre-emulsion forms uniform nanoparticles on cooling — a solvent-free, scalable, reproducible route. |
| **Process** | hot HPH, 200–2,000 bar; NLC often optimal near 700 bar, 2 passes. |

| **Lipid Nanoparticles — mRNA & Gene Therapy** [New] | |
|---|---|
| **Application** | Cationic nanoemulsions and lipid nanoparticles for nucleic-acid and vaccine delivery. |
| **Why homogenise** | Generates the fine, uniform lipid nanocarriers that protect and deliver the payload; a scalable production route alongside microfluidics. |
| **Process** | hot HPH, 100–2,000 bar; controlled temperature and passes |

| **Parenteral / TPN Lipid Emulsions** [New·Sterile] | |
|---|---|
| **Application** | APPLICATION  Intravenous lipid emulsions for clinical (parenteral) nutrition and injectable drug carriers. |
| **Why homogenise** | Homogenisation is the final, critical step setting mean droplet size and the large-droplet tail — the quality attributes that govern patient safety and compliance with pharmacopoeial (USP) limits. |
| **Process** | multi-pass to ~1,000+ bar under a Quality-by-Design control strategy; double-packed aseptic execution |

| **Cell Disruption & Biotech** [Biotech] | |
|---|---|
| **Application** | Rupture of yeast, bacterial and mammalian cells to release recombinant proteins, enzymes and intracellular products. |
| **Why homogenise** | Mechanical, additive-free lysis at controlled, repeatable intensity — scalable from lab to full production for downstream recovery. |
| **Process** | 600–1,500 bar, 1–3 passes; chilled to protect the product. |

| **Antacids & Pharmaceutical Suspensions** [Pharma] | |
|---|---|
| **Application** | Liquid antacid and mineral suspensions, oral pharmaceutical dispersions. |
| **Why homogenise** | De-agglomerates and uniformly suspends the active solid for a smooth, stable, pourable product with consistent dosing. |
| **Process** | 150–400 bar, single or two-stage. |

# 04 - Chemical & Industrial

Beyond food and pharma, the homogeniser is a workhorse of the chemical industry: dispersing pigments and nano-materials, emulsifying oils and silicones, and turning solids into stable, usable liquids.



| **Pigment & Ink Dispersions** [Coatings] | |
|---|---|
| **Application** | Organic and inorganic pigment dispersions for paints, inks and coatings. |
| **Why homogenise** | De-agglomerates pigment clusters and distributes them uniformly for full colour strength, gloss and stability against re-settling. |
| **Process** | 300–1,000 bar, 1–4 passes; hard-faced valve for abrasion |

| **Silicone Emulsions** [Specialty] | |
|---|---|
| **Application** | Silicone oil-in-water emulsions for release agents, textiles, polishes and care products. |
| **Why homogenise** | Produces fine, stable, dilutable emulsions of an otherwise difficult-to-disperse phase. |
| **Process** | two-stage, 200–500 bar |

| **Colloidal Silica & Nano-Oxide Dispersions** [Nano] | |
|---|---|
| **Application** | Colloidal silica, metal-oxide and ceramic nanoparticle dispersions. |
| **Why homogenise** | Breaks hard agglomerates and delivers the narrow, uniform particle distribution these functional dispersions demand. |
| **Process** | 500–1,500 bar, multiple passes |

| **Latex, Polymer & Monomer Emulsions** [Polymer] | |
|---|---|
| **Application** | Synthetic-resin, monomer and latex emulsions for adhesives, coatings and polymerisation feeds. |
| **Why homogenise** | Creates the fine, uniform droplet size that controls reaction kinetics and final product properties. |
| **Process** | 150–500 bar; volatile monomers stay contained under pressure |

| **Wax, Fuel-Oil & Lubricant Emulsions** [Industrial] | |
|---|---|
| **Application** | Wax emulsions, fuel-oil and water blends, lubricant and grease additive systems. |
| **Why homogenise** | Handles materials that are solid or immiscible at ambient temperature as stable, pumpable, uniform emulsions. |
| **Process** | 150–400 bar, hot where waxes must stay molten |

| **Graphene & 2D-Material Exfoliation** [New] | |
|---|---|
| **Application** | Liquid-phase exfoliation and dispersion of graphene, carbon nanotubes and layered nano-materials. |
| **Why homogenise** | Shear and cavitation exfoliate and disperse 2D materials into stable conductive pastes and functional inks — a genuinely new class of application. |
| **Process** | 500–1,500 bar, multiple passes |

