HIGH SHEAR
IN-LINE MIXERS

S I L V E R S O N
For over 50 years Silverson has specialised in the manufacture of quality High Shear Mixers for processing and manufacturing industries worldwide.

With customers in over 140 countries and serving industries as diverse as food, pharmaceuticals, cosmetics, chemicals, luboils and petrochemicals, Silverson has become a world leader in the field of High Shear Mixing. Time and again companies specify Silverson Mixers as the “standard” equipment for their manufacturing processes.

A truly international company, Silverson is represented by a network of associated companies, distributors and agents in over 40 countries, serving North America, Europe, Asia, Australasia, South America and Africa.
The Silverson Advantage

**SPEED** The exceptionally rapid Silverson mixing action substantially reduces process times compared with conventional agitators and mixers and can reduce mixing times by up to 90%.

**VERSATILITY** The advantage of the Silverson approach to mixing is that any one machine can perform the duties that in the past may have required several different pieces of process equipment.

Unrivalled versatility allows any machine to be adapted to perform the widest range of mixing applications - mixing, emulsifying, homogenising, disintegrating, dissolving, dispersing, blending, particle size reduction and de-agglomerating.

**AERATION FREE** As the Silverson In-Line mixer and the associated vessel and pipework form a closed system, the mixing process is completely aeration free. This is particularly important for applications where air entrainment creates a problem.

**SELF-PUMPING** Silverson In-Line mixers provide a high volume centrifugal pumping action which, in most cases, will be sufficient for the process requirements without the need for auxiliary pumps.

If, due to viscosity, vertical head or pipeline losses, the In-Line mixer’s output falls below the required figure, it may be supplemented by the insertion of an auxiliary pump into the system without reducing the efficiency of the mixer.

**GUARANTEED EFFICIENCY** The Silverson In-Line mixer design makes it physically impossible for any materials - liquid or solid - to pass from the inlet to the outlet without being subjected to intense mechanical and hydraulic shear as they pass through the rotor/stator workhead. Bypassing is impossible.

**LOWER POWER REQUIREMENTS** As the Silverson In-Line mixer’s energy is concentrated on processing the small volume of material inside the workhead at any given moment, power is not wasted moving large volumes of liquid and consequently less power is normally required than for the equivalent batch mixer. This is particularly beneficial when processing large volumes of material.

**INCREASING EXISTING PRODUCTION** Where existing agitators and conventional mixers are being used, the addition of a Silverson In-Line mixer will greatly reduce the process time, whilst at the same time improving product uniformity. Easily installed, Silverson In-Line mixers can substantially increase existing production with a minimum of capital investment by saving the need for additional mixing vessels, pipework and auxiliary equipment.
What will the Silverson do?

**BLENDING** In blending liquids of similar or greatly varying viscosities, the unique Silverson mixing action can rapidly produce a guaranteed homogeneous product, normally in a single pass.

**EMULSIFYING AND HOMOGENISING** The special high shear rotor/stator design means that emulsions (typically in the range of 0.5 to 5 microns) can be easily achieved, in many cases dispensing with the need for more costly and complicated equipment such as high pressure homogenisers.

**DISINTEGRATION** All Silverson mixers are able to disintegrate matter of animal, vegetable, mineral or synthetic origin in a single operation.

**PARTICLE SIZE REDUCTION** For particle size reduction, the high shear rotor/stator action will ensure the rapid and uniform milling of both solid and semi-solid materials into either solution or fine suspension. The degree of size reduction will always depend on the hardness or toughness of the product but in many applications the use of a Silverson will dispense with the need for conventional size reduction equipment, such as dispersers/cavitation mixers, grinders and mills and at a fraction of the cost.

**GELLING AND SOLUBILISING** The solution of gums, alginates, C.M.C., carbolpol, etc., can be a slow and difficult process if a conventional agitator or mixer is used. Agglomerates frequently form and these can only be removed slowly by the washing action of the agitator.

The addition of a Silverson In-Line mixer to the system however will greatly reduce the process time and improve the product quality and uniformity.

**DE-AGGLOMERATION** The Silverson rotor/stator workhead rapidly disintegrates and disperses agglomerates to give a totally uniform and homogeneous mix.
EXPERIENCE AND KNOW HOW
Silverson has been the leader in High Shear Mixing technology for over 50 years and has built up a detailed and extensive knowledge of mixing process requirements. This accumulated knowledge enables our technical staff and sales representatives to clearly identify a client’s needs and recommend the type of mixer most suited to provide an efficient and economical solution.