VALIDATION

# Then & Now: What Has Changed

The original process reports have aged well. The core science is intact and every fundamental principle still holds. What has moved on is the unit of measure, the pressures and particle sizes now achievable, and most of all the breadth of products the technology serves. This edition reflects all three.

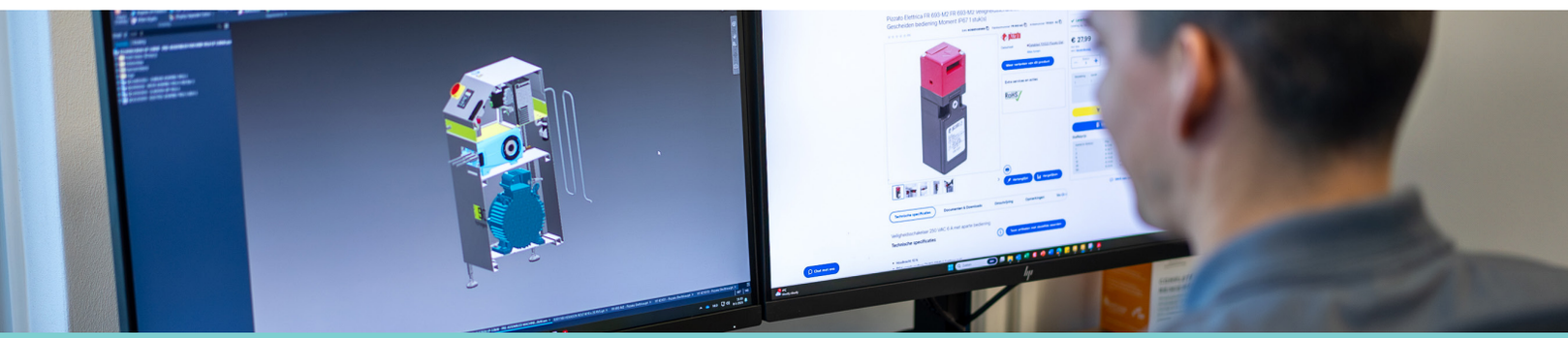
| The fundamentals — validated against current practice | | |
|---|---|---|
| **Topic** | **Original field manual (1970s)** | **Today & the BOS MG-series (2026)** |
| Pressure units | psi (pounds per square inch) | bar / MPa — this manual is fully metric |
| Practical pressure ceiling | ~8,000–10,000 psi (≈ 550–690 bar) | MG-series to 1,400–1,700 bar; UHPH beyond |
| Typical fineness quoted | Micrometres (1–4 $\mu$m common) | Routine sub-micron; nanoemulsions 100–200 nm |
| Terminology | “High-energy equipment”, colloid mill | HPH / UHPH; colloid mill now a niche tool |
| Preservation role | Not applicable | UHPH also reduces microbial load without heat |
| Emulsifier trade-off | Established & still cited | Confirmed — unchanged and still valuable |
| Emulsion / dispersion theory | Sound | Fully current — no revision needed |

### What is genuinely new

Whole application families have appeared since the original reports and are covered in this edition: plant-based & alternative-protein beverages; pharmaceutical nanoemulsions; liposomes, solid lipid nanoparticles and nanostructured lipid carriers; lipid nanoparticles for mRNA and gene therapy; injectable / parenteral (TPN) lipid emulsions to pharmacopoeial limits; large-scale cell disruption for biotechnology; and graphene, carbon-nanotube and nano-oxide dispersions. Several dated entries from the original index — reconstituted tobacco leaf and road-building asphalt emulsions among them — have been retired as they fall outside the industries BOS serves today.

## The bottom line

The heritage know-how is still correct the physics does not age. This edition keeps what works, restates it in today’s units and pressures, and extends it into the dairy-alternative, pharmaceutical and nanotechnology markets that now drive demand for high-pressure homogenisation.



QUICK REFERENCE

# Process & Machine Selector

A starting-point summary for matching an application to pressure, process route and a BOS MG-series machine. Final parameters are always confirmed by trial.

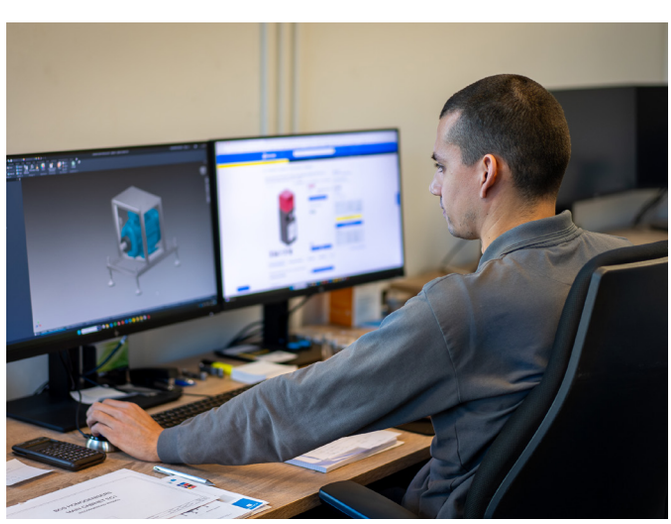
| Application > process > suggested MG-series fit | | | | |
|---|---|---|---|---|
| **Application group** | **Pressure (bar)** | **Stages/passes** | **Target result** | **Suggested MG fit** |
| Milk, cream & recombined dairy | 150–250 | 2-stage · 1 | No cream line, mouth-feel | MG30 / MG120 / MG124 |
| Plant-based & protein beverages | 150–1,000+ | 1–2 | Suspension stability | MG12 / MG30 / MG45 |
| Coffee whitener & creamers | 150–300 | 2-stage · 1 | Whitening, feather resist. | MG12 / MG30 |
| Flavour / cloud emulsions | 200–350 | 2-stage · 2–3 | < 2 $\mu$m, no ringing | MG4 / MG14 |
| Sauces, dressings, purées | 100–350 | 1–2 | Body, gloss, stability | MG12 / MG18 / MG30 |
| Baby & infant food | 100–250 | 1–2 | Smooth, particle-free | MG4 / MG12 |
| Pharma nanoemulsions & carriers | 500–1,500 | 3–6 | 100–200 nm | MG2 / MG3 / MG14 / MG18 |
| Parenteral / TPN lipid emulsions | up to 1,000+ | multi-pass | USP particle limits | MG3 / MG14 (aseptic) |
| Cell disruption (biotech) | 600–1,500 | 1–3 | Cell lysis, recovery | MG3 / MG14 / MG18 |
| Pigment / nano-material dispersions | 300–1,500 | 1–4 | De-agglomeration | MG14 / MG18 / MG45 |

## Configure your machine

- One or two-stage & hydraulic homogenising valves.
- Ceramic or tungsten-carbide valves & coated plungers.
- Double-packed cylinder for aseptic / sterile processing.
- Automatic PLC/HMI pressure control & transducers.
- EHEDG execution & food-grade lubricants.

**Not sure where to start?**

Send us your product's phase (emulsion or dispersion), target particle size, pre-mix viscosity, capacity and any temperature or sterility constraints. The BOS Customer Service Laboratory can run a feasibility trial and recommend a validated pressure, valve and machine configuration. Explore the full MG-series at **www.boshomogenisers.com/machines**



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