EXTENSIVE TEST FACILITIES
Available for the use of all clients, Silverson maintains a dedicated test facility equipped with a wide range of laboratory and production scale machines. Here customers may test new products and discuss their applications with our technical staff. If preferred, Silverson mixers can be provided for on-site trials at the customer’s own premises to allow evaluation when operating under actual production conditions.

CUSTOMISATION
Increasingly today’s process manufacturers require equipment to be designed to meet their own particular needs. Silverson, working in close co-operation with the customer, has a positive approach and flexibility which allows custom designed and built mixers specifically suited to the individual user’s requirements.

WORLDWIDE SUPPORT
A truly international company, Silverson is represented by a network of associated companies, distributors and agents in over 40 countries, serving Europe, North America, Asia, Australasia, South America and Africa.

INSTALLATION
Silverson offers expert advice on the installation of their equipment and, if required, our local technical staff can assist and supervise the installation and start up.

AFTER SALES SERVICE
With over 50 years of experience Silverson realises the importance their customers place on reliable and rapid back-up service.

Our large stock of manufactured parts enables us to despatch most standard spares the same day they are ordered.
1. The high speed rotation of the rotor blades within the precision machined mixing workhead exerts a powerful suction, drawing liquid and solid materials into the rotor/stator assembly.

2. Centrifugal force then drives materials towards the periphery of the workhead where they are subjected to a milling action in the precision machined clearance between the ends of the rotor blades and the inner wall of the stator.

3. This is followed by intense hydraulic shear as the materials are forced, at high velocity, out through the perforations in the stator, then through the machine outlet and along the pipework. At the same time, fresh materials are continually drawn into the workhead, maintaining the mixing and pumping cycle.
How to Use the In-Line Mixer

Single Pass Method

There are basically three types of operation for which single pass processing can successfully be used.

▶ CONTINUOUS BLENDING  The ingredients are metered into the mixer or a manifold just prior to the rotor/stator workhead. This will ensure that products that react together are mixed immediately on contact. This method is ideal for continuous liquid/liquid blending and for products where aeration must be avoided, e.g. detergents.

▶ SERIES PROCESSING  In certain cases where a higher degree of homogenisation or comminution is required than can be obtained by a single pass through the In-Line mixer, it is possible to achieve the required results by using two or more machines in series.

▶ PRE-MIX METHOD  The ingredients are coarsely pre-mixed in a holding vessel with a Silverson batch mixer or a simple agitator. A single pass through the In-Line mixer will then ensure an agglomerate free homogeneous product. All the product must pass through the In-Line mixer’s rotor/stator workhead as by-passing is impossible.

Recirculation Method

Where a higher degree of homogenisation, emulsification or particle size reduction is required, a recirculation method is recommended. Here product is drawn from the bottom of the vessel, processed through the high shear rotor/stator workhead and passed back into the top of the vessel.

In small vessels this will ensure adequate in-tank movement but in larger vessels an auxiliary in-tank mixer or agitator will be required.

Additional fluid ingredients can be fed into the inlet pipeline and will be drawn immediately into the workhead and uniformly mixed before entering the vessel.

Where quality assurance (QA) demands a set number of passes through the rotor/stator workhead the product can be passed back and forth between two separate vessels.
MATERIALS OF CONSTRUCTION

Unless otherwise stated, all product contact parts are constructed in Grade 316 Stainless Steel. Where required, machines can be constructed in non-standard materials, such as carbon steel or Hastelloy.

MOTORS

The standard range of motors available includes:

- TEFV: Totally Enclosed Fan Ventilated.
- ExN T3: Non-sparking
- EEExd: Flameproof
- CENELEC/EURONORM/BASEEFA Groups 2A, 2B, T1 - T4

IP55 Weatherproof/Hoseproof enclosure is standard for all motors. Other types of enclosures and standards i.e. C.S.A., U.L., or P.T.B. certified are available on request.

OPERATING PRESSURES

All standard models are designed for operation on pressures not in excess of 40 psi (2.8 bar). These models can also be supplied with pressure ratings of 100 psi (7 bar) and 200 psi (14 bar). High pressure units, i.e. rated over 200 psi (14 bar) are available on request.

INLET AND OUTLET CONNECTIONS

All standard sanitary screw or flange fittings are available on request (e.g. ISS, DIN, RJT, SMS, ASA, Tri-clamp etc.).

CLEANING

Silverson In-Line mixers are designed for cleaning in place (CIP), a short run between successive operations in water, detergent or an appropriate solvent being all that is required. If manual cleaning is necessary, dismantling is easy and downtime minimal.

SEALING

Single Mechanical Shaft sealing

The In-Line mixer shaft is normally sealed by a single mechanical shaft seal with carbon versus ceramic faces and viton elastomers. Other elastomers and PTFE are available as optional extras.

Tungsten carbide versus silicon carbide hard faces are recommended when processing mildly abrasive products.

Double Mechanical Shaft sealing

Double mechanical shaft seals are required when processing products that are abrasive, sticky or viscous or when the system is under vacuum.

The seals are mounted back to back in a chamber which must be flushed with a compatible non-flammable fluid at a pressure not less than 15 psi (1 bar) in excess of pressure in the system. This type of arrangement is suitable for operation under positive pressure, atmospheric pressure and vacuum. Sealant flushing systems can be supplied as an optional extra.
A comprehensive range of workheads and screens is available for all Silverson high shear mixers. These easily interchangeable workheads offer great versatility by allowing any machine to be adapted to perform a wide range of mixing operations including emulsifying, homogenising, disintegrating, dissolving, dispersing, blending, particle size reduction and de-agglomerating. Changing from one head or screen to another is quick and simple.

**GENERAL PURPOSE DISINTEGRATING HEAD**
Used for a wide range of applications, this head will give the greatest throughput. Suitable for the blending of liquids of similar or greatly varying viscosities, its uses also include the disintegration of solid and semi-solid materials.

**SQUARE HOLE HIGH SHEAR SCREEN™**
The configuration and fine internal tolerances of this stator provide exceptionally high shear rates which are ideal for the rapid size reduction of soluble and insoluble granular solids. It is also suitable for the preparation of emulsions, gels and thickeners and fine colloidal suspensions.

**SLOTTED DISINTEGRATING HEAD**
For the disintegration of fibrous materials such as animal and vegetable tissue, as well as the disintegration and solubilisation of “elastic” materials such as rubbers and polymers.

**EMULSOR SCREENS**
These screens are suitable for liquid/liquid preparations and are especially useful for all emulsions. Emulsor screens are available in fine, medium or coarse perforations.
Standard Multi-purpose In-Line Mixers

The Silverson “standard” series of multi-purpose In-Line mixers are able to perform the widest variety of applications - mixing, emulsifying, homogenising, disintegrating and dissolving - with an efficiency and flexibility unmatched by other machines.

Each machine employs the special “Interchangeable” Silverson Rotor/Stator Mixing Head, which allows it to be used on a wide variety of different products, while the robust and simple construction ensures that cleaning and maintenance are kept to an absolute minimum.

► INTERCHANGEABLE WORKHEADS Interchangeable workheads are available to adapt the machine for varying processes. Changing from one head or screen to another is quick and simple. See page 9.

► NO BY-PASSING The In-Line mixer’s design makes it physically impossible for any materials - liquid or solid - to pass from the inlet to the outlet without being subjected to intense mechanical and hydraulic shear as it passes through the rotor/stator workhead. By-passing is impossible.

► SELF PUMPING Silverson In-Line mixers provide a centrifugal pumping action which, in many cases will be sufficient for the process flow requirements without the need for auxiliary pumps.

► HYGIENIC CONSTRUCTION Designed to comply with FDA, 3A and GMP standards, these machines are ideally suited for industries where Cleaning In Place (CIP) procedures are the norm. Not only do these include the food, pharmaceutical and cosmetic industries but also more diverse industries such as chemicals and paints where modern manufacturing techniques and maximum equipment utilisation require a rapid changeover from one product to another.

The high standard of finish and crevice free construction help set new standards in In-Line mixer hygiene.

► EASY MAINTENANCE The robust and simple construction ensures that maintenance is easy and downtime minimal. Quick release nuts for the front cover are available on request.

► VERTICAL IN-LINE Standard multi-purpose In-Line mixers are also available in a vertical configuration. Their construction allows additional inlets to be fitted where two or more individual ingredients need to be fed into an In-Line mixer.
Standard Multi-purpose In-Line Mixers

**HIGH CAPACITIES** The Silverson “standard” series of multi-purpose High Shear In-Line mixers are available in a wide range of sizes with self-pumping capacities from 15 litres up to 200,000 litres per hour.

These high self-pumping capacities can substantially reduce existing mixing times resulting in increased production with a minimum of capital investment by saving on the need for additional mixing vessels, piping and auxiliary equipment.

In many cases a Silverson In-Line mixer can be used to replace an existing centrifugal pump to provide both processing and pumping benefits.

**HIGH SHEAR RATES** The largest Silverson In-Line mixers provide some of the highest rotor tip speeds and shear rates in the industry.

These high shear rates give better particle size reduction, emulsification, dissolving and dispersion, in many cases eliminating the need for more expensive and complicated equipment such as colloid mills, high pressure homogenisers and media mills.

**FLEXIBILITY** Suitably installed, any Silverson High Shear In-Line mixer can easily be used to mix two or more individual process vessels. Alternatively it can be mounted on a mobile base (see optional extras - page 17) so it can be moved from vessel to vessel.
International Standards and changing process requirements mean that today’s pharmaceutical, biotechnology and food companies are demanding ever increasing standards of hygienic construction in the process equipment used.

To meet future demands Silverson has developed a new Ultra-Hygienic In-Line Mixer.

Designed to comply with FDA, 3A, GMP and EHEDG standards, these machines are ideally suited for industries where advanced Clean-In-Place (CIP) and Sterilise-In-Place (SIP) are required.

**DESIGN** The UHLS Ultra-Hygienic In-Line Mixer series has all the qualities and flexibility of the Silverson Standard Multi-Purpose series but incorporates many additional features. These include:

- Self-draining bottom outlet
- Single piece inlet plate and stator
- Hygienic Metal Bellows shaft seal
- Electropolished finish to 0.5 µm Ra
- Crevice-free construction
- No metal-to-metal contact
- No castings - no porosity
- All 316L stainless steel construction of wetted parts
- Environmentally friendly - minimises cleaning materials

Stainless steel motors are available as an optional extra.

**INTERCHANGEABLE WORKHEADS** Interchangeable workheads are available to adapt the machine for varying purposes.

Separate stators and Inlet Mounting Plates are available for less stringent applications or to suit individual customer preferences.

**REDUCED OPERATING COSTS** The Ultra-Hygienic In-Line Mixer is designed for Clean-In-Place (CIP)/Sterilise-In-Place (SIP). Its hygienic construction shortens the required CIP/SIP cycle time and minimises the use of cleaning chemicals. In addition to this, the fact that manual dismantling and cleaning is not required significantly reduces operating costs, increases reliability and avoids accidental damage to the machine’s internal components.
Multi-stage In-Line Mixers

The Multi-stage In-Line Mixer has been specifically developed for those applications where a higher degree of shear is required than is available from the single stage standard multi-purpose In-Line Mixers.

It differs from the standard single stage In-Line Mixer in that its multi-toothed rotor consists of two concentric sets of blades and teeth running against two separate stators.

**INTENSE SHEAR** The Multi-stage In-Line’s design quadruples the number of shearing actions per revolution of the rotor resulting in substantially faster mixing times by reducing the number of recirculation passes required. The use of two concentric stators and multi-toothed rotors also increases the number of products that can be processed in a single pass.

As material passes through the Multi-stage workhead it is subjected to increasing rates of shear. The inner rotor subjects the product to an initial mixing action, reducing the size of large particles and producing a uniform pre-mix. The inner rotor also acts as the prime mover for the product, forcing it into the outer multi-bladed rotor/stator assembly where the greatly increased tip speeds and shear rates complete the mixing cycle by producing a completely homogeneous product.

**STATOR SELECTION** As with standard In-Line mixers, a complete range of workheads and stator screens is available for the Multi-stage In-Line mixer. Using two separate stators allows the user to optimise the mixer configurations to suit each individual process.
The Multishear Mill has been specifically developed for those applications where a higher degree of shear is required than is available from the standard In-Line mixers.

It is designed to meet the requirement for a high speed machine which eliminates, as far as possible the need for conventional media or colloid milling.

The Multishear Mill differs from the standard In-Line mixer in that its rotor consists of three or four sets of finely machined teeth running against three or four sets of stators.

This multistage rotor/stator workhead provides intense high shear with a three stage machine performing over 3 million individual shearing actions per second and a four stage machine over 5 million per second.

This high degree of shear eliminates the need for conventional media milling, except on the hardest of solids. However, even if conventional milling is still needed, rapid pre-milling by the Silverson Multishear Mill will enable the product to be passed through the conventional media mill at a much faster rate. This is because most media mills work best when fed with a product of a uniform and low particle size. The total process time therefore will still be only a fraction of what would be needed by conventional methods alone.

**TYPICAL APPLICATIONS**
- Pigments
- Dyestuffs
- Presscakes
- Titanium dioxide
- Bone slurries etc.
This range of In-Line mixers has been specifically developed for the disintegration and solubilisation of polymers into bitumen for the production of modified bitumens.

**DESIGN** The design is similar to the standard multi-purpose In-Line mixers, but the cylindrical body walls are jacketed for oil heating. This ensures that the product cannot cool and solidify inside the machine.

When processing products that solidify when cold it is essential to ensure thorough heat saturation before start-up. The design of these machines ensures that heat can reach all areas where residue may be present.

Sealing is by means of a graphite/carbon fibre gland packing which is designed for operation on bitumens.

Standard mechanical shaft seals are available according to the application on request.

As with all Silverson units, interchangeable stators are available to adapt the machine for varying processes.

**MODIFIED BITUMEN PRODUCTION** Polymers and rubbers such as SBS, APP, PVC, EVA and Butyl are blended with bitumen primarily for use in the production of road surfaces and roofing felts. These polymers modify the bitumen to improve its physical stability, flexibility and resistance to extreme temperatures.

While some polymers dissolve readily, others such as SBS are more difficult to dissolve/disperse, and require high shear to achieve a satisfactory mixing time. Silverson Jacketed In-Line mixers are widely used for this purpose. The bitumen/polymer mix is recycled through the Silverson In-Line mixer where the high shear rotor/stator workhead rapidly disintegrates the polymer pieces. This high shear action exposes constantly increasing areas of fresh polymer to the surrounding bitumen, so reducing the process time.

**TYPICAL APPLICATIONS**
- Polymer modified bitumen for the production of modified road bitumen and roofing felts.
- Bitumen emulsions
- Underseals and waterproofing compounds
- Bitumen cable insulation.
Dimensions of larger models available on request.
Capacities available on request

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Dimensions of larger models available on request.
Capacities available on request

All dimensions shown are in millimetres. The dimensions shown are approximate only and certified diagrams should be used for installation purposes. Silverson reserves the right to change dimensions and specifications without notice.
Motor Power Ratings and Optional Extras

▶ MOTOR POWER RATINGS Motor power ratings in this brochure are based on operation on 50 cycle electricity supply and on materials of viscosity of up to 10,000 centipoise and specific gravity up to 1.4. For operation on 60 cycle electricity supply (because of the higher shaft speeds) and on materials of higher viscosity or specific gravity higher power motors will be required.

If variable speed is particularly required it can be achieved by the separate installation of a frequency inverter and these are available as an optional extra on certain machines. Electrical switchgear is not supplied.

▶ OPTIONAL EXTRAS

Hard Tipped Rotors Available as an optional extra for processing abrasive products.

Autoclaving Quick release facilities may be incorporated to allow the mixer to be detached from its motor to permit autoclaving.

Special Paint Finish Epoxy paint or other finishes on non-contact parts are available if required.

Multiple Inlet Connections Additional inlet connections and special manifolds are available for applications where two or more individual products need to be fed into the In-Line mixer, or where product streams need to be kept separate until they are processed.

Mobile Trolleys Mobile trolleys constructed in either 304 stainless steel or mild steel with an epoxy paint finish are available for situations where the In-Line mixer has to be moved from vessel to vessel.

Selecting the Correct Machine

Although all Silverson In-Line mixers have an efficient non-positive pumping action, it is important to remember that they are primarily mixers - not pumps.

The machine should be sized by the application and not the throughput. This is particularly important if the product requires emulsification, homogenisation or particle size reduction.

The size of machine required and its pumping efficiency will depend on the product characteristics, especially viscosity and specific gravity, and the pipework layout.

Silverson’s technical staff have extensive knowledge of in-line mixing applications and can offer expert advice in selecting the correct size machine. Their recommendations can be confirmed by trials either at Silverson’s dedicated test facility or on-site.
Other Silverson Products

From small laboratory units to 8,000 gallon production scale machines, the Silverson range offers consistently high quality equipment producing uniform and reliable results.

► MULTI-PURPOSE LABORATORY MIXERS
For everyday laboratory work Silverson offers a full range of multi-purpose laboratory mixers with capacities from 1 ml to 12 litres.

► HIGH SHEAR BATCH MIXERS
This highly efficient range of mixers can dramatically improve product quality and offers considerable reductions in processing times. For increased flexibility, small to medium scale machines can be used with a mobile floor stand.

► FLASHBLEND
For high speed entraining and instant dispersion of powder into liquid. Designed to produce a homogeneous agglomerate-free solution/dispersion without entraining air, the Flashblend range comprises units capable of incorporating up to 33,000 lbs/hour of powder.

► DISINTEGRATOR 2500
SOLID/LIQUID MIXING SYSTEMS
Designed to disintegrate and solubilise whole bales or blocks of rubbers and polymers rapidly without the need for any preliminary crumbling. Other uses include disintegration of large solids in the food industry, dispersion of filter cakes and disintegration of solid gums, resins and varnishes, etc.
